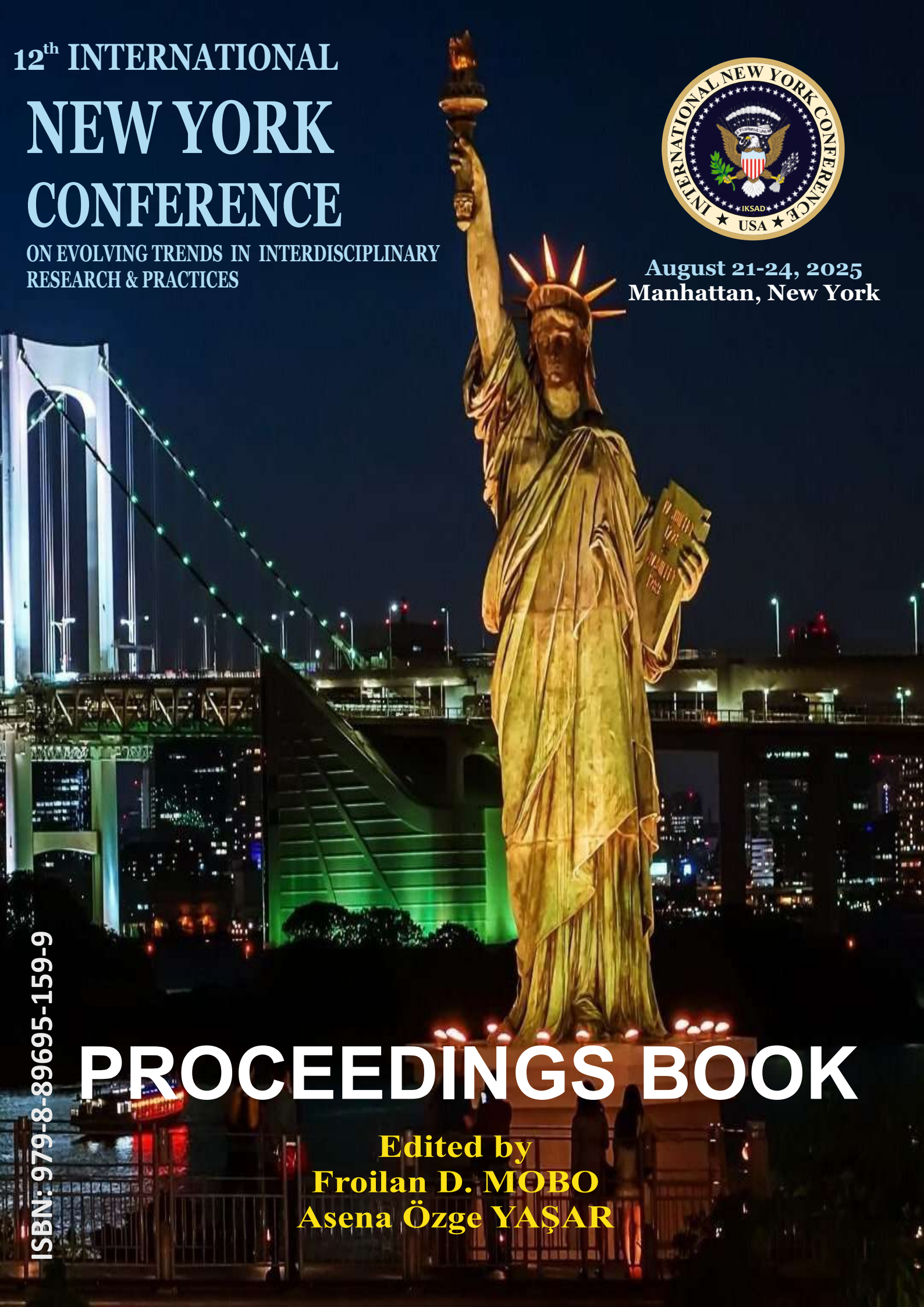


12th INTERNATIONAL

NEW YORK CONFERENCE

ON EVOLVING TRENDS IN INTERDISCIPLINARY RESEARCH & PRACTICES

August 21-24, 2025
Manhattan, New York

PROCEEDINGS BOOK

Edited by
Froilan D. MOBO
Asena Özge YAŞAR

ISBN: 979-8-89695-159-9

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Froilan D. MOBO
Asena Özge YAŞAR

31.08.2025

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ISBN - 979-8-89695-159-9

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12th INTERNATIONAL NEW YORK CONFERENCE ON EVOLVING TRENDS IN INTERDISCIPLINARY RESEARCH & PRACTICES

PARTICIPATION

Face to Face & Online

DATE - PLACE

August 21-24, 2025

Manhattan, New York City

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TOTAL PAPERS: 153

The number of papers from foreign countries: **101**

The number of papers from Türkiye: **52**

LANGUAGES

Turkish, English

PROCEEDINGS BOOK

August 21-24, 2025
Manhattan, New York City

PHOTO GALLERY













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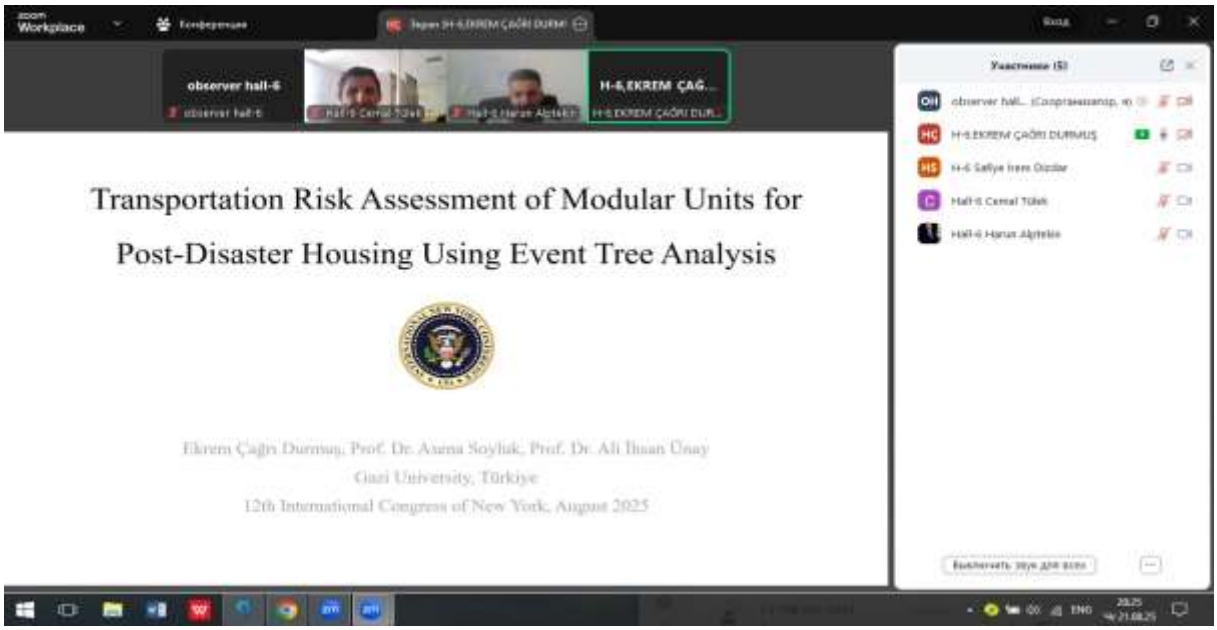
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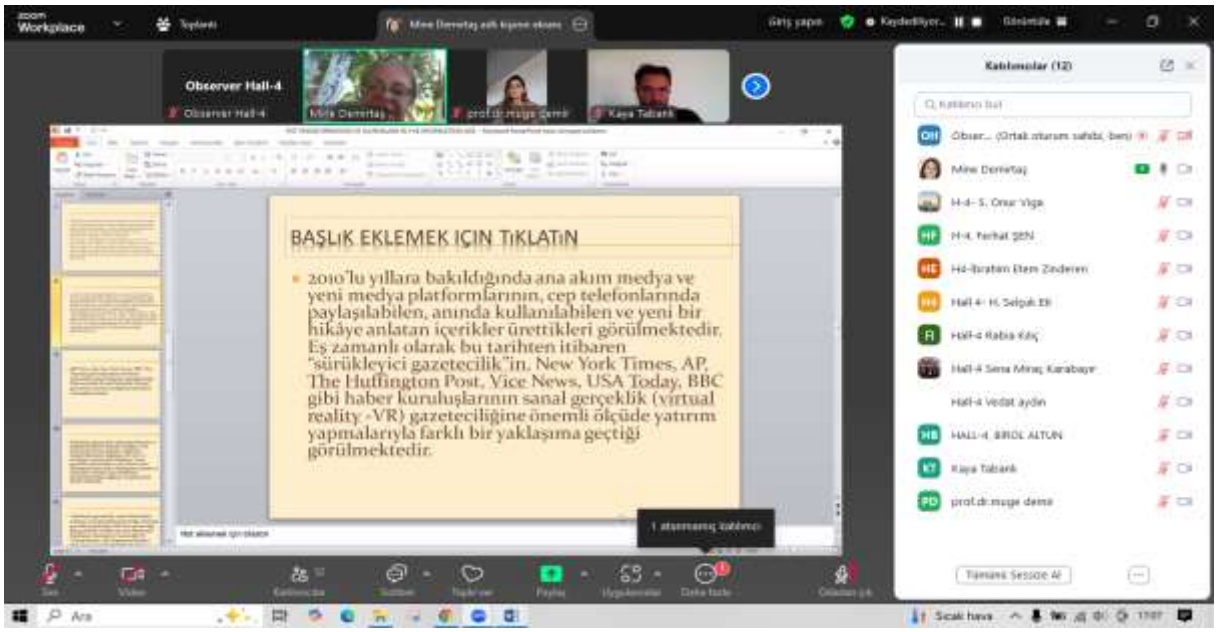


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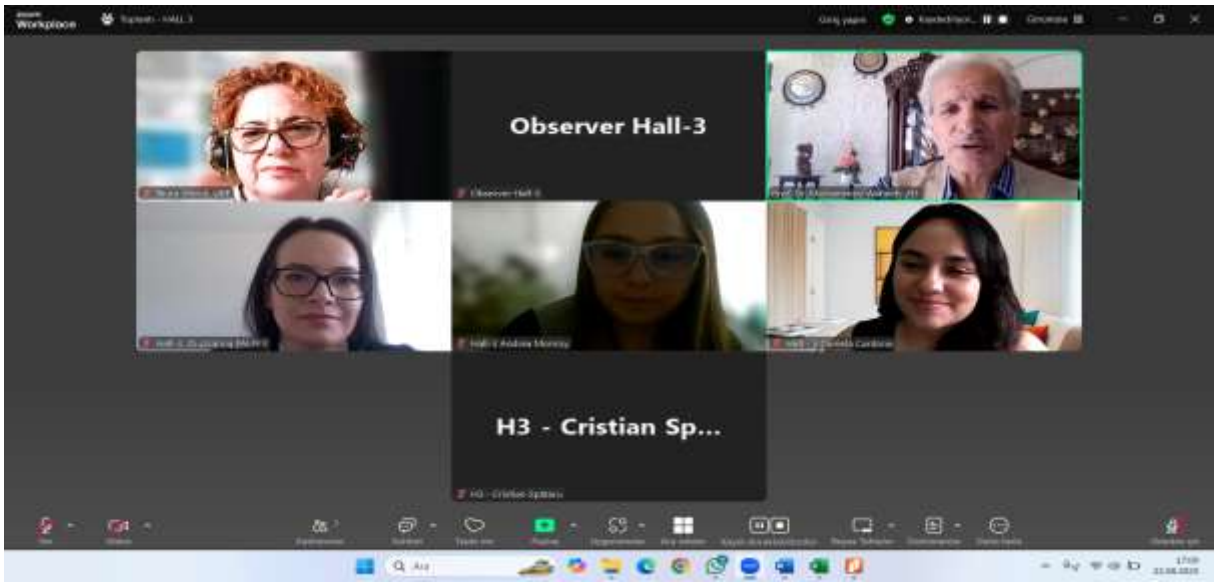
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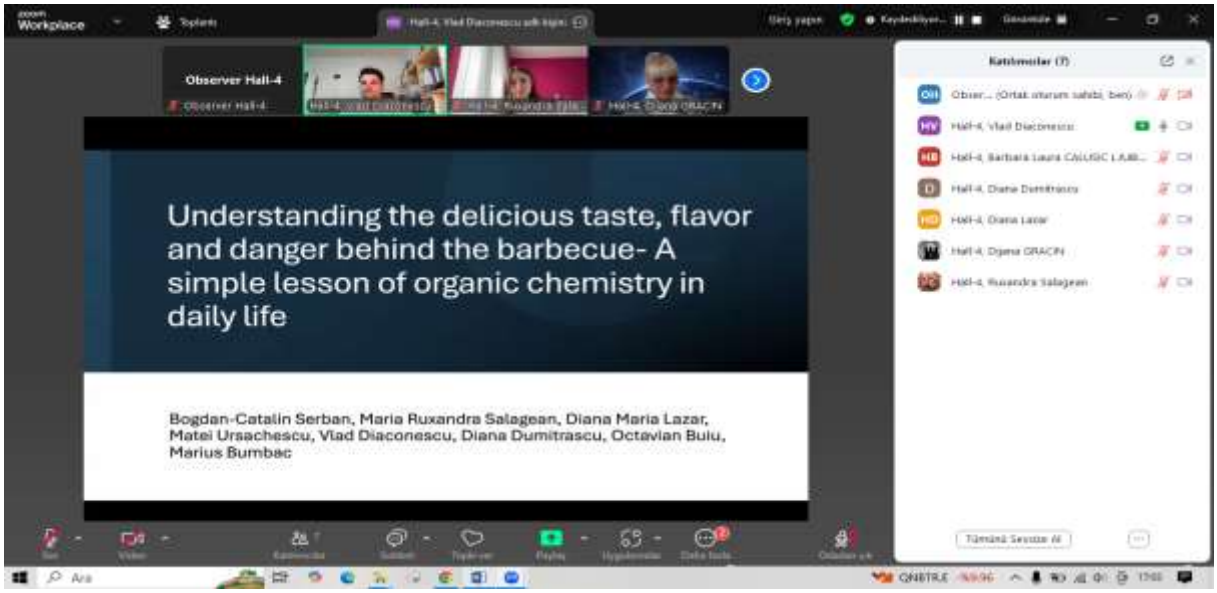




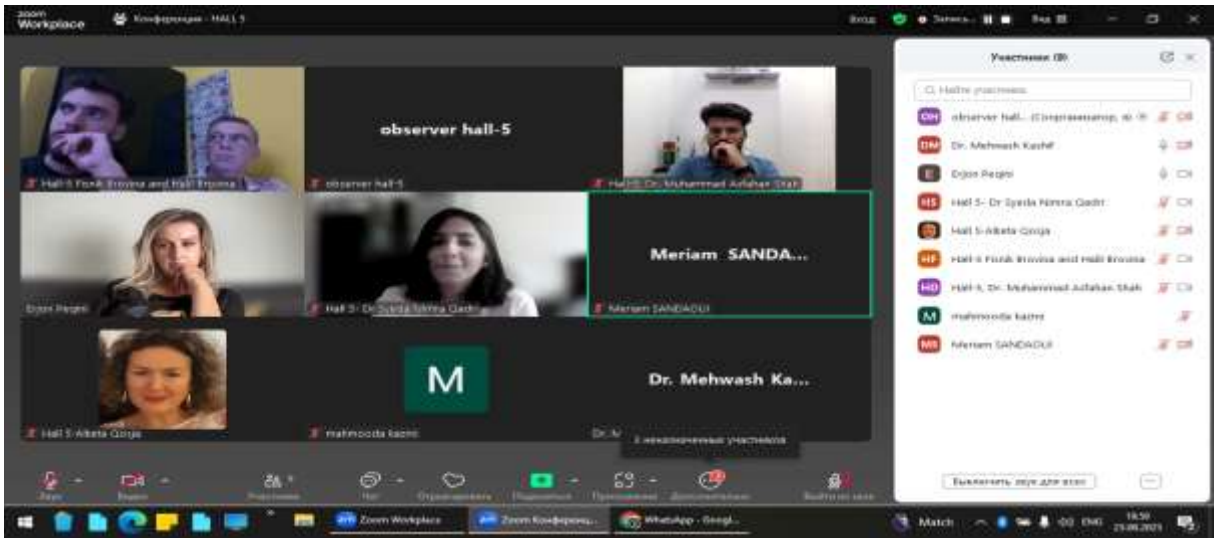
PROCEEDINGS BOOK


Observer Hall-3
H3 - Cristian Sp...


Observer hall-1


Observer Hall-4
Understanding the delicious taste, flavor and danger behind the barbecue- A simple lesson of organic chemistry in daily life
Bogdan-Catalin Serban, Maria Ruxandra Salagean, Diana Maria Lazar, Matei Ursachescu, Vlad Diaconescu, Diana Dumitrascu, Octavian Buiu, Marius Bumbac







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12th INTERNATIONAL NEW YORK CONFERENCE ON EVOLVING TRENDS IN INTERDISCIPLINARY RESEARCH & PRACTICES

August 21-24, 2025

Manhattan, New York City



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Meeting ID: 813 0348 3436
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Meeting ID: 813 0348 3436
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FACE TO FACE PRESENTATIONS

Venue: Riu Plaza Times Square

23.08.2025

New York Local Time: 14:^{00}–16:^{00}

HEAD OF SESSION: Leslie R. Robinson

AUTHORS	AFFILIATION	TOPIC TITLE
Dana Badau Adela Badau	*Transilvania University of Brasov, Romania*	COMPARING THE MOTOR EFFECTIVENESS OF TRADITIONAL PHYSICAL EDUCATION METHODS WITH BLENDED METHODS THAT INTEGRATE ARTIFICIAL INTELLIGENCE (AI) AT THE HIGH SCHOOL LEVEL
Adela Badau Irina-Mihaela Trifan	*Transilvania University of Brasov, Romania* *"G.E. Palade" University of Medicine, Romania*	THE EFFECTIVENESS OF THE DECO–S.E. PROGRAM IN DEVELOPING SOCIO-EMOTIONAL SKILLS IN EARLY EDUCATION: EVIDENCE FROM AN EXPERIMENTAL STUDY
Sonila Daiu Krisalda Mihali	*University Metropolitan Tirana, Albania*	CODING LITERACY AS LINGUISTIC EMPOWERMENT: A CROSS-DISCIPLINARY FRAMEWORK
Asena Özge YAŞAR	*Archrono Academy LLC. Georgia, USA*	TWO CONTINENTAL FACES OF PUBLIC ARCHAEOLOGY: A COMPARATIVE PERSPECTIVE FROM TÜRKİYE AND THE UNITED STATES
Iliass Nadif Wail El Mouhri Naoual Tajat Idriss Bakas Samir Qourzal Malika Tamimi	*Ibn Zohr University, Morocoo*	IN-SITU UNIFORM GROWTH OF POLYPYRROLE ON MAGNETIC Fe_3O_4@NiMgAl-LDH: APPLICATION IN THE ADSORPTIVE REMOVAL OF DICHLORPROP-P HERBICIDE FROM WASTEWATER
Joada Fetiu	*Universiteti Politeknik i Tiranes, Albania*	MEASUREMENT OF FINANCIAL FAILURES OF COMPANIES INCLUDED IN THE FTSE100 INDEX TRADING ON THE LONDON STOCK
Cevat CELEP	*Girne American University*	THE EFFECT OF POWER SOURCES USED BY SCHOOL ADMINISTRATORS ON THE ORGANIZATIONAL COMMITMENT OF TEACHERS
Abbos Utkirov Meylievich	*Westminster International University in Tashkent, Uzbekistan*	A SURVEY-BASED EVALUATION OF TOTAL QUALITY MANAGEMENTDIMENSIONS AND THEIR INFLUENCE ON FINANCIAL AND NON-FINANCIAL PERFORMANCE IN HEIS
Josip Balen Edvin Borovac Dunja Caleta Gabrijel Krilcic	*University of J.J. Strossmayer Osijek, Croatia* *TTTech Auto.d.o.o., Croatia*	INTELLIGENT FIRE SAFETY IN INDOOR ENVIRONMENTS: TECHNOLOGIES FOR FIRE PREVENTION, DETECTION, AND SUPPRESSION



Meeting ID: 813 0348 3436
Passcode: 212223

Hall-1
21.08.2025
Moderator: Dr. Mah Ru Nisa Atif
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Faizan Afzal	PRESCRIPTION DRUG MISUSE (PDP): A COESSENTIAL AND DESCRIPTIVE TYPE OF STUDY IN PUBLIC AND PHARMACIES TO EVALUATE ROOT CAUSE OF DRUG MISUSE	Hajvery University, Euro campus, Pakistan
Bismillah Iftikhar Sumbal Imran Asifa Javaid Saim Naseer Dr. Mah Ru Nisa Atif	ICTAL-INDUCED CARDIOVASCULAR DISEASE AND ASSOCIATED NEUROLOGICAL COMORBIDITIES: A META-ANALYTICAL APPROACH	Hajvery University, Euro campus, Pakistan
Nino Dzadzamia Nika Gachechiladze	THE IMPACTS OF SELF-DIAGNOSING MENTAL HEALTH DISORDERS THROUGH SOCIAL MEDIA IN YOUNG ADULTS	Georgian-American University, Georgia Tbilisi State Medical University, Georgia
Beyza Dilman Assoc. Prof. Halime Ugur	PROTECTIVE EFFECTS OF GRAPE SEED PROANTHOCYANIDINS AT THE GENE LEVEL IN DIABETIC NEPHROPATHY	Istanbul Medeniyet University, Türkiye
Gavkharoi Umurzakova	INFLUENCE OF SUNSHINE (IN HOURS) ON THE DEVELOPMENT OF STROKES AMONG THE POPULATION IN SOUTHERN KYRGYZSTAN	Osh State University, Kyrgyzstan
Luiza Gabunia Giorgi Varazi Nana Gorgaslidze Elena Varazi Levan Ratiani	EVALUATION THE EFFECTIVENESS OF EXISTING HEALTH PROMOTION STRATEGIES AND PROGRAMS IN GEORGIA	Tbilisi State Medical University, Georgia
Varazi Elena Kuridze Nino Gabunia Luiza	RECENT EVIDENCES IN THE DIRECTION OF STIMULATING WOUND HEALING WITHOUT THE DEVELOPMENT OF PATHOLOGICAL SCARRING	Tbilisi State Medical University, Georgia
Reinaldo Luiz Brunello Junior Selma Siéssere Paulo Batista de Vasconcelos Luiz Gustavo de Sousa Simone Cecilio Hallak Regalo Marcelo Palinkas	PRELIMINARY ELECTROMYOGRAPHIC ANALYSIS OF MASTICATORY AND FACIAL MUSCLES AFTER MIDFACE LIFTING THROUGH SUPRAPERIOSTEAL HYALURONIC ACID FILLER IN THE ZYGOMATIC ARCH IN ADULT WOMEN	University of São Paulo, Brazil

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Hall-2
21.08.2025
Moderator: Bidzina Abesadze
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Faiz Benzaibak	CALCULATING OPTIMAL SOLAR PANEL AND BATTERY CONFIGURATIONS FOR A 3 MW SOLAR POWER SYSTEM	Istanbul Aydin University, Türkiye
S. Tariq L. H. Omari F. Mezzat V. Tuyikeze E. K. Hlil	EXPLORING STRUCTURAL, ELECTRONIC, OPTICAL, AND PHOTOCATALYTIC PROPERTIES OF NOVEL DOUBLE PEROVSKITES Cs 2 InSbX 6 (X = F, Cl) UNDER STRAIN	Hassan II University, Morocco University Mohammed V of Rabat, Morocco École Normale Supérieure, burundi University Grenoble Alpes, France University Grenoble Alpes, France
Manana Chumburidze Aza Iphshiradze Anano Khetsuriani	ABOUT THE EFFICIENT MANAGEMENT ALGORITHMS FOR E-COMMERCE MODELS AND THEIR APPLICATIONS	Akaki Tsereteli State University, Georgia
Otari Bregadze Luka Kurdadze Vazha Kelikhashvili	RESEARCH OF THE MECHANISM OF EMISSION GAS REDUCTION IN THE AVIATION FIELD	Georgian Aviation University, Georgia
Zurab Kopaleishvili	INCREASING THE FLIGHT SAFETY OF RESCUE DRONES AND HELICOPTERS WITH A DEVICE TO PREVENT BIRDS FROM GETTING INTO THE ENGINES	Georgian Aviation University, Georgia
Bidzina Abesadze	DETERMINATION OF THE RHEOLOGICAL PARAMETERS OF THE MATERIAL BY AN IMPROVED METHOD ON THE EXAMPLE OF THE CREEP PROCESS UNDER TORSIONAL DEFORMATION	Georgian Aviation University, Georgia
Kamala Mammadzada	CONSTRUCT A DIGITAL TWIN USING FUZZY LOGIC FOR A WASTEWATER TREATMENT BIOREACTOR	Azerbaijan State of Oil and Industry University, Azerbaijan
Irakli Gobejishvili	PRE-STRESSED SEISMIC-RESISTANT SUSPENDED SPATIAL STRUCTURAL SYSTEM FOR HIGH-RISE BUILDINGS	Georgian Technical University, Georgia

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Hall-3
21.08.2025
Moderator: Dr. Aysegul Terkan Gurcan
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Yahaya HALIDU	SUNNI-SUFI CONUNDRUM: MUSLIMS, SPIRITUALITY AND THE SEARCH FOR MEANINGS IN ISLAMIC RELIGIOSITY WITHIN THE SUFI TRADITION IN WEST AFRICA	The University of Texas at Austin, USA
Yahaya HALIDU	VIOLENCE IN MUSLIM WEST AFRICA: THE CRISIS OF RELIGIOUS POLITICS AND SECULAR IDEOLOGIES	The University of Texas at Austin, USA
ABODOHOUI Orerien Olivier	STRUGGLE FOR FREEDOM IN OLAUDAH EQUIANO'S THE INTERESTING NARRATIVE OF THE LIFE OF OLAUDAH EQUIANO	Enseignant-Chercheur à l'Université d'Abomey-Calavi (Bénin)
Furkan BALTACI Yiğitcan Efe SEVIMLISOY Vural KENDİRCİ	THE IMPACT OF EARTHQUAKE ON GASTRONOMIC CULTURAL HERITAGE: A QUALITATIVE STUDY	Hasan Kalyoncu University, Türkiye
Duygu Sabancılar Iştın Hülya Cankorur Rabia Sultan Güler Başak Deniz	THE AESTHETICS OF SHARING: IDENTITY, MEMORY, AND PUBLICNESS IN ESRA ERSEN'S AŞURE PERFORMANCE	Balıkesir University, Turkey Rahmi Kula Anatolian High School, Balıkesir, Turkey Manisa Celal Bayar University, Manisa, Turkey
Zumrud Ibrahim Mansimova	THE GRAY WOLF PARADIGM OF THE FIRST ANCESTOR IN AZERBAIJANI FOLKLORE (AS A ZOMORPHEME)	Presidium Office of the ANAS, Azerbaijan
Petra Pelletier	ETHICAL ISSUES IN PANDEMICS AND DISASTERS	University of Paris Cité, France
Dr. Aysegul Terkan Gurcan	THREADS OF THE UNCONSCIOUS: SYMBOLISM AND SPATIAL MEMORY IN CHIHARU SHIOTA'S INSTALLATION THE KEY IN THE HAND	Segi University, PISA, Malaysia

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Hall-4
21.08.2025
Moderator: Prof. Dr. Müge DEMIR
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Mine DEMİRTAŞ Nizam Kaan DEMİRTAŞ Mahmut YAVAŞ	THE TRANSFORMATION OF JOURNALISM IN THE INFORMATION AGE: THE CASE OF IMMERSIVE JOURNALISM	İstanbul Beykent University, Türkiye
Zekeriya ŞAHIN Şaban Onur VIGA	THE FUTURE OF CRYPTOCURRENCIES IN CLASSICAL FINANCIAL SYSTEMS: REGULATORY RISKS AND MARKET IMPACTS	Istanbul Esenyurt University, Türkiye
Prof. Dr. Müge DEMIR Dr. Kaya TABANLI	THE DIZZYING PACE OF TECHNOLOGICAL ADVANCEMENTS HAS LED TO PROFOUND CHANGES IN ALL ASPECTS OF DAILY LIFE, RESHAPING INDIVIDUAL LIFESTYLES	Altınbaş University, Türkiye
Elif AKDEMİR Rabia KILIÇ Sena Miraç KARABAYIR Dr. Farid HUSEYNOV	ASSESSMENT OF THE USABILITY LEVEL OF E-GOVERNMENT AND PUBLIC APPLICATIONS	Gebze Technical University, Türkiye
Dr. Birol ALTUN	WORK-LIFE BALANCE ISSUES EXPERIENCED BY REMOTE WORKERS DURING THE COVID-19 PANDEMIC	Indepedent Researcher
Vedat AYDIN İbrahim Etem ZINDEREN	CONSTRUCTING VIRTUAL IDENTITY ON SOCIAL MEDIA: A QUALITATIVE INQUIRY INTO DISSOCIATIVE IDENTITY DISORDER	Atatürk University, Erzurum, Türkiye
Res. Assist. Ferhat Şen Prof. Dr. Müge Demir	THE AESTHETIC AND PERCEPTUAL CONSTRUCTION OF SPACE IN DIGITAL ART: AN ANALYSIS IN THE CONTEXT OF REFİK ANADOL'S ART PRACTICES	Haliç University, Türkiye Altınbaş University, Türkiye
Asst.Prof. Dr. Hasan Selçuk ETİ	DIGITALIZATION AND SUSTAINABLE STORE OPERATIONS: A NEW ERA IN THE RETAIL SECTOR	Tekirdag Namik Kemal University, Türkiye
Asst.Prof. Dr. Hasan Selçuk ETİ	THE IMPACT OF CONSUMER HABITS ON THE E-COMMERCE SECTOR AND THE TRANSFORMATION IN MARKETING STRATEGIES IN THE POST-PANDEMIC PERIOD: A COMPARISON OF TRENDYOL, HEPSİBURADA AND AMAZON TURKEY	Tekirdag Namik Kemal University, Türkiye

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Hall-5
21.08.2025
Moderator: PhD. Diaa Ayoub Ibrahim
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Diaa Ayoub Ibrahim	PRODUCTION OF Vicia faba INTERSPECIFIC HYBRID THROUGH In vitro PROPAGATION TECHNIQUE	Duhok University, Iraq
Hassani Mohamed Zyade Souad Raji Yousra	FUNCTIONALIZATION OF MOROCCAN GHASSOUL CLAY FOR ENHANCED ADSORPTION OF REFRACTORY POLLUTANTS	Hassan II University of Casablanca, Morocco
Halima EL HARAKATI Meryem Moutataouia Nihad Chakri Miloudi Hlaibi Noureddine Kamil	Ag 2 ZnP 2 O 7 : A NOVEL APPROACH TO ENHANCING PHOTOCATALYTIC ACTIVITY FOR ENVIRONMENTAL APPLICATIONS	University Hassan Second, Morocco University Mohammed 6 Polytechnic, Morocco
Lordford Tettey-Larbi Serwaa Adjei-Kyereme Thomas Onomah Amin Shahrokhi Edit Tóth-Bodrogi Tibor Kovács	REVIEW OF THE RADIOLOGICAL EXCESS LIFETIME CANCER RISK ASSESSMENT IN TOBACCO CIGARETTE	University of Pannonia, Hungary
Ahmad Abu Arra Eyüp ŞİŞMAN	EVALUATING THE TRENDS OF HYDROLOGICAL DROUGHT USING FREQUENCY INNOVATIVE TREND ANALYSIS METHODOLOGY (F-ITA) IN THE KONYA CLOSED BASIN, TÜRKİYE	Yıldız Technical University, Istanbul, Türkiye. An-Najah National University, Nablus, Palestine.
Ahmad Abu Arra Eyüp ŞİŞMAN	EVALUATING THRESHOLD LEVEL UNCERTAINTY IN HYDROLOGICAL DROUGHT THROUGH THE STREAMFLOW DROUGHT INDEX (SDI)	Yıldız Technical University, Istanbul, Türkiye. An-Najah National University, Nablus, Palestine.
Abel Fantahun Ketema, Serhan Ilkentapar, Burak Uzal	INFLUENCE OF NAOH and Na_2SiO_3 ACTIVATOR SYSTEMS ON 3D PRINTABILITY OF FLY ASH-SLAG BASED GEOPOLYMER MORTARS	Erciyes University, Türkiye. Abdullah Gül University, Türkiye
DAHMANI Maroua, ANTRAOUI Ilyas, KHETTABI Ali	ONE-DIMENSIONAL ACOUSTIC STUDY OF A HYBRID SYSTEM WITH HELMHOLTZ RESONATORS AND CLOSED RESONATORS FOR FILTERING APPLICATIONS	University Mohamed I, Morocco
Chakri Nihad Moutataouia Meriem El Amrani Btissam Berrada Faouzi Amraoui Fouad	CHARACTERIZATION OF NATURAL POZZOLAN AND SANDSTONE AND THEIR PERFORMANCE IN WASTEWATER TREATMENT	University of Hassan II, Morocco
Meryem Moutataouia Halima ELHARAKAT Amine ARAJLI Nihad CHAKRI Rachida EL OUATIB Noureddine KAMIL	ENHANCING PHOTOCATALYTIC EFFICIENCY OF PHOSPHATE-BASED MATERIALS FOR EFFECTIVE DEGRADATION OF PERSISTENT ORGANIC POLLUANTS	University of Hassan II, Morocco

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Hall-6
21.08.2025
Moderator: Prof. Dr. Asena SOYLUK
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Safiye İrem DIZDAR	ARTIFICIAL LIGHTING EFFECTS ON CULTURAL HERITAGE	Yeni Yüzyıl University, Türkiye
Dr. Harun ALPTEKIN Dr. Cemal TÜLEK	A CURRENT REVIEW ON THE BIOLOGICAL BASIS AND BREAKING METHODS OF SEED DORMANCY	Faculty of Agriculture, Department of Plant Protection, Iğdır, Türkiye
Dr. Cemal TÜLEK Dr. Harun ALPTEKIN	THE ROLE OF MULCH APPLICATIONS IN WEED MANAGEMENT: EFFECTS OF THICKNESS, TYPE, AND TIMING	Faculty of Agriculture, Department of Plant Protection, Iğdır, Türkiye
Ekrem Çağrı DURMUŞ Prof. Dr. Asena SOYLUK Prof. Dr. Ali İhsan ÜNAY	TRANSPORTATION RISK ASSESSMENT OF MODULAR UNITS FOR POST-DISASTER HOUSING USING EVENT TREE ANALYSIS	Gazi University, Türkiye

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Meeting ID: 813 0348 3436
Passcode: 212223

Hall-7
21.08.2025
Moderator: Academician Dr. Ivan Pavlovıc
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Rajaa TESSE Bouchaib BAHLAOUAN Ilham Boumendil Said EL ANTRI Nadia BOUTALEB	INITIAL APPLICATION OF THE BIOCOUPLER MT TEMPORARY IMMERSION SYSTEM FOR MICROPROPAGATION OF ARGANIA SPINOSA (SKEELS L.)	Hassan II University of Casablanca, Morocco Higher Institutes of the Nursing Professions and Techniques of Health ISPITS, Morocco
Ilham BOUMENDİL Rajaa TESSE Fatima-Zahra YASSİF Mhammed SISOUANE Amal SAFİ	SUSTAINABLE AND COST-EFFECTIVE APPROACH TO RECYCLING SALTED ANCHOVY BONES: DESALTING COMBINED WITH NUTRITIONAL ENRICHMENT USING PLANT-BASED MEALS	Hassan II University of Casablanca, Morocco University Ibn Tofail, Morocco Chouaib Doukkali University, Morocco
Academician Dr. Ivan Pavlovıc Prof Dr Slavica Zivkovic, PhD Aleksandra Tasic	OCCURENCE OF PARASCARIS EQUORUM OF DOMESTIC MOUNTAIN HORSE IN SERBIA	Scientific Institute of Veterinary Medicine of Serbia, Belgrade, Serbia Agricultural School PKB, Belgrade, Serbia
Martins GDSB, Elias CN, Marques AA, Souza BM	SELECTION BIOMATERIALS FOR APPLICATION AS BONE GRAFTS	Instituto Militar de Engenharia - IME
Martins GDSB, Elias CN, Marques AA, Silva MHPD	DIPYRIDAMOLE INCORPORATION INTO HYDROXYAPATITE	Instituto Militar de Engenharia - IME
Tukhtamushova A.U. Yunusov M.Yu.	THE IMPORTANCE OF USING INDUSTRIAL WASTE IN THE PRODUCTION OF ECONOMICALLY EFFICIENT MATERIALS	Tashkent Institute of Chemical Technology, Uzbekistan
Hasna JINNOU Said ARIF Mohamed Achraf HASNAI	THE CONTRIBUTION OF SPRAYING DRONES TO PRECISION AGRICULTURE IN THE TADLA PLAIN: EFFICIENCY, BENEFITS, AND CHALLENGES	Sultan Moulay Slimane University, Morocco
Jarcău Mihaela Poroch-Seriţan Maria	RHEOLOGICAL BEHAVIOR AND SHELF-LIFE CORRELATION OF FRESH QUINCE, APPLE, BLUEBERRY AND SEA BUCKTHORN JUICES	University Ştefan cel Mare of Suceava, Romania

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Meeting ID: 813 0348 3436
Passcode: 212223

Hall-1
22.08.2025
Moderator: Assist. Prof. Dr. Mustafa Tuncer OKUMUŞ
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Assist. Prof. Dr. Mustafa Tuncer OKUMUŞ Mehmet Şükrü AKTULUM	THE RELATIONSHIP BETWEEN PSYCHOLOGICAL RESILIENCE AND JOB STRESS: THE CASE OF KAHRAMANMARAŞ SOCIAL SERVICE WORKERS	Kahramanmaraş Istiklal University, Türkiye
PhD. Emel Aner Aktan, Beste Bosnalı	GENÇ BİREYLERDE ÖLÜM ANKSİYETESİ VE DEPRESYON ARASINDAKİ İLİŞKİ: DERLEME ÇALIŞMASI	Nişantaşı University, İstanbul, Turkey. Kent University, İstanbul, Turkey
Gülşah GÜLER Prof. Dr. Uğur BÜYÜK	TEACHER PERSPECTIVES ON THE IMPLEMENTATION CHALLENGES OF A NEW SCIENCE CURRICULUM	Erciyes University, Türkiye
Gülşah GÜLER Prof. Dr. Uğur BÜYÜK	THE IMPACT OF THE TURKISH CENTURY MAARIF MODEL ON INTERDISCIPLINARY INTERACTION AND SKILL DEVELOPMENT IN SCIENCE EDUCATION	Erciyes University, Türkiye
Aydın SELLIOĞ	HOPELESSNESS SCALE FOR SCIENCE EDUCATION: A STUDY ON VALIDITY AND RELIABILITY	Mersin University, Faculty of Education, Science Education, Mersin, Türkiye.
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Hall-2
22.08.2025
Moderator: MD Nazmul Hossain
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Manana Chumburidze Aza Iphshiradze Anano Khetsuriani	ABOUT THE DIGITAL STRATEGY AND THEIR APPLICATIONS	Akaki Tsereteli State University, Georgia Loan Officer at Microfinance Bank, Georgia
Meftun Deniz Seyhun Doğan	SOCIAL MEDIA PLATFORMS' ROLE IN DIGITAL ENTREPRENEURSHIP	İstanbul University, Türkiye
MD Nazmul Hossain Syod Ahsanul Islam Ashik Sahariya Afroje	ZERO TRUST ARCHITECTURE: A WAY TO ENHANCE ENTERPRISE SECURITY	RUDN University, Russia
Nana Shonia Lili Maglaperidze Kristine Lomtadze	GLOBAL TRENDS OF SUSTAINABLE FINANCING AND GEORGIAN REALITY	Akaki Tsereteli State University, Georgia
Diana Bibileishvili Thebea Giorgadze Dielo Giorgadze	KEY CHALLENGES IN THE DEVELOPMENT OF GEORGIA'S CAPITAL MARKET AND STRATEGIES FOR ITS ENHANCEMENT	Akaki Tsereteli State University, Georgia Free University of Tbilisi, Georgia
David Mamrikishvili Venera Chakvetadze	INVESTMENT POLICY ANALYSIS OF THE MANDATORY FUNDED PENSION SYSTEM IN GEORGIA: INTERNATIONAL EXPERIENCE AND CHALLENGES	Ilia State University, Georgia

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Hall-3
22.08.2025
Moderator: Prof. Dr. Mohammed Waheeb
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Jenny Andrea Monroy Cortez	MANAGERIAL COMPETENCIES FOR MANAGING CHANGE AND INNOVATION IN NGOS OPERATING AS SERVICE PROVIDERS FOR THE ICBF IN THE CITIES OF CALI AND BOGOTÁ	Corporación Universitaria Minuto De Dios, Colombia
Zsuzsanna Pálffy	FROM LOCAL TO GLOBAL: CULTURAL INFLUENCES IN CEO SUSTAINABILITY AND EMBEDDEDNESS NARRATIVES IN THE COSMETICS AND FASHION INDUSTRY	Széchenyi István University, Hungary
Prof. Dr. Mohammed Waheeb	TOURISTIC ROUTES IN SITE OF JESUS BAPTISM AND FUTURE PERSPECTIVES- JORDAN-SOUTH LEVANT	The Hashemite University, Jordan
Teuta XHINDI Olgerta IDRIZI	UNDERSTANDING GENDER GAPS AND THEIR ECONOMIC IMPACT: THE CASE OF ALBANIA (2000–2021)	European University of Tirana, Albania Mediterranean University of Albania, Albania
Cristian Romeo SPĂTARU Valer Bocan Cristian Constantin POPESCU	RETHINKING GROWTH AND INNOVATION: THE ROLE OF ARTIFICIAL INTELLIGENCE IN EUROPE'S INDUSTRIAL TRANSFORMATION	"Alexandru Ioan Cuza" University of Iasi, Romania POLITEHNICA University of Timisoara, Romania
Dr.Blendi Himçi Rexhina DEBROVA	CIVIL LIABILITY IN THE CONTEXT OF ARTIFICIAL INTELLIGENCE: CONTEMPORARY APPROACHES AND CHALLENGES FOR THE ALBANIAN LEGAL SYSTEM	University of Elbasan "Aleksandër Xhuvani", Albania

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Hall-4
22.08.2025
Moderator: Bogdan-Catalin Serban
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Bogdan-Catalin Serban, Vlad Diaconescu, Matei -Gabriel Ursachescu, Maria Ruxandra Salagean, Diana Maria Lazar, Diana Dumitraşcu, Octavian Buiu, Marius Bumbac	METAL-BASED DRUGS : A SHORT REVIEW AND FUTURE PROSPECTIVE	National Institute for Research and Development in Microtechnologies–IMT Bucharest, Voluntari, Romania. Zentiva Romania S.A, Bucharest, Romania University of Medicine and Pharmacy "Carol Davila", Bucharest, Romania National College “B. P. Hasdeu”, Buzău, Romania University of Medicine and Pharmacy "Carol Davila," Bucharest, Romania National College “Saint Sava”, Bucharest, Romania Valahia University of Targoviste, Romania
Bogdan-Catalin Serban, Matei -Gabriel Ursachescu, Vlad Diaconescu, Maria Ruxandra Salagean, Diana Maria Lazar, Diana Dumitraşcu, Octavian Buiu, Marius Bumbac	CONTROVERSIES AND FACTS ABOUT DARK CHOCOLATE: QUO VADIS?	---
Bogdan-Catalin Serban, Maria Ruxandra Salagean, Diana Maria Lazar, Matei -Gabriel Ursachescu, Vlad Diaconescu, Diana Dumitraşcu, Octavian Buiu, Marius Bumbac	UNDERSTANDING THE DELICIOUS TASTE, FLAVOR AND DANGER BEHIND THE BARBECUE - A SIMPLE LESSON OF ORGANIC CHEMISTRY IN DAILY LIFE	---
Bogdan-Catalin Serban, Matei -Gabriel Ursachescu, Diana Maria Lazar, Maria Ruxandra Salagean, Vlad Diaconescu, Diana Dumitraşcu, Octavian Buiu, Marius Bumbac	UNDERSTANDING BRONSTED ACIDS AND BASES: BEYOND OF FIELD AND RESONANCE EFFECTS	---
Bogdan-Catalin Serban, Maria Ruxandra Salagean, Matei -Gabriel Ursachescu, Diana Maria Lazar, Vlad Diaconescu, Diana Dumitraşcu, Octavian Buiu, Marius Bumbac	INORGANIC COMPOUNDS FROM WHO’LIST OF ESSENTIAL MEDICINES: A REVIEW	---
Teuta Qerimi Sadiku, Albiona Demiri Bekteshi	THE EFFICIENCY OF THE BANKING SYSTEM IN THE REPUBLIC OF NORTH MACEDONIA	University of Tetovo, Tetovo, North Macedonia Ss. Cyril and Methodius

		University in Skopje, North Macedonia
Barbara Laura Ćalušić Ljubičić Assoc. prof. Dr. Danijela Lucić Assoc. Prof. Dr. Dijana Gracin	REVIEW OF RESEARCH ON CROATIAN WAR VETERANS AND THEIR FAMILIES: THE ROLE OF THE FAMILY IN THE REINTEGRATION OF CROATIAN VETERANS	University, Zagreb, Republic of Croatia
Moataz Mobasher	ENHANCING THERAPEUTIC MANAGEMENT THROUGH HEALTHCARE DIGITIZATION: A THEORETICAL APPROACH	The Bucharest University of Economic Studies, Doctoral School of Management, Bucharest, Romania.
Olga Berta Szabóné	THE DEVELOPMENT OF DIGITAL COMPETENCE IN THE EVERYDAY OPERATIONS OF BUSINESSES	University of Nyíregyháza, Hungary

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Hall-5
22.08.2025
Moderator: Van Hiep Huynh
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Meriem SANDAOUI Sanae EL GHACHTOULI Mohammed AZZI Zaina ZAROUAL	COMPARATIVE EVALUATION OF SONOCHEMISTRY AND THE FENTON REACTION FOR THE TREATMENT OF ANTIBIOTIC FAMILIES: INVESTIGATING THEIR SYNERGISTIC POTENTIAL	Laboratory Interface Materials Environment, Morocco
Mahmood Hassan Hami Nadhim M. Faleh	QUANTIFYING AERODYNAMIC TRADE-OFFS IN SINGLE-SLOTTED FLAP CONFIGURATIONS	Mustansiriyah University, Baghdad, Iraq
Van Hiep Huynh Tien Khang Huynh	LABORATORY EVALUATION OF THE POTENTIAL APPLICATION OF A MIXTURE OF THERMAL POWER PLANT ASH AND SALINE SAND FOR ROAD SUBGRADE STABILIZATION	Travinh University, Vietnam
Aseel K. Al-anbari Ali T. AL-Taie Mouhannad M. Aljaf Muazaz A. Al-Hadeethi	DIAGNOSIS OF PHENOLS AND ANTIOXIDANT ACTIVITY OF LEAVES IN SOME IRAQI MYRTACEAE'S GENERA BY HPLC	University of Diyala , Iraq Mustansiriyah University, Iraq Baghdad University, Iraq
Guli Raimova	EFFECT OF POLYPHENOLS ON HAEMOSTASIS SYSTEM IN RATS WITH STREPTOZOTOCIN-INDUCED TYPE II DM	National University of Uzbekistan
Giovana Dornelas Azevedo Romero Nicole Barbosa Bettiol Selma Siéssere Franciele Aparecida de Carvalho Márcio de Menezes Simone Cecilio Hallak Regalo Marcelo Palinkas	EVALUATION OF THE ELECTROMYOGRAPHIC ACTIVITY OF MASTICATORY MUSCLES IN ADULT WOMEN AFTER HYALURONIC ACID APPLICATION IN THE MANDIBULAR ANGLE REGION	University of São Paulo, Brazil
Salome Bezarashvili Giga Sordia Mariam Managadze	MICROPLASTICS IN THE ENVIRONMENT: A GROWING THREAT	Tbilisi State Medical University, Georgia

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Hall-6
22.08.2025
Moderator: Josip Balen
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Alaa Elshair Kubilay Ayturan Fırat Hardalaç Boran Demirciler	HIGH-PERFORMANCE DEFECT DETECTION IN PHOTOVOLTAIC MODULES USING THE SPHERE DATASET AND CASCADE R-CNN	Gazi University, Ankara, Turkey. Huawei Turkey R&D Center, 34768, İstanbul, Turkey
Mirsade Sağlamtaş Merve Teke Budaklı	COMPARISON OF THE PERFORMANCE OF ANN, SVM, AND RANDOM FOREST ALGORITHMS IN THE CLASSIFICATION OF EMG SIGNALS	Turkish-German University, İstanbul, Turkey
Etibar Vazirov Farid Mirzaliyev Tunjay Akbarli	PREDICTING DIABETES WITH INTERPRETABLE MACHINE LEARNING: A COMPARATIVE STUDY OF CLASSICAL AND DEEP MODELS	ADA University, Azerbaijan Independent Researcher Ilgar Ibrahimov Named Secondary School No. 1, Salyan, Azerbaijan
Pratiksha Choudhuri Sofiya Chavarekar Dr. Mahendran Botlagunta	AI-DRIVEN DRUG DISCOVERY AND COMPUTATIONAL MODELING TO TARGET SDHB/SDHD MUTATIONS LINKED TO CANCER AND RARE DISORDERS	VIT Bhopal University, India
Khawla ABA-TALIB Abdessamad ZOUINE	OPTIMIZATION OF TRANSPORTATION ROUTES USING AI ALGORITHMS	Chouaib Doukkali University, Morocco
Vladimir Saveliev	SIMULATION OF THE MOIRE EFFECT IN CUBIC LATTICES	Konyang University, Public Safety Research Center, Nonsan, South Korea

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Hall-7
22.08.2025
Moderator: Nguyen Kim Dung
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Albana HODAJ	THE CRISIS OF CRITICAL THINKING IN THE AGE OF ARTIFICIAL INTELLIGENCE: BETWEEN TECHNOLOGICAL CONVENIENCE AND THE VALUE OF KNOWLEDGE	University "Aleksandër Moisiu", Albania
Anar Ismailov Alekper Ismailov Pakiza Ismailova Ayten Hajiyeva Sadykh Abdinbekov Lala Rustamova L.A. Ismayılzada	THERMO-FIELD FRENKEL EFFECT IN In 0.93 Sm 0.07 Se SINGLE CRYSTALS	Azerbaijan Technical University Ministry of Science and Education of Azerbaijan
Fitimtar Zekthi	DEPOLITICIZED DEMOCRACY: ELECTORAL INVINCIBILITY AND THE EROSION OF ACCOUNTABILITY IN ALBANIA (2013–2025)	European University of Tirana, Albania
Nguyen Kim Dung	COMPLETING THE LEGAL FRAMEWORK FOR INVESTMENT CAPITAL GOVERNANCE IN PRIVATE HIGHER EDUCATION INSTITUTIONS IN VIETNAM TODAY	VNU, Hanoi- University of Law, Vietnam
Nguyen Kim Dung	COMPLETING THE LEGISLATION ON INVESTMENT FORMS IN PRIVATE HIGHER EDUCATION INSTITUTIONS IN VIETNAM TODAY	VNU, Hanoi- University of Law, Vietnam
Anay Pinto Valencia	ADDRESSING RESISTANCE TO CHANGE AND THE NEED FOR INNOVATION IN RESPONSE TO THE CHALLENGES OF POPULATION DECLINE IN HIGHER EDUCATION	Corporacin Universitaria Minuto De Dios, Colombia
Florina Paşcu	EXECUTIVE COACHING SHAPES POSITIVE CHANGES IN MANAGERIAL COMMUNICATION	Babeş - Bolyai University, Cluj -Napoca, Romania
Lala MAMMADOVA	LEGAL FRAMEWORK AND PRACTICAL IMPLEMENTATION OF EXTRADITION PROCEDURE IN THE REPUBLIC OF AZERBAIJAN	Baku State University, Azerbaijan

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Hall-1

23.08.2025
Moderator: Prof. Dr. Nevra ALKANLI
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Hilal DOĞAN	ANALYSIS OF RADIATION DOSE LEVELS FOR GUARDS WHO EXPOSED TO RADIATION FROM PRISONER PATIENTS IN PET/CT UNITS	Health Sciences University, Türkiye
Nevra ALKANLI Arzu AY Sedat ÜSTÜNDAĞ Nilgün TAN TABAKOĞLU	GENOTYPIC PROFILE AND CLINICAL SIGNIFICANCE OF PLASMINOGEN ACTIVATOR INHIBITOR-1 4G/5G GENE VARIATION IN PATIENTS UNDERGOING HEMODIALYSIS TREATMENT	Haliç University, Türkiye
Arzu AY Nevra ALKANLI Hakan AKDERE Gökhan ÇEVIK Nilgün TAN TABAKOĞLU Seva Bilgesu İVRENDI Yakup BAŞAR Doğa ERDAL	THE ROLE OF MATRIX METALLOPROTEINASES IN DEVELOPMENT OF INTERSTITIAL CYSTITIS	Trakya University, Türkiye
Aykut EKİYOR Bengü Berika KALFA Ayhan ERENER	PERSPECTIVES ON GENERAL AND PRIVATE HEALTH INSURANCE AMONG INDIVIDUALS WITHOUT PRIVATE HEALTH INSURANCE	Ankara Hacı Bayram Veli University, Türkiye
Aykut EKİYOR Bengü Berika KALFA Ayhan ERENER	INSURANCE LITERACY FROM THE PERSPECTIVE OF INSURANCE COMPANY MANAGERS: THE CASE OF ANKARA PROVINCE	Ankara Hacı Bayram Veli University, Türkiye
Ayşenur BASMACI Börte KÖSE MUTLU	ENVIRONMENTAL INVESTMENTS AND INVESTOR BEHAVIOR: A DID ANALYSIS OF BIST SUSTAINABILITY INDEX FIRMS	Istanbul Technical University, Türkiye

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Hall-2
23.08.2025
Moderator: Assoc. Prof. Dr. Seyithan SEYDOŞOĞLU
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Zeynep Nur Onsekiz Beyzanur Durmaz Cansu Çetin Serkan Öztürk	SYNTHESIS OF A DI-CATIONIC SURFACTANT CONTAINING TWO LONG CARBON CHAINS AND PYRIDIUM CATION, AND ITS EFFECTIVENESS AGAINST METAL CORROSION	Bursa Uludag University, Türkiye
Suleyman Serdar Alkanli	INTEGRATION OF ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING FOR MOLECULAR IMPRINTING STUDIES IN CELL CULTURE	Haliç University, Faculty of Medicine, Department of Biophysics, Istanbul, Türkiye.
Assoc. Prof. Dr. Murat UYAR Enes CANLI	COMPARATIVE DETECTION OF PHOTOVOLTAIC PANEL FAULTS USING U-NET AND YOLOV8 MODELS BASED ON THERMAL IMAGES	Bursa Uludag University, Bursa, Türkiye
Murat ŞEN	DETERMINATION OF DYNAMIC CHARACTERISTICS OF A CRANKSHAFT THROUGH MODAL AND ROTORDYNAMICS ANALYSIS	Firat University, Elazığ, Türkiye
M.Sc. Mehmet Metehan TOPDEMİR Prof. Dr. Osman BİCAN Assoc. Prof. Dr. Zühtü Onur PEHLİVANLI	IMPACT-ORIENTED ANALYSIS OF AEROSPACE-GRADE ISOGRID PANELS WITH VARYING RIB THICKNESSES	Kırıkkale University, Türkiye
Furkan AKIN Ahmet FEYZİOĞLU Hüseyin HALİLOĞLU Trevor OMORUYI	INVESTIGATION OF MULTI-CRITERIA DECISION-MAKING METHODS IN THE DESIGN OF A MANNED FIGHTER AIRCRAFT FOR THE AFRICAN REGION	Marmara University, Türkiye University of Chester, UK
İlayda MÜFTÜOĞLU Ahmet FEYZİOĞLU Hüseyin HALİLOĞLU Trevor OMORUYI	MULTI-CRITERIA DECISION ANALYSIS OF UNMANNED AERIAL VEHICLE PYLON DESIGNS USING THE ANALYTIC HIERARCHY PROCESS	Marmara University, Türkiye University of Chester, UK
Ömer Ümit OKÇU Nuray ÖZER	THE GROWTH AND SPORULATION ABILITY OF TRICHODERMA HARZIANUM AT DIFFERENT SALT CONCENTRATIONS	Tekirdağ Namık Kemal University, Türkiye
Ömer Ümit OKÇU Nuray ÖZER	POTENTIAL USE OF PROPOLIS EXTRACT (API10) FOR THE CONTROL OF SEED-BORNE ALTERNARIA ALTERNATA IN SUNFLOWER	Tekirdağ Namık Kemal University, Türkiye

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Hall-3
23.08.2025
Moderator: Prof. Dr. Leyla KHORSHTD
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Büşra BEKAR TOPRAK	BEYOND COMPLIANCE: A BEHAVIORAL FRAMEWORK FOR ADVANCING FOOD SAFETY CULTURE IN THE GLOBAL FOOD INDUSTRY	Dimes Gıda San. Ve Tic. A.Ş., Izmir, Türkiye
Elif Nur YILDIRIM-OZTURK	RECALL OF CARBOMER-CONTAINING EYE GELS IN THE UNITED KINGDOM: AN EVALUATION FROM A PHARMACOVIGILANCE AND PUBLIC HEALTH PERSPECTIVE	Konya Provincial Health Directorate
Büşra HANÇERLİOĞLU Leyla KHORSHTD Dilek SARI	PERCEPTIONS AND ATTITUDES OF NURSES WORKING IN THE ANESTHESIA INTENSIVE CARE UNIT TOWARDS THE COVID-19 PANDEMIC	Ege University Hospital, İzmir
Leyla KHORSHTD	COMPLICATIONS RELATED TO INSULIN THERAPY AND ADMINISTRATION IN DIABETIC INDIVIDUALS	Ege University Hospital, İzmir
Belma UZUN	THE INVESTIGATION OF THE EFFECT OF ELECTRONIC CIGARETTE ADDICTION ON SUBSTANCE ADDICTION BEHAVIOR	İstanbul Gedik University
Sevcan Filiz AVCI DAŞ Prof. Dr. Uğur BÜYÜK	THE ROLE OF ROBOTICS COMPETITIONS IN ENHANCING MIDDLE SCHOOL SCIENCE LEARNING: A QUALITATIVE STUDY ON TEACHER PERSPECTIVES	Ministry of National Education, Türkiye Erciyes University, Türkiye

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Hall-4
23.08.2025
Moderator: Rezart Xhani
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Fereh Mammadova, Mahira Amirova	LIPID PANEL AND APOPTOTIC BIOMARKERS IN HIGH-RISK POPULATIONS FOR ISCHEMIC HEART DISEASE	Azerbaijan Medical University, Faculty of Public Health, Biochemistry Department, Baku, Azerbaijan
Zamira Cabiri Brunilda Mehilli Elona Dybeli Rajmonda Oboni Blerina Bani Kace Baushi Armela Kapaj Flora Zeqo	ASSESSING KNOWLEDGE AND PREVENTIVE PRACTICES REGARDING BREAST CANCER AMONG FEMALE POPULATIONS: A QUANTITATIVE ANALYSIS	University of "Aleksandër Xhuvani", Albania
Lulzime Ballazhi Edita Alili-Idrizi Merita Dauti Sihana Ahmeti-Lika Drita Havziu-Yzeiri Hanife Rustemi-Ahmeti Arbnora Qahili-Nazifi	PERFORMANCE-ENHANCING DRUGS AND THEIR EFFECTS ON HUMAN PHYSIOLOGY	University of Tetovo, North Macedonia
Nino Japaridze Ketevan Khazaradze	THE ROLE OF SPORT IN ADOLESCENT USING MODERN TECHNOLOGIES	Tbilisi State Medical University, Georgia
Jonatas Silva de Oliveira Rafaelly Camargo Amanda Costa Ferro Beatriz Ribeiro Ribas Joelson Azevedo Maranhão Sousa Janaina Habib Jorge	EFFECT OF SURFACE MODIFICATION ON THE MECHANICAL AND BIOLOGICAL PROPERTIES OF 3D-PRINTED DENTURE BASE RESIN	São Paulo State University (Unesp), Brazil
Rezart Xhani Eugen Tata Herion Dredha	RADICAL CYSTECTOMY TIMING IN MUSCLE-INVASIVE BLADDER CANCER: DOES EARLY ALWAYS MEAN BETTER?	Tirana University, Faculty of Medicine, Department of Urology, Tirana, Albania

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Hall-5
23.08.2025
Moderator: Suveybe Öztürk
New York Local Time: 10:00–12:30
Ankara Local Time: 17:00–19:30

Author(s)	Title	Affiliation
Younes Yassine El Mahjoub Aouane	THE ROLE OF PHYSICAL ACTIVITY TO MITIGATE ACADEMIC BURNOUT AMONG MOROCCAN ADOLESCENTS	Ibn Tofail University, Morocco
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Assoc. Prof. Dr. Aida Bendo Msc. Anxhela Ahmataj	AN OVERVIEW OF REPAIRING ACHILLES TENDON RUPTURE	Sports University of Tirana, Albania
PhD. Rando Kukeli Msc. Victoria Kukeli	INVESTIGATION OF FITNESS CENTER DENSITY, INFRASTRUCTURE, AND INSTRUCTOR DEMOGRAPHICS IN TIRANA, ALBANIA	Sports University of Tirana, Albania
PhD. Rando Kukeli Msc. Victoria Kukeli	LITERATURE REVIEW ON COMBINED STRENGTH AND ENDURANCE TRAINING'S IMPACT ON VO2MAX ENHANCEMENT	Sports University of Tirana, Albania
Fisnik Brovina Halil Brovina	A DIFFERENT GAME. HOW ALBANIA'S ARENA KOMBËTARE REDEFINES SUSTAINABLE DEVELOPMENT	Sports University of Tirana, Albania International European University, Poland
Ph.D. (c) Erjon Peqini, Prof. Dr. Bardhyl Misja, Albano Pjerrza, Ana Kola, Alda Lleshi, Blerim Bushaj, Syrja Uraj, Arsid Temja	ANTHROPOMETRIC PROFILE OF 8–9-YEAR-OLD CHILDREN IN SHKODËR, ALBANIA: GENDER DIFFERENCES AND BMI CATEGORIZATION	University Luigj Gurakuqi. Shkodër, Albania. Sports University of Tirana, Tiranë, Albania
Mehwash Kashif, Syeda Nimra Qadri, Muhammad Asfahan Shah, Mahmooda Kazmi	PROBIOTICS FOR ORAL HEALTH - A META-ANALYSIS	Karachi Medical and Dental College, Karachi, Pakistan Jinnah University for Women, Pakistan

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Author(s)	Title	Affiliation
Dr. Christina A. DeCoursey Dr. Aliaa N. Hamad	EMOTIONS ACROSS THE ESSAY REVISITED	Nazarbayev University, Astana, Kazakhstan University in Cairo
Özge Nur ÖZSUNKAR Birsel AYBEK	AN ANALYSIS OF THE 5th GRADE SCIENCE TEXTBOOK UNIT "OUR NEIGHBORS IN THE SKY AND US" IN TERMS OF CRITICAL THINKING STANDARDS AND COMPONENTS OF LOGICAL THINKING	Kahramanmaras Sutcu Imam University, Kahramanmaras, Turkey. Cukurova University, Adana, Turkey
Şüra TEKIN Assoc. Prof. Dr. Buket ÜNDEMIR	COMPARATIVE ANALYSIS OF TURKISH EDUCATION PROGRAMS IN 1924 AND 2024 WITHIN THE CURRICULUM AND INSTRUCTION	Marmara University, Türkiye Niğde Ömer Halisdemir University, Türkiye
The-Hung Nguyen Hoang-Phuong Luong Nguyen My-Linh Nguyen Thi Kim-Lien Tran Thi Thanh-Phat Nguyen	KEY FACTORS IN THE DETERMINATION OF DOMINANT DISCHARGE	Nam Can Tho University, Vietnam
Dr. Anjeza Xhaferaj	NAVIGATING THE LABYRINTH OF PATRONAGE: DEMOCRATIZATION CHALLENGES IN ALBANIA'S POLITICAL LANDSCAPE	European University of Tirana
Ph.D Mujkan MEMMEDZADE	PEDAGOGICAL ANALYSIS OF REFORMS IN THE HIGHER MILITARY EDUCATION SYSTEM IN AZERBAIJAN	Military Scientific Research Institute, Azerbaijan
Adina Ioana Saplontai Botis	TECHNOLOGY'S ROLE IN POST-PANDEMIC STRATEGY AND INNOVATION IN THE GLOBAL COMPANY	The Bucharest University of Economic Studies, Bucharest, Romania.
Lykesta Murtaj Vjollca Bakiu Megi Kola	DIGITAL TRANSFORMATION IN ACCOMMODATION STRUCTURES: STRATEGIES FOR INCREASING COMPETITIVENESS	University of Tirana, Albania

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PERCEPTIONS AND ATTITUDES OF NURSES WORKING IN THE ANESTHESIA INTENSIVE CARE UNIT TOWARDS THE COVID-19 PANDEMIC

ANESTEZİ YOĞUN BAKIM BİRİMİNDE ÇALIŞAN HEMŞİRELERİN COVİD-19 SALGININA YÖNELİK ALGI VE TUTUMLARI

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ABSTRACT

The individual and professional characteristics of healthcare workers, who are at high physical and psychological risk because they care for infected individuals during the COVID-19 pandemic, have shaped their perceptions and attitudes towards the epidemic. This study was conducted to examine the perceptions and attitudes of nurses working in the anesthesia intensive care unit during the COVID-19 pandemic and to identify the factors affecting these perceptions and attitudes.

The study population consisted of all nurses (n = 65) who had been working in the Intensive Care Unit of the Department of Anesthesiology and Reanimation at Ege University Hospital for at least six months and who were working in the clinic between May 2022 and December 2022. The study sample consisted of 30 nurses from this population who agreed to participate in the study.

A survey form and the Scale for Assessing Perceptions and Attitudes Towards the Covid-19 Pandemic were used to collect research data (Artan et al., 2020). The scale consists of four subscales: general perception of the disease, avoidance behaviors, perception of causes, and perception of control. Data were collected using an online survey form prepared via Google Forms. The Mann-Whitney U test was used in data analysis. The mean score for the Illness Perception subscale was 24.63 ± 3.05, the mean score for the Causes Perception subscale was 45.90 ± 8.64 the mean score for the Control Perception subscale was 41.00 ± 8.10, and the mean score for the Avoidance Behaviors subscale was 41.00 ± 8.10.

It was determined that perception of control scores varied according to length of service, with perception of control scores increasing as years in the profession increased. It was also determined that education level caused differences in perceived avoidance scores, with those with master's and doctoral degrees having higher perceived control scores than those with bachelor's degrees. Consequently, it can be said that intensive care nurses have strong beliefs regarding their perceptions and attitudes towards the COVID-19 pandemic. This result can be explained by nurses' high awareness of the virus that causes infection in the COVID-19 pandemic. The study results may guide efforts to prepare nurses for future social disasters.

ÖZET

COVID-19 pandemi döneminde enfekte bireylere bakım verdikleri için fiziksel ve psikolojik yönden yüksek risk altında olan sağlık çalışanlarının bireysel ve mesleki özellikleri, salgına karşı geliştirdikleri algı ve tutumlarını şekillendirmiştir. Bu araştırma, COVID-19 pandemisinde anestezi yoğun bakım biriminde çalışan hemşirelerin salgına yönelik algı ve tutumlarını incelemek, bu algı ve tutumları etkileyen faktörleri belirlemek amacıyla yapılmıştır.

Çalışmanın evrenini, Ege Üniversitesi Hastanesi Anesteziyoloji ve Reanimasyon Anabilim Dalı Yoğun Bakım Ünitesi'nde en az altı aydır çalışmakta olan, Mayıs 2022 - Aralık 2022 tarihleri arasında klinikte çalışan tüm hemşireler (n=80), Çalışmanın örneklemini; ise bu evrenden araştırmaya katılmayı kabul eden 30 hemşire oluşturmuştur. Araştırma verilerinin toplanmasında Anket Formu ve Covid-19 Salgınına Yönelik Algı ve Tutumları Değerlendirme Ölçeği kullanılmıştır. Artan ve ark. (2020) tarafından geliştirilen Covid-19 Salgınına Yönelik Algı ve Tutumları Değerlendirme Ölçeği, hastalığa yönelik genel algı, kaçınma davranışları, nedenler algısı ve kontrol algısı olmak üzere 4 alt ölçekten oluşmaktadır. Araştırma verileri, Google Form aracılığı ile hazırlanan online anket formu ile toplanmıştır. Verilerin analizinde Mann-Whitney U testi kullanılmıştır.

Ölçeğin Hastalık algısı alt ölçek puan ortalaması 24,63 ± 3,05; nedenler algısı alt ölçek puan ortalaması 45,90 ± 8,64; kontrol algısı alt ölçek puan ortalaması 41.00 ± 8,10; kaçınma davranışları algısı alt ölçek puan ortalaması 41.00 ± 8,10 olarak bulunmuştur. Meslekte çalışma süresine göre kontrol algısı puanlarının farklılık gösterdiği, meslekte çalışma yılı arttıkça, kontrol algısı puanlarında artma olduğu belirlenmiştir. Eğitim düzeyinin kaçınma algısı puanlarında farklılığa neden olduğu, lisans mezunlarına oranla, yüksek lisans ve doktora mezunu olanların kontrol algısı puanlarının daha yüksek olduğu belirlenmiştir.

Sonuç olarak, yoğun bakım hemşirelerinin COVİD-19 Salgınına Yönelik Algı ve Tutumlarına ilişkin inançlarının yüksek olduğu söylenebilir. Bu sonuç hemşirelerin COVID-19 pandemisinde enfeksiyona yol açan virüse yönelik farkındalıklarının yüksek olması ile açıklanabilir.

GİRİŞ

COVID-19 virüsü ilk olarak Çin'in Hubei Eyaleti Wuhan kentinde, 2019 Aralık ayında solunum yolu semptomları geliştiren bir grup hasta üzerinde yapılan araştırmalar neticesinde Ocak 2020' de tanımlanmıştır (Zhu ve ark., 2019). Salgın, 11 Mart 2020 tarihinde Dünya Sağlık Örgütü tarafından pandemi olarak ilan edilmiştir (WHO,2020). DSÖ'nün COVID-19 veri panosuna göre, 2025 yılı itibarıyla dünya genelinde bildirilen toplam COVID-19 kaynaklı ölüm sayısı 7 milyonu aşmıştır (WHO,2025).

COVID-19 pandemisi, birçok uluslararası hükümeti enfeksiyonları kontrol altına almak veya en azından hızlı bulaşmasını azaltmak için titiz ve ciddi kararlar almaya zorlamıştır. Birçok ülkede sokağa çıkma yasağı ilan edilmiş, yerel ve uluslararası uçuşlar yasaklanmış, okullara, üniversitelere ve ticari faaliyetlere katılım askıya alınmış, her türlü toplantı, etkinlik iptal edilmiş ve insanlardan evde kalmaları istenmiştir. Bunun yanında, medyada her ülkede yeni teyit edilen vakaların ve bildirilen yeni ölümlerin sayısı saatlik olarak duyurulmuştur ve vatandaşlar bu konulara odaklanmıştır. Sonuçta, insanlar tüm dünyayı etkileyen bu salgından oldukça etkilenmiş ve çok çeşitli psikolojik rahatsızlıklar ortaya çıkmıştır (Ghazawy ve ark., 2020).

Wuhan'dan erken gelen anektod niteliğindeki kanıtlar, bu benzeri görülmemiş durumun ön saflardaki sağlık bakım personelinin ruh sağlığını nasıl etkilediğini göstermiştir (Kang ve ark., 2020). COVID-19 pandemisi, dünya genelinde sağlık sistemlerini önemli ölçüde zorlamış ve bu süreçte sağlık çalışanlarının, özellikle hemşirelerin, rollerini daha da görünür hale getirmiştir. Bu süreçte hemşireler,

yalnızca klinik bakım sağlayıcıları olarak değil, aynı zamanda halk sağlığı savunucuları, eğitimciler ve kriz yöneticileri olarak da ön plana çıkmıştır (Zhang ve ark., 2022). COVID-19 pandemisi, sağlık çalışanları üzerinde benzeri görülmemiş bir baskı oluşturmuştur. Hemşireler, hastalarla doğrudan temas halinde olmaları nedeniyle hem fiziksel hem de psikolojik açıdan yüksek risk altında kalmıştır. Bu süreçte, hemşirelerin bireysel ve mesleki özellikleri, salgına karşı geliştirdikleri algı ve tutumları şekillendirmiştir. Hemşireler, sağlık sisteminin ön saflarında yer alarak, enfekte bireylerle doğrudan temas kurmuş, uzun saatler boyunca yoğun baskı altında çalışmış ve aynı zamanda kişisel sağlıkları ve ailelerinin güvenliği konusunda sürekli kaygı yaşamışlardır (Shaukat ve ark., 2020). Salgın sürecinde hemşirelerin COVID-19'a yönelik algıları ve tutumları; yalnızca bireysel psikolojik tepkilerle değil, aynı zamanda demografik ve mesleki değişkenlerle de şekillenmiştir. Mevcut literatür, hemşirelerin salgın algısının; evli olup olmadıkları, çocuk sahibi olmaları, yaşadıkları hane halkının özellikleri (örneğin yaşlı bireylerin varlığı), sahip oldukları kronik hastalıklar, cinsiyetleri, eğitim düzeyleri ve COVID-19 hastalarına bakım verip vermeme gibi faktörlerden etkilenebileceğini ortaya koymaktadır (Alshutwi, 2022; Lee ve ark., 2022). Örneğin, çocuk sahibi hemşirelerin çocuklarına hastalık bulaştırma endişesi nedeniyle daha yüksek düzeyde korku ve stres yaşadıkları, bunun da mesleki motivasyonlarını ve hasta bakımına ilişkin tutumlarını olumsuz etkilediği gösterilmiştir (Sampaio ve ark., 2021). Benzer şekilde, kronik hastalığı bulunan hemşirelerin enfekte olma riskine karşı daha hassas davrandıkları ve bu durumun bakım sürecinde çekinceli tutumlara yol açtığı belirtilmektedir (Sun ve ark., 2020). Cinsiyetin de önemli bir etken olduğu; kadın hemşirelerin duygusal tepkilerinin daha yoğun olduğu ve bu durumun hem tükenmişlik düzeylerini hem de hasta merkezli bakım yaklaşımlarını etkilediği vurgulanmaktadır (Alsharif, 2022).

Ayrıca, eğitim düzeyi hemşirelerin salgınla ilgili bilgiye erişimini, dolayısıyla risk algısını ve baş etme stratejilerini belirleyen bir unsur olarak öne çıkmaktadır. Daha yüksek akademik düzeye sahip hemşirelerin COVID-19 hakkında daha doğru bilgiye sahip olmaları, onları daha kontrollü ve rasyonel kararlar almaya yönlendirebilmiştir (Lee ve Kim, 2022). Öte yandan, doğrudan COVID-19 hastalarına bakım vermek zorunda kalan hemşirelerin yalnızca fiziksel değil, aynı zamanda psikolojik anlamda da yüksek düzeyde etkilenmiş oldukları; izolasyon, sosyal damgalanma ve travma sonrası stres gibi sonuçlar yaşadıkları belirlenmiştir (Cai ve ark., 2020).

Bu araştırmanın amacı; COVID-19 pandemisi süresince hemşirelerin salgına yönelik algı ve tutumlarını incelemek, bu algı ve tutumları etkileyen başlıca demografik ve mesleki faktörleri ortaya koymaktır.

ARAŞTIRMA SORULARI:

1. Hemşirelerin COVID-19 Salgınına Yönelik algı ve tutum düzeyi nedir?

2. Hemşirelerin COVID-19 Salgınına Yönelik algı ve tutumlarını etkileyen etmenler nelerdir?

GEREÇ VE YÖNTEM:

Tanımlayıcı türdeki bu çalışma COVID-19 pandeminde hemşirelerin salgına yönelik algı ve tutumlarını incelemek, bu algı ve tutumları etkileyen başlıca demografik ve mesleki faktörleri ortaya koymak amacıyla yapılmıştır.

Çalışmanın evrenini, Ege Üniversitesi Hastanesi Anesteziyoloji ve Reanimasyon Anabilim Dalı Yoğun bakım Ünitesi'nde en az altı aydır çalışmakta olan, Mayıs 2022 - Aralık 2022 tarihleri arasında klinikte çalışan tüm hemşireler (n=80), Çalışmanın örneklemini; ise bu evrenden araştırmaya katılmayı kabul eden 30 hemşireler oluşturmuştur.

VERİ TOPLAMA: Araştırma verilerinin toplanmasında Anket Formu ve Covid-19 Salgınına Yönelik Algı ve Tutumları Değerlendirme Ölçeği kullanılmıştır. Araştırma verileri, Google Formlar aracılığı ile hazırlanan online anket formu ile toplanmıştır. Veriler anket formu ile toplanmıştır. Anket formu Hastaları Tanıtıcı Özellikler Soru ile toplanmıştır. Anket Formunda hemşirelerin çalıştığı klinik, yaş,

cinsiyet, eğitim durumu, medeni durum, meslekte geçen süre, ilgili klinikte çalışma yılı, kronik hastalık, çocuk sayısı, evde 65 yaş üstü birey varlığı, evde kronik hastalığı olan birey varlığı ile ilgili toplam 11 soru yer almıştır. 4 alt ölçekten oluşan Covid-19 Salgınına Yönelik Algı ve Tutumları Değerlendirme Ölçeği Artan ve ark. tarafından 2020 yılında geliştirilmiştir. Ölçeklerin her biri bağımsız olarak değerlendirilmekte olup ayrı puanlar elde edilmektedir. Ölçeklerin alt boyutlarının da ayrı ayrı ele alınması ve değerlendirilmesi uygun olduğu yazarlar tarafından belirtlmetedir. Tüm ölçekler için alınan yüksek puanlar o alandaki inancın yüksek olduğuna işaret etmektedir. 1. Hastalık hakkında Genel Algı, a)Nedenler ve b)Kontrol Algısı Ölçekleri "1- Kesinlikle Katılmıyorum" ile "5-Kesinlikle Katılıyorum" arasında işaretleme yapılabilen 5'li likert türündedir. Anketin hastalığa yönelik genel algıyı değerlendiren alt ölçeği, "bulaşıcılık" ve "tehlike" alt boyutlarını kapsayan 8 maddeden oluşmaktadır.

2.nedenler: 18 maddelik ikinci alt ölçek (Nedenler), hastalığa neden olan faktörleri değerlendirmektedir. Komplo alt boyutu, koronavirüsün bir tür komplo motivasyonuyla yaratıldığına yönelik inanç ifadelerinin yer aldığı bir algıyı değerlendirmektedir. Çevre alt boyutu ise hastalığın çevresel sebeplerden ötürü ortaya çıktığına dair bir algıyı değerlendirmektedir. İnanç alt boyutu ise hastalığı dini gerekçelere dayandırma düzeyini ölçmektedir.

3.Kontrol alt ölçeği; hastalığa yönelik kontrol algısını değerlendirmektedir ve 13 maddeden oluşmaktadır. Kontrol algısı ölçeğinden alınan yüksek puanlar kontrol algısının yüksek olduğunu ifade eden olumlu bir tabloyu ifade etmektedir. Makro kontrol, kişisel kontrol ve kaçınılmazlık alt boyutları bulunmaktadır

4. Kaçınma davranışlarını değerlendiren alt ölçek ise "Bu davranışı hiç yapmadım." ve "Bu davranışı çok sık yaptım." arasında seçeneklerin yer aldığı 5'li likert tipi 14 ifadeden oluşmaktadır. Bu ölçeğin alt boyutları ise; bilişsel kaçınma, ortak alanlardan kaçınma ve kişisel temastan kaçınma şeklindedir. Kaçınılmazlık alt boyutundaki tüm ifadeler ters kodlama gerektirmekte olup bu alt boyuttan alınan yüksek puanlar, kişinin hastalıktan kaçınabileceğine dair inancının yüksek olduğunu göstermektedir.

Verilerin analizi: Araştırmada elde edilen verilerin analizi için SPSS 24.0 (Statistical Package of Social Sciences for Windows) istatistik paket programı kullanılmıştır. Araştırma verilerinin sayısal ve yüzdelik dağılımları, puan ortalamaları, minimum ve maksimum değerleri verilmiş, verilerin analizinde Mann-Whitney U testi kullanılmıştır.

Bağımlı ve Bağımsız Değişkenler: Hemşirelerin yaş grubu, cinsiyeti, medeni durumu, Çocuk sahibi olma, Evde 65 yaş üstü birey varlığı, Evde kronik hastalığı olan birey varlığı araştırmanın bağımsız değişkenini; Hastalık algısı, nedenler algısı, kontrol algısı ve kaçınma davranışları algısı alt ölçek puan ortalamaları araştırmanın bağımlı değişkeni oluşturmuştur.

Araştırma Etiği: Çalışmanın yürütülebilmesi için Ege Üniversitesi Hastanesi Girişimsel Olmayan Etik Kurulundan (15.05.2022 tarihli; sayılı ve E- 99166796-050.06.04-687708) Onay numaralı) ve Ege Üniversitesi Başhekimliğinden (25.04.2022 tarihli ve E-69631334-100-662633 sayılı) yazılı izin alınmıştır. Uygulama öncesinde hemşirelere araştırma hakkında bilgi verilerek ve katılımın tamamen gönüllülük esasına dayandığı anlatılarak onamları alınmıştır. Çalışmada kullanılan ölçeği geliştiren araştırmacılardan ölçek kullanım izni alınmıştır.

Tablo 1. Covid-19 Salgınına Yönelik Algı ve Tutumları Değerlendirme Ölçeği Alt Boyutlarını Güvenirlik Katsayıları

Boyut	Alt Boyut	Madde Sayısı	Cronbach's Alpha
Hst algısı	Tehlikelilik	5	0,697
	Bulaşıcılık	3	-0.222

Nedenler	Komplo	6	0,957
	Çevre	8	0.754
	İnanç	4	0,687
Kontrol	Makro	4	0,750
	Kişisel	5	0.775
	Kaçınılmazlık	3	0.769
Kaçınma davranışları	Bilişsel Kaçınma	7	0.890
	Ortak Alanlardan Kaçınma	4	0.765
	Kişisel Temastan Kaçınma	3	0,878

Çalışmada ölçeğin alt boyut ve onların da alt ölçeklerinin güvenriliğinin oldukça yüksek olduğu belirlenmiştir (Tablo 1).

BULGULAR

Tablo 1. Hemşirelerin tanımlayıcı özelliklerine göre dağılımı

TANITICI ÖZELLİKLER	**n**	**%**
Covid-19 hastasına bakım verme		
Bakım veren	22	73,3
Bakım vermeyen	8	26,7
Yaş ortalaması	**31,46 + 3,42 yıl**	
Meslekte çalışma süresi ortalaması	**7,90 + 4,31 yıl**	
Yaş grubu		
26-32 yaş grubu	17	56.7
33-40 yaş grubu	13	43.3
Cinsiyet		
Kadın	24	80
Erkek	6	20
Eğitim durumu		
Lisans	21	70.0
Yüksek lisans	8	26.7
Doktora	1	3.3
Medeni durum		

Evli	20	66.7
Bekar	10	33.3
Meslekte çalışma yılı		
1-5 yıl	9	30.0
6-18 yıl	21	70.0
Kendisinde kronik hastalık öyküsü		
Olan	2	6,7
Olmayan	28	93.3
Çocuk sahibi olma		
Olan	17	56.7
Çocuğu olmayan	13	43.3
Evde 65 yaş üstü birey varlığı		
Bulunan	6	20.0
Bulunmayan	24	80.0
Evde kronik hastalığı olan birey varlığı		
Bulunan	11	36,7
Bulunmayan	19	63.3

Hemşirelerin yaş ortalaması 31,46 + 3,42 yıl, meslekte çalışma süresi ortalaması 7,90 + 4,31 yıl olarak saptanmıştır (Tablo 1).

Tablo 3. Hemşirelerin Covid-19 Salgınına Yönelik Algı ve Tutumları Değerlendirme Ölçeği boyutları ve Alt Boyutları puan ortalamaları ve medyan değerleri

Boyut	**Alt Boyut**	**Ort. + S.D.**	**Min.**	**Max.**	**Medyan**
Hastalık algısı	Tehlikelilik	13.03 ± 3.13	7	20	12
	Bulaşıcılık	11.6 ± 1.16	9	14	12
TOPLAM		**24,63 ± 3,05**	**18**	**32**	**24**
Nedenler algısı	Komplo	16.76 ± 5.98	6	30	16
	Çevre	21.26 ± 4.83	14	31	21
	İnanç	7.87 ± 2.68	4	16	7
TOPLAM		**45,90 ± 8,64**	**25**	**63**	**46**
Kontrol algısı	Makro	10.33 ± 2.59	4	15	10
	Kişisel	14.96 ± 3.35	10	22	15

	Kaçınılmazlık	11,3 ± 3.64	3	15	12
TOPLAM		**41.00 ± 8,10**	**29**	**60**	**41**
Kaçınma davranışları algısı	Bilişsel Kaçınma	15.70 ± 6.59	7	27	17
	Ortak Alanlardan Kaçınma	7,80 ± 2,94	3	13	9
	Kişisel Temastan Kaçınma	11.3 ± 3.64	3	15	12
TOPLAM		**34,8 ± 9,86**	**13**	**50**	**36**
	TÜM ÖLÇEK	**108,30±15,76**	**80**	**139**	**106**

Ölçek toplam puan ortalaması 108,30±15,76; Hastalık algısı alt ölçek puan ortalaması **24,63 ± 3,05;** Nedenler algısı alt ölçek puan ortalaması **45,90 ± 8,64;** kontrol algısı alt ölçek puan ortalaması **41.00 ± 8,10;** kaçınma davranışları algısı alt ölçek puan ortalaması **41.00 ± 8,10** olarak bulunmuştur.

Meslekte çalışma süresine göre kontrol algısı puanlarının farklılık gösterdiği, meslekte çalışma yılı arttıkça, kontrol algısı puanlarında artma olduğu belirlenmiştir (45,50; p=0,025; p<0.05).

Tablo 4. Yaş, Eğitim düzeyine, meslekte çalışma süresine ve Covid-19 hastasına bakım vermeye göre COVİD-19 Salgınına Yönelik Algı ve Tutumları Ölçeğinin alt boyut puanları

Özellikler			Hst. algısı	2.nedenler algısı	3.kontrol algısı	4.kaçınma algısı
Yaş	26-32 yaş grubu	Ort.+Ss (min: max:) Median	24,47 ± 2,51 25	44,76 ± 6,72 44	40,52 ±7,84 42	35,29 ± 10,75 34
	33-40 yaş grubu	Ort.+Ss (min: max:) Median	24,86 ± 3.33 24	47,38 ±10,77 47	41,61 ± 8,93 40	34,15 ±8,96 38
	Test değeri	Mann-Whitney - U	109,50	88,00	102,50	100,50
		p	0,967	0,363	0,742	0,680
Meslekte çalışma süresi	1-5 yıl	Ort.+Ss (min: max:) Median	23,42± 2,34 23	44,21 ± 6,22 44	41,07 ±8,40 42	38,42 ±9,93 41
	6-18 yıl	Ort.+Ss (min: max:) Median	25,68±3,28 26	47,37 ± 10,28 46	40,93 ±8,29 40	31,62 ± 8,92 30
	Test değeri	U	76.00	60,00	45,50	61,50
		p	0,422	0,125	**0,025***	0,137

Eğitim düzeyi	Lisans	Ort.+Ss (min: max☺ Median	24,23 ± 2,96 24	47,76 ± 7,99 48	39,19 ± 8,79 39	33,42 ±9,50 32
	YL+ dok	Ort.+Ss (min: max☺ Median	25,55 ±3,24 25	41,55 ± 8,97 41	45,22 ±4,68 46	38.00 ±10,53 42
	Test değeri	U	67,50	110.00	87,50	61,50
		p	0,967	0,951	0,313	**0,034 ***
Covid-19 hastasına bakım verme	Bakım veren	Ort.+Ss (min: max:) Median	24,68 ± 2,95 24	47,13 ±7,77 47	40,22 ± 7,64 40	34,77, ± 8,29 34
	Bakım vermeyen	Ort.+Ss (min: max:) Median	24,50 ±3,54 23	42,50 ± 10,50 41	43,12 ± 9,81 44	34,87 ± 14,03 40
	Test değeri	U	76,00	69,00	70,50	80,50
		p	0,597	0,393	0,420	0,730

Eğitim düzeyinin kaçınma algısı puanlarında farklılığa neden olduğu, lisans mezunlarına oranla, YL + doktora mezunu olanların kontrol algısı puanlarının daha yüksek olduğu belirlenmiştir (U=61,50; p= 0,034).

Tablo 5.Medeni duruma, evde kronik hst olan birey varlığına, çocuk sahi bi olmaya ve evde 65 yaş üzerinde birey varlığına göre COVİD-19 Salgınına Yönelik Algı ve Tutumları Ölçeğinin alt boyut puanları

Özellikler			**Hst. algısı**	**Nedenler algısı**	**Kontrol algısı**	**Kaçınma algısı**
Cinsiyet	Kadın	Ort.+Ss (min: max:) Median	24,08 ± 2,60 24	47,75 ± 8,08 48	41,25± 8,70 41	35,45 ± 9,42 34
	erkek	Ort.+Ss (min: max:) Median	26,83 ± 3,97 26	38,50 ± 7,25 39	40.00± 6,35 41	32,16 ±12,08 38
	Test değeri	Mann-Whitney - U	42,50	25.00	72,00	61,00
		p	0,129	**0,013**	1.000	0,595

Medeni Durum	Evli	Ort.+Ss (min: max:) Median	24,45 ± 3,01 24	47,50 ± 8,26 48	42,05± 9,12 42	35,55 ± 9,50 38
	Bekar	Ort.+Ss (min: max:) Median	25,00 ± 3,26 25	42,70 ± 8,92 43	38,90 ±5,82 39	33,30 ±10,92 33
	Test değeri	Mann-Whitney - U	94,00	70,50	80,00	87,50
		p	0,812	0,198	0,397	0,588
Çocuk Sahibi Olma	Var	Ort.+Ss (min: max:) Median	24,52 ± 3,20 24	47,76 ± 8,43 49	41,35± 8,17 42	35,11 ± 8,03 38
	Yok	Ort.+Ss (min: max:) Median	24,76 ± 2,97 24	43,46 ± 8,62 42	40,53 ± 8,55 40	34,38 ± 12,20 34
	Test değeri	U	109,50	81,00	102,00	110,50
		p	0,967	0,229	0,742	1.000
Evde 65 Yaş Üzerinde Birey Varlığı	Var	Ort.+Ss (min: max:) Median	26,16 ± 2,31 26	48,33 ± 7,78 46	37,50 ± 7,86 37	30,83 ± 7,46 29
	Yok	Ort.+Ss (min: max:) Median	24,25 ± 3,13 24	45,29 ± 8,89 45	41,87 ± 8,21 41	35,79 ± 10,27 38
	Test değeri	U	40,50	56,50	51,00	46,50
		p	0,104	0,432	0,296	0,191
Evde Kronik Hst Olan Birey Varlığı	Var	Ort.+Ss (min: max:) Median	24,36 ± 2,69 24	46,27 ± 6,19 49	39,45 ± 8,59 36	33,72 ±9,44 27
	Yok	Ort.+Ss (min: max:) Median	24,78 ± 3,30 24	45,68 ± 9,94 44	41,89 ± 8,06 41	35,42 ± 10,30 38
	Test değeri	U	95,50	99,00	84,50	91,00
		p	0,703	0,832	0,395	0,582

Tartışma:

COVID-19 pandemisi süresince hemşirelerin salgına yönelik algı ve tutumlarını incelemek, bunları etkileyen başlıca demografik ve mesleki faktörleri saptamak amacıyal yapılan bu çalışmada ölçek toplam puan ortalaması 108,30±15,76; Hastalık algısı alt ölçek puan ortalaması 24,63 ± 3,05; Nedenler algısı alt ölçek puan ortalaması 45,90 ± 8,64; kontrol algısı alt ölçek puan ortalaması 41.00 ± 8,10; kaçınma davranışları algısı alt ölçek puan ortalaması 41.00 ± 8,10 olarak bulunmuştur. Aşılama toplumda farklı gruptaki tüm bireyleri ilgilendirmektedir. Konuya ilişkin az sayıda çalışma yapılmıştır. Bu çalışmalarda seçilen örneklem grupları; toplumdaki bireyler (Kaçan ve ark., 2021), sağlık bilimleri fakültesi öğrencileri (Ekici ve ark., 2023), gebe kadınlar (Tahan ve Karakaş, 2023) ve sağlık çalışanlarından (Demir, & Aygun, 2025; Abolfotouh et al., 2020) oluşmuştur. Al-Dossary ve ark., (2020) hastalık, nedenler, kontrol ve kaçınma davranışları algısı alt ölçek puan ortalamasını sırasıyla; 24,63 ± 3,05; 45,90 ± 8,64; 41.00 ± 8,10; 41.00 ± 8,10 olarak saptamıştır, sonuç olarak hemşirelerin COVID-19'un yönetimi ve önlenmesine ilişkin olumlu algıları olduğunu bulmuşlardır. Çalışma sonuçlarımız Al-Dossary et al., (2020) 'nin çalışma sonuçlarını destekler niteliktedir. Kaçan ve ark., (2021)' nın örneklemini toplumdaki bireylerin oluşturduğu çalışmasında; Covid-19 salgınına yönelik algı ve tutum ölçeğinin "hastalık", "nedenler", "kontrol" ve "kaçınma davranışı" algısı alt boyu puan ortalamaları sırasıyla 17,557+5,289; 52,672+9,503; 36,968+6,180; 40,570+10,041 olarak bulunmuş olup bu sonuçlar çalışmamızdaki sonuçlara benzerlik göstermektedir. Ekici ve ark., (2023) örneklemini Sağlık Bilimleri Fakültesi öğrencilerinin oluşturduğu çalışmalarında Covid-19 salgınına yönelik algı ve tutum ölçeğinin "hastalık", "nedenler", "kontrol" ve "kaçınma davranışı" algısı alt boyu puan ortalamaları sırasıyla 3.92±0.50; 2.7±0.54; 2.8±0.54; 2.9±0.72 olarak bulunmuş olup bu sonuçlar çalışmamızdaki sonuçlardan farklılık göstermektedir. Tahan ve Karakaş (2023)'ın örneklemini gebelerin oluşturduğu çalışmasında; Covid-19 salgınına yönelik algı ve tutum ölçeğinin "hastalık" ve "nedenler" algısı alt boyu puan ortalamalarını sırasıyla 3,74±0,49; 2,94±0,51 olarak bulunmuştur, bu sonuçlar çalışmamızdaki sonuçlardan farklılık göstermektedir.

Çalışma bulgularımız, sosyodemografik değişkenlerin çoğunun COVID-19 salgınına yönelik algı ve tutum alt boyutların büyük çoğunluğunda farklılığa neden olmadığı, ancak hemşirelerin eğitim düzeyinin ve mesleki deneyim süresinin alt boyut puanlarında farklılığa neden olduğu görülmüştür. Meslekte çalışma süresine göre "kontrol algısı" puanlarının farklılık gösterdiği, meslekte çalışma yılı arttıkça, kontrol algısı puanlarında artma olduğu belirlenmiştir. Eğitim düzeyinin "kaçınma algısı" alt ölçek puanlarında farklılığa neden olduğu, lisans mezunlarına oranla, YL ve doktora mezunu olanların kontrol algısı puanlarının daha yüksek olduğu belirlenmiştir. Bu sonuç eğitimin ve deneyimin tutum üzerinde olumlu bir etkisi olduğunu göstermektedir.

Suudi Arabistan'da yapılan bir çalışmada, bakalorya derecesine sahip, evli ve kadınlarda COVID-19'a ilişkin daha iyi tutuma ve önleyici klinik deneyimlere sahip oldukları saptanmıştır (Al-Dossary et al., 2020). Çalışmamızda meslekte çalışma süresine göre kontrol algısı puanlarının farklılık gösterdiği, meslekte çalışma yılı arttıkça, kontrol algısı puanlarında artma olduğu belirlenmiştir. Eğitim düzeyinin kaçınma algısı puanlarında farklılığa neden olduğu, lisans mezunlarına oranla, yüksek lisans ve doktora mezunu olanların kontrol algısı puanlarının daha yüksek olduğu belirlenmiştir.

Diğer çalışmalarda; cinsiyetin hemşirelerin bakım algılarını ve tutumlarını etkilediği görülmüştür (Alsharif, 2022); daha yüksek eğitim düzeyine sahip hemşireler, salgına karşı daha olumlu tutumlar sergilemişlerdir. Bu durum, onların stres düzeylerini azaltmış ve mesleki rollerini daha etkin bir şekilde yerine getirmelerine katkı sağlamıştır. COVID-19 hastalarına doğrudan bakım veren hemşireler, yüksek düzeyde psikolojik stres ve sosyal damgalanma yaşamışlardır. Bu durum, onların mesleki kimliklerini ve toplum içindeki rollerini yeniden değerlendirmelerine neden olmuştur (Lee ve ark., 2022).

Çalışmamız bu sonuçlarla benzerlik göstermemektedir. Çalışma sonuçlarımızın hemşirelerin gelecekteki benzer krizler karşısında desteklenmesine yönelik stratejilerin geliştirilmesine katkı sağlayacağı düşünülmektedir.

Sonuç: Meslekte çalışma süresine göre kontrol algısı puanlarının farklılık gösterdiği, meslekte çalışma yılı arttıkça, kontrol algısı puanlarında artma olduğu belirlenmiştir. Eğitim düzeyinin kaçınma algısı puanlarında farklılığa neden olduğu, lisans mezunlarına oranla, yüksek lisans ve doktora mezunu olanların kontrol algısı puanlarının daha yüksek olduğu belirlenmiştir.

Sonuç olarak, yoğun bakım hemşirelerinin COVİD-19 Salgınına Yönelik Algı ve Tutumlarına ilişkin inançlarının yüksek olduğu söylenebilir. Bu sonuç hemşirelerin COVID-19 pandemisinde enfeksiyona yol açan virüse yönelik farkındalıklarının yüksek olması ile açıklanabilir.

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METAL-BASED DRUGS: A SHORT REVIEW AND FUTURE PROSPECTIVE

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ABSTRACT

Metal-based drugs are medicines that utilize metal ions or metal ion-based complexes as key elements for therapeutic or diagnostic purposes. Metallodrugs have been used for centuries, but in recent decades, these drugs have received significant attention in medicinal chemistry due to their outstanding properties. These properties arise from the versatile chemistry of metals, including multiple oxidation states, various coordination geometries, and the ability to form active complexes with a wide range of ligands. These characteristics provide significant advantages over traditional drugs.

The aim of this paper is to review the most important metal-based drugs used for therapeutic purposes, as follows:

- Cisplatin: A coordination complex of platinum that is used as a chemotherapy medication. It is classified by the World Health Organization (WHO) as an essential drug.
- Carboplatin: Sold under the brand name *Paraplatin* (among others), it is used to treat several types of cancer. It is included in the 2023 WHO List of Essential Medicines.
- Oxaliplatin: Listed as an essential medicine by the WHO since 2023 and sold under the brand name *Eloxatin*, it is another example of a platinum-based antineoplastic drug.
- Lanthanum carbonate: Used as a phosphate binder.
- Bismuth subsalicylate: A colloidal drug used to treat discomfort in the stomach and gastrointestinal tract.
- Auranofin: A gold salt used as an antirheumatic agent.
- Aurothioprol: A gold salt used as an antirheumatic agent.

- Sodium aurothiomalate: A gold-based medicine used for its immunosuppressive and antirheumatic effects.
- Lithium carbonate: A medication used to treat manic episodes of bipolar disorder.
- Silver diamine fluoride: A liquid used in dentistry to treat and prevent tooth decay.
- Silver sulfadiazine: A topical antibiotic listed as an essential drug by the WHO.

For all the above-mentioned drugs, the mechanisms of action, therapeutic indications, and common side effects are discussed in detail.

Lastly, the paper reviews ruthenium-based drugs, which have progressed to clinical trials as alternatives to platinum-based chemotherapy. Examples include NAMI-A, KP1019, and BOLD-100. Possible strategies for the synthesis of new metal-based drugs are also suggested.

Keywords: metal- based drugs, WHO, chemotherapy.

COMPLICATIONS RELATED TO INSULIN THERAPY, AND ADMINISTRATION IN DIABETIC INDIVIDUALS

DİABETİK BİREYLERDE İNSÜLİN TEDAVİSİNE VE UYGULAMASINA İLİŞKİN KOMPLİKASYONLAR

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ABSTRACT

Today the prevalence of diabetes mellitus is increasing. The goal of diabetes treatment is to achieve glycemic control and prevent complications. To this purpose, individuals with both type I and type II diabetes can now begin insulin therapy earlier. The preferred protocol for insulin therapy is the one that best mimics physiological insulin and best suits the patient's lifestyle. Insulin can be administered subcutaneously, either daily with an insulin pen or with an insulin infusion pump. Another way to administer insulin is intravenously as pulsatile intravenous infusion therapy. Complications can arise in individuals receiving insulin therapy, whether using an insulin pen or an insulin infusion pump. Complications related to insulin pump therapy include insulin precipitation in the catheter, an inadequate alarm system, infusion set obstruction, and pump malfunction, skin complications such as lipoatrophy, lipohypertrophy, infection, local insulin allergy, and allergies due to the materials used, and metabolic complications such as ketoacidosis and hypoglycemia. Misuse of SC insulin injections can negatively impact insulin regulation, leading to bleeding, hematoma, leakage, ecchymosis, and pain at the injection site. Hypoglycemia is the most important and common complication of insulin therapy. It is associated with closely monitored glycemic control and a long time to diagnose diabetes. Nurses are responsible for both administering insulin to diabetic patients and educating them about self-injection techniques. They should inform patients about rotating injection sites, symptoms of complications and other precautions to prevent local complications, and they should monitor patients for these complications during follow-up visits and guide them toward tests and treatments to alleviate complications, in accordance with physicians' recommendations. In this review article insulin-related complications were examined and recommendations were made regarding the management of patients and nursing care.

Key words: complication, diabetes, insulin, pump therapy

ÖZET

Günümüzde diabetes mellitus prevalansı artmaktadır. Diabet tedavisinin amacı, glisemik kontrolü sağlamak ve komplikasyonları önlemektir. Bu amaçla günümüzde hem tip I hem de tip II diabette insulin tedavisine daha erken başlanmaktadır. İnsulin tedavisi için tercih edilen protokol, fizyolojik insulini en iyi taklit eden ve hastanın yaşam tarzına en uygun olanıdır. İnsülin subkutan olarak ya her gün insulin kalemi ile veya bir insulin infüzyon pompası ile uygulanır. İnsülinin uygulamanın diğer bir yolu, pulsatile intravenöz infüzyon tedavisidir. İnsulin kalemi ile veya bir insulin infüzyon pompası ile insulin uygulanan hastalarda komplikasyonlar gelişebilir. İnsulin pompası tedavisine ilişkin komplikasyonlar, insülinin kateterde presipitasyonu, yetersiz alarm sistemi, infüzyon setinte tıkanıklık, infüzyon pompasında işlev bozukluğu, ve lipoatrofi, lipohipertrofi, enfeksiyon, local insulin allerjisi, kullanılan meteryale ilişkin komplikasyonlar ve ketosidoz ile hipoglisemi gibi deriye ilişkin komplikasyonlardır. Subkutan insülinin yanlış kullanımı, insulin regülasyonunu olumsuz yönde etkileyebilir, kanama, sızıntı, ekimoz, enjeksiyon bölgesinde ağrıya neden olabiir. Hiperglisemi insülin tedavisinin en yaygın görülen

komplikasyonudur. Hipoglisemi, glisemik kontrolün yakından izlenmesiyle ilişkilidir ve uzun süredir diabet tanısı alma ile ilişkilidir. Hemşireler, diabetik hastaya hem insulin uygulamakla hem de onları kendi kendine enjekiyon uygulama konusdn aeğitmekle sorumludur. Onlar hastaları enjeksiyon bölgelerini değiştirme, komplikasyonların semptomları, local komplikasyonlara yönelik diğer önlemler hakkında bilgilendirmeli, kontrol ziyaretleri sırasında bu komplikasyonlar açısından hastaları izlemelidir ve onlara testler ve komplikasyonları azaltmaya yönelik tedaviler hakkında hekim önerilerine uygun biçimde rehberlik etmelidir. Bu derleme makalede insulin bağlı komplikasyonlar incelenmiş ve hastaların yönetimine ve hemşirelik bakımına ilişkin önerilerde bulunulmuştur.

Anahtar kelimeler: komplikasyon, diabet, insülin, pompa tedavisi

GİRİŞ

Özellikle gençlerde olmak üzere günümüzde DM insidansı ve prevalansı giderek artmaktadır (Binder et al., 2015; Guo ve Wang, 2017; Dinçoğlu, 2020). Diyabetli bireyleri tedavi ederken kandaki glukoz seviyesini normal sınırlarda tutarak hipoglisemiyi, kilo artışını ve komplikasyonların gelişmesini önlemek amaçlanır (Abacı ve ark., 2008; Dinçoğlu, 2020). Anabolik bir hormon olan protein yapısındaki insulin diabetik hastalarda tedavi amacıyla kullanılır (Dinççağ, 2011). Tip 1 diyabetiklerde ömür boyu, (Pickup ve ark., 2002; Demir ve ark., 2022), tip 2 diyabetiklerde yaklaşık olarak hastaların üçte birine insulin verilir (Büyükyılmaz ve ark., 2018). Tedavinin etkinliği ve güvenirliği açısından doğru dozda insülin verilmesi önemlidir. İnsülin uygulama tekniği ve hangi vücut bölgesine verildiği önem taşımaktadır (Demir ve ark., 2022). 1970 yılında kullanılmaya başlayan insulin pompası vasıtasıyla (Pickup ve ark., 2002) kısa etkili insulin verilmesine günümüzde her iki diabet türünde daha erken dönemde başlanmaktadır (Guo and Wang, 2017) ve fizyolojik insülini en iyi taklit eden, bireyin yaşam biçimine en uygun insülin tedavi şeması uygulanır (Dinçoğlu, 2020).

Doğru dozdaki ve doğru subkutan enjeksiyon tekniği ile insülin uygulanması, istenmeyen etkilerin önlenmesi yönünden önem taşır (Büyükyılmaz ve ark., 2018). İnsulin ya her gün insulin enjektörü/kalemi ile veya elektromekanik bir infüzyon pompası ile deri altina sürekli olarak uygulanır (Pickup ve ark., 2002; Demir ve ark., 2022), ancak üçüncü bir yöntem olan pulsatil tedavi yönteminde insulin intravenöz olarak verilir. Pulsatil intravenöz insülin infüzyon tedavi yöntemi; pankreasın karaciğere sinyal göndermesini taklit ederek, karbonhidrat mekanizmasını yenileyerek diyabet hastalığının asıl sorununun giderilmesini sağlamaktadır (Kösedağ ve Hamzaoğlu, 2021). Diyabetli bireyler subkutan enjeksiyon için genellikle tek kullanımlık insülin iğnelerini tekrar kullanmaktadır, ancak iğnelerin tekrar kullanılması önemli maliyet tasarrufları sağlasa da uzmanlar ve üreticiler, insülin iğnelerinin tekrar kullanılmamasını tavsiye etmektedir (Zabaleta-del-Olmo ve ark., 2016). Diyabette doğru enjeksiyon tekniği insülinin ve yapılan diğer ilaçların en iyi işlev görmesini sağlar (Blanco ve ark., 2013). Son on yıllarda infüzyon pompası vasıtasıyla sürekli subkutan insülün infüzyonu giderek artmıştır (Schober and Rami, 2009). İnsülin pompası 24 saat boyunca hastanın üstünde durur ve yaklaşık 3 gün yetecek kadar insülin içermektedir (Kösedağ ve Hamzaoğlu, 2021), tip 1 diyabetli hastalar için güvenilir bir yöntemdir (Abacı ve ark., 2008; Büyükkaya Besen ve Dervişoğlu, 2021). İnfüzyon pompası vasıtasıyla sürekli subkutan insülün infüzyonu, glisemik kontrolü en iyi hale getirmek için yoğun insulin tedavisi olarak günlük insulin enjeksiyonuna bir alternative olarak kullanılır ve mikrovasküler komplikasyonların gelişme riskini azalttığı belirlenmiştir (Hoogma et al., 2006). İnsülinin intravenöz olarak verildiği pulsatil tedavi yönteminde ise; uygulama başlangıçta haftada 2 kez yaklaşık 3 saat surer, hasta bu dönemde yürüme, kitap okuma gibi bazı fiziksel faaliyetlerde bulunabilirler, insülünin etkisi yaklaşık 7-30 gün arası devam eder, düzenli devam eden tedavilerde ayda 2-4 kez uygulama yeterlidir (Kösedağ ve Hamzaoğlu, 2021).

İnsülin pompaları hiperglisemiyi tedavi etmeyi amaçlar, tip 1 diyabette kullanılır (Tuncel, 2007), pulsatil yöntem ise pankreasın karaciğeri uyaran doğal yöntemini taklit eder, prediyabette tip 1 ve tip 2 diyabette uygulanır (Kösedağ ve Hamzaoğlu, 2021). Pompa kullanılarak sürekli subkutan insulin infüzyonu; hem metabolik kontrol hem de hipoglisemi sıklığını azaltır (Hatun ve Çizmecioğlu, 2003; Abacı ve ark., 2008; Conwell ve ark., 2008). Yapılan bir çalışmada; pulsatil intravenöz insülin infüzyon tedavi yönteminin, karbonhidrat metabolizmasını düzelterek komplikasyonların oluşmasını önlemeye yönelik uygulanabilecek bir tedavi olduğu belirtilmektedir (Kösedağ ve Hamzaoğlu, 2021).

İnsülin infüzyon pompası bireyin öz bakımına katkı sağlar (Polat ve Avdal, 2021) ve burada sadece hızlı etkili insülinler kullanılır (T.C. Sağlık Bakanlığı, 2020). Ancak insülin pompaları 8 yaşından küçüklerde, görme ve işitme bozukluğu olan, eğitim düzeyi düşük ve zeka geriliği olan tip 1 ve tip 2 diyabetiklerde kullanılmaz. Malignitede, obezlerde, son dönem böbrek yetmezliği olanlarda ve otonom nöropatisi olanlarda insulin pompa kullanımına diabet ekibi karar verir (Tuncel, 2007). Bir rezervuar ve insülinin verilmesini sağlayan infüzyon pompası, taşınabilir elektromekanik bir sistemdir, sensörlü, setli, setsiz çeşitleri vardır. İnfüzyon setinin 48-72 saatte bir değiştirilmesi gerekir. Bolus insülin öğünlerden önce veya yüksek kan şekerini düzeltmek amacı ile hızlı etkili insülinin cilt altına hemen gönderilmesidir. İnsülin pompasının avantajlarından biri, diyabete bağlı komplikasyonların yavaşlatılması/ önlenmesidir. İnsülin pompası kullanıldığında daha iyi kan şekeri kontrolü, HbA1c düzeyinde düşüş olur (T.C. Sağlık Bakanlığı, 2020).

Insulin tedavisine ve uygulanmasına bağlı gelişen komplikasyonlar

Günümüzde diabet giderek arttığından ve tip 1 diabetiklerde sürekli subkutan insulin tedavisi görme oranı artığından, olası komplikasyonları incelemek önem taşımaktadır (Conwell et al., 2008). İnsülin pompası ile veya iğne kullanılarak insulin subbkutan dokuya verildiğinde gelişebilecek komplikasyonlar şunlardır.

1**)Cihazda kateter, pompa, iğne gibi bölümlerdeki işlev bozukluğı ile ilgili sorunlar**; İnsülin pompa ile subkutan dokuya verildiğinde set tıkanabilir veya setler birbirinden ayrılabilir, bu alarm vermez; bu durumda sadece hızlı etkili insülin kullanıldığından *ve* insülin akışı durduğu için hiperglisemi gelişebilir, keton oluşabilir, bunu önlemek ve erken fark etmek için kan şekeri düzenli olarak ölçülmelidir (T.C. Sağlık Bakanlığı, 2020). İnfüzyon pompası kullanan hastalarda; infüzyon setinde tıkanıklık, ve infüzyon bölgesinde enfeksiyon en sık rastlanan durumlardır, bunlara yol açan en büyük neden, insülinin presipitasyonu veya aggresyonudur (Guilhem ve ark., 2006; Guo ve Wang, 2017).

2)Hipoglisemi: Hipoglisemi insülin tedavisinin en sık görülen ve en önemli komplikasyonudur (Tuncel, 2007; Demir ve Ark., 2022). Sıkı glisemik kontrol ve uzun diyabet tanı süresiyle ilişkilidir. Hipoglisemi riski pompa ile insülin verilen diabetiklerde daha az sıklıkta görülür (Lenhard ve Reeves, 2001; Dinççağ, 2011). Hasta bazı aktivitelere katıldığında insülin akışı kasıtlı olarak kesilebilir veya bazen kasıtsız olarak kateter tıkanması veya yanlış yerleştirilmesi, pildeki zayıflama gibi nedenlerle hipoglisemi gelişebilir. Kısa etkili insülinin akışının kesilmesi sonucu olarak ketonemi ve ketoasidoz gelişebilir. Pompa tedavisinde insülinin akışı hastanın aktivitelere katılması gbi kasıtlı nedenlerle kesilebilir, veya kateter tıkanıklığı, kateterin yanlış takılması, bataryanın tükenmesi gibi nedenlerle kasıtsız olarak de oluşabilir. Çoğunlukla hastanın yetersiz eğitimi nedeniyle, özellikle acil önlemleri almaması nedeniyle açıklanamayan hipoglisemi gelişebilir (Lenhard ve Reeves, 2001).

3) Cilt komplikasyonları: İnsülin pompası ile veya her gün insulin kalemi ya da normal iğne ile SC yolla enjekte edildiğinde ciltte komplikasyonlar gelişebilir (Annersten ve Willman, 2005; Tuncel, 2007; Dinççağ, 2011; Binder ve ark., 2015; Sayınalp, 2021; Demir ve ark., 2022).

3.1.Enjeksiyon bölgesindeki ciltte kanama, sızıntı ve hafif ağrı, ekimoz, hematom: Özellikle asit insülinler (örn. glargin) ile enjeksiyon sırasında hafif ağrı hissedilebilir, önemsizdir (Dinççağ, 2011).

Hatalı SC enjeksiyon ile ilgili uygulamalar insülin regülasyonunu olumsuz yönde etkileyerek bu komplikasyonlara neden olur (Büyükyılmaz ve ark., 2018).

3.2. Apse: İnsülüne bağlı olarak ciltte allerji, hijyen koşullarına uyulmadığı takdirde enfeksiyon enfeksiyon/apse gelişebilir. İnsülin pompasının kateterinin cilde takıldığı bölgede enfeksiyon gelişebilir ve yaygın olarak görülür. Enfeksiyon bazen cerrahi debridman gerektiren sellülit veya abse oluşumuna yol açabilir. Kateter bölgesinde enfeksiyonun yıllık hasta izleminin her 100 yılı için 7.3 ile 11.3 olduğu tahmin edilmektedir (Lenhard ve Reeves, 2001).

3.3.Lipodistrofi: Lipodistrofi subkutan enjeksiyonun en yaygın komplikasyonlarından biridir ve ya lipohipertrofi ve lipoatrofi şeklinde görülür (Blanco ve ark., 2013). İnsülinin subkutan dokuya anormal reaksiyonuna lipodistrofi denir (Mokta et al., 2013), lastik gibi şişlik şeklinde görülür, bazen sert bazen yumuşak olabilir, tam olarak nedeni bilinmemektedir, hasta enjeksiyon bölgelerini rote edemediğinde, aynı bölgeye enjeksiyon uygulama nedeniyle tekrarlı travmanın ve tekrar tekrar aynı iğneyi kullanma gibi enjeksiyona ilişkin etmenlerin rol oynadığı bilinmektedir (Blanco ve ark., 2013). Herhangi bir insulin formülasyonu lipodistrofiye yol açabilir, günlük kullanılan insulin kaleminin iğnesi veya normal enjektör iğnesini değiştirme ve enjeksiyon yerini sık değiştirme yararlı olabilir (Mokta et al., 2013). İnsülin lipohipertrofisi yağ dokusunun şişmesine benzer, iyi huylu tumöre benzer bir görünümü belirtir (Mokta et al., 2013). Lipodistrofi, kısa etkili regular insuline oranla orta ve uzun etkili insülinlerde iki kat fazla görülür, çünkü enjeksiyon bölgesinde daha uzun sure kalır ve lokal antijen için bir kaynak oluştururlar (Mokta et al., 2013). Gözle muayene yeterli değildir, bölgeleri palpe etmek gerekir. İnsüline bağlı olarak gelişen lipohipertrofi (Richardson ve Kerr, 2003; Guo ve Wang, 2017) ve lipoatrofi subkutan insülin enjeksiyonu ile ilişkilidir (Conwell et al., 2008). Lipohipertrofidir sık görülür, insülinin adipoz doku birikimini arttırıcı etkisi nedeniyle oluşur, her türlü insuline bağlı olarak gelişebilir (Sayınalp, 2021). Lipohipertrofi, insulin tedavisinin en sık görülen (Guo ve Wang, 2017; morfolojik olarak çıkıntılı veya düz dokularda gelişen komplikasyonudur (Richardson ve Kerr, 2003; Luo ve ark. 2021). İnfüzyon seti cilde sürekli olarak aynı bölgeye yerleştirildiğinde veya insulin kaleminin/ insülin enjektörünün iğnesi ile aynı bölgeye insulin enjekte edildiğinde, yani enjeksiyon bölgesi değiştirilmediğinde (Dinççağ, 2011; Sayınalp, 2021) ya da yanlış enjeksiyon tekniği (Büyükyılmaz ve ark., 2018) nedeniyle gelişebilir. Lipohipertrofi geliştiğinde insülinin sistemik dolaşıma emilimi (Richardson ve Kerr, 2003) ve glisemik regülasyonu bozulur (Sayınalp, 2021), yüksek HbA1c seviyesi nedeniyle beklenmeyen hipoglisemiye yol açar, insülinin emiliminde bozukluğa yol açtığından, sonuç olarak daha fazla insuline gereksinim duyulur, bu da sağlık bakım maliyetini arttırır (Büyükyılmaz ve ark., 2018; Demir ve ark., 2022). Insülin pompası kullananlar, her gün SC enjeksiyon yapılanlara oranla daha düşük lipohipertrophi riski taşır (Demir ve ark., 2022). Bazen gözlemle ve palpe edilerek saptanamaz (subklinik lipohipertrofi), tanı konması için ultrason gerektirir. Lipohipertrofik dokunun içine yapılan daha yüksek dozdaki insülin enjeksiyonları daha yüksek maliyete yol açar, bu nedenle bu komplikasyonun zamanında saptanması hastaların hasarsız bölgelere enjeksiyon yapmalarını sağlamak açısından önemlidir (Luo ve ark. 2021). Lipohipertrofi gözlem ve enjekte edilen bölgelerin palpasyonu ile saptanır. Normalde deri iyice/sıkıca sıkıştırılabilir, oysa lipohipertrofik lezyonları sıkıştırılamaz (Blanco ve ark., 2013).

3.3.Lipoatrofi: Lipoatrofi saflaştırılması az olan insülinin enjekte edildiği dokuda yağın lokalize kaybıdır (Sayınalp, 2021), bazı insülinlerin lipolitik bileşenlerine bağlı olarak gelişen immünolojik temele dayanır (Blanco ve ark., 2013), nadir görülür (Mokta et al., 2013). Lipoatrofi yara izi bırakır, insulin preparatlarındaki kirliliğin veya diğer komponentlerin neden olduğu lipolitik bir reaksiyon vardır, çoğunlukla kadınları etkiler, tip 1 diabette daha sık görülür, literatürde görülme sıklığının yaklaşık %30 ile %50 arasında değiştiği bildirilmektedir (Blanco ve ark., 2013). Aynı enjeksiyon bölgesinin tekrar tekrar kullanılması lipoatrofi riskini artırır; zamanla hastalar bu bölgelerin nispeten ağrısız olduğunu öğrenir ve bu bölgeleri kullanmaya devam eder (Richardson ve Kerr, 2003).

3.4.Lokal allerjik reaksiyonlar: İnsülüne yönelik lokal allerjik reaksiyonlar (Lenhard ve Reeves, 2001; Büyükyılmaz ve ark., 2018; Sayınalp, 2021), eritem, pruritis ve endurasyon olarak görülür (Richardson ve Kerr, 2003; Guo ve Wang, 2017). Günümüzde insan insülinleri ve analog insülin kullanımı ile nadir görülen bir komplikasyondur (Dinççağ, 2011).

3.5.Kullanılan malzemelere yönelik allerjiler: İnfüzyon seti ve sensörün silikon yapısı ile yapışkan bantların içerdiği maddelere karşı ciltte alerjik bulgular gelişebilir (Tuncel, 2007; T.C. Sağlık Bakanlığı, 2020) İnsülin pompasının kateterinin infüzyon setleri ve bant bileşenlerine atfedilen kontakt dermatit vakaları da gelişebilir. Çok nadir durumlarda, kontakt dermatit bant ve/veya kateter tipinin değiştirilmesine rağmen devam eder ve o kadar şiddetlidir ki pompa ile sürekli infüzyon akışının kesilmesi gerekir (Lenhard ve Reeves, 2001).

4)Kilo artışı: İyileşmiş glisemik kontrolün en yaygın etkisi olan kilo alma (Lenhard ve Reeves, 2001), insülin tedavisinin başlangıcında gelişir, nedeni kaybedilmiş yağ ve kas dokusunun yeniden kazanılması (Dinççağ, 2011), fazla karbonhidrat/ kalori alımı, (T.C. Sağlık Bakanlığı, 2020) su ve tuz tutulumu olması ve glukozürinin azalmasıdır. Ancak sonraları hipoglisemi korkusu ve dengesiz beslenme bu sorunun devam etmesine yol açar Ayrıca ozmotik diürezin azalması ve Na+ tutulumuna bağlı başlangıçta ödem görülebilir (Dinççağ, 2011). Ancak insülin pompası kullanıldığında her hasta kilo almayabilir (Lenhard ve Reeves, 2001).

SUBKUTAN YOLLA INSULIN VERILMESINE BAĞLI KOMPLIKASYONLARA İLİŞKİN ARAŞTIRMA SONUÇLARI

Literatürde insülinin pompa ile sürekli verilmesinin olumlu sonuçlarını vurgulayan araştırmalar ile sistematik review ve meta analiz çalışmaları yapılmıştır. Glisemik kontrol ve insülün dozunu kıyaslayan toplam 12 randomize kontrollü araştırma ile yapılan bir metaanaliz çalışmasında; enjeksiyona oranla sürekli infüzyonla insulin verilmesinin, mikrovasküler komplikasyonları önlediği sonucuna varılmıştır (Pickup ve ark., 2002). yapılan bir sistematik review ve meta analiz çalışmasında 2008 ile 2015 yılları arasındaki yayınlar incelenerek, hem çocuklarda hem de erişkinlerde; çoklu günlük insülün enjeksiyonu yapılan hastalara oranla, sürekli SC insülin infüzyonu yapılanlarda glycosylated hemoglobinde anlamlı bir azalma olduğu sonucuna varılmıştır (Benkhadra, et al., 2017). Diğer bir sistematik reviewda ve metaanaliz çalışma sonuçlarına gore; beş çalışmada iğnelerin tekrar kullanımı ile enfeksiyon riski arasında bir ilişki bulunamamıştır, beş kesitsel çalışmada iğnelerin tekrar kullanımı ile lipohipertrofi arasında bir ilişki bulunamamıştır, iki çalışmada ise tekrar kullanılan iğnelerde daha yüksek düzeyde ağrı algılanmıştır. Yazarlar, SC insulin enjeksiyon için iğnelerin tekrar kullanımına veya tek sefer kullanımına ilişkin destekleyen veya karşı çıkan bir kanıt bulunmadığı sonucuna varmışlardır (Zabaleta-del-Olmo ve ark., 2016).

Diabetik bireylerde sürekli subkutan insulin infüzyonu, kronik böbrek yetmezliği, retinopati, uzun süreli komplikasyonların gelişmesini azaltır. Tip 1 diabetli hastalarda sürekli subkutan insulin infüzyonunun, glukoz kontrolü ve mikrovasküler komplikasyonlar üzerine uzun sureli etkilerini incelemek amacıyla yapılan bir çalışmada, hastalarda HbA1c'nin, sürekli subkutan insulin infüzyonundan bir yıl sonra %8.4 ± 1.3'dan %7.7 ± 1.3'e kadar anlamlı derecede azaldığı, ayrıca 4 yıllık izlem sonunda retinopati prevalansının %39'dan %3.6'ya, albuminuri prevalansının %12'den %2.5'e, kronik böbrek yetmezliği prevalansının %9'dan % 1.4'e düştüğü belirlenmiştir (Lenhard ve Reeves, 2001).

Insulin verilen cilt bölgesinde lokal komplikasyon gelişmesi ile ilgili çalışmaların çoğu düşük yaş grubundaki tip-1 diyabetiklerde yürütülmüştür. Yaş ortalaması 14.9 ± 4.7 yıl olan ve tip-1 diabet tanı konma süresi 7.3 ± 4.1 yıl olan, 0 ile 21 yaş arasında tip -1 diabet açısından, en az 1 yıldır izlenen bireylerde yapılan bir anket çalışmasında, insülüne bağlı lokal komplikasyonlar saptanmıştır. Diabetik bireylerin %11.8'inde lipohipertrofi, %7.5'inde yara, %21.7'sinde allerji, %55.5'inde kanama, %41.3'ünde ekimoz, ve %47.2'si ağrı geliştiği saptanmış olup, çalışmada tip -1 diabeti olan genç

bireylerde lokal komplikasyonların yaygın olduğu sonucuna varılmıştır. Hastaların yaklaşık %12'sinde bu komplikasyonarın metabolic kontrolü etkilediği bulunmuştur (Demir ve ark., 2022).

Pompa kullanılarak sürekli insulin infuze edilen 3-20 yaş arasındaki hastalarda deriye ilişkin gelişen komplkasyonların sıklığını ve özelliklerini belirlemek amacıyla toplam 55 hasta ile yapılan bir anket çalışmasında, etkilenen cilt bölgelerinin fotografları çekilmiş ve hastaların %43'ünde kateter takılma bölgesinde deri komplikasyonları geliştiği, %24'ünde skar oluştuğu, %20'sinde lipohipertrofik bölgeler geliştiği, %6'sinda pigment değişiklikleri ve lipoatrofi geliştiği, %24'ünde cilt komplikasyonları nedeniyle kateter yerleştirilen bölgelerin değiştirildiği ve hiçbir hastada pompa kullanılarak sürekli insulin infuzyonuna ara verilmediği saptanmıştır (Binder ve ark., 2015).

Sürekli subkutan insulin pompasi ile insulin infüzyonuna bağlı komplikasyonların; okul çağındakilere oranla, çok küçük çocuklarda dermatolojik komplikasyonların daha sık görülüp görülmediğini incelemek amacıyla yapılan bir çalışmada, insulin pompa tedavisini 4 ay ve daha uzun süredir alan 78 çocuk, iki ayrı grup halinde çalışma kapsamına alınmıştır. En yaygın dermatolojik komplikasyonların, cilde giriş yerinde 3 mm.'den daha küçük skarlar ve lipohipertrofik bölgeler olduğu saptanmıştır (Schober ve Rami, 2009).

Ayrıca subklinik lipohipertrofi ile ilgili ultrasonun kullanıldığı çalışmalar da yapılmıştır. Insülün enjeksiyonu yapılan diabetik bireylerde subklinik lipohipertrofi prevalansının incelendiği çalışmada, en az bir yıldır sürekli insülin tedavisi alan toplam 316 diabetik bireyde; subklinik lipohipertrofinin kanıtı açısından hem klinik muayene hem de ultrason taraması yapılmış; sonuç olarak subklinik lipohipertrofinin toplam prevalansının %19,9 olduğu, insülün enjekte edilen diabetiklerde yaygın olduğu ve glisemik kontrolde bozulma ile ilişkili olduğu bulunmuştur, ayrıca aşamalı obezitenin, bölgelerin doğru olmayan şekilde rotasyonunu, insülin iğnesinin 4 defadan daha fazla kullanımının ve tip 1 diabetin subklinik lipohipertrofi ile bağlantılı olduğu, sonuç olarak subklinik lipohipertrofinin insülin enjekte edilen diabetiklerde yaygın olduğu ve glisemik kontrolde bozulma ile ilişkili olduğu bulunmuştur (Luo ve ark., 2021).

Lipohipertrofi sıklığını belirlemek amacıyla yapılan bir çalışmada, 430 insülin enjeksiyonu yapan diabetik hastaya anket uygulanmış, hastaların %64.4'ünde lipohipertrofi geliştiği, ve lipohipertrofi varlığı ile enjeksiyon bölgelerini rote etmeme arasında güçlü bir ilişki bulunmuştur (Blanco ve ark., 2013).

Toplam 6 aydan daha uzun süredir insülin pompa kliniğine başvuran (n=92) insülin pompa tedavisi alan bireylerde anket kullanılarak gelişen komplikasyonlar incelenmiş ve en sık rastlanan komplikasyonun infüzyon seti sorunları, kıvrılma, (64.1%) ve tıkanma (54.3%) olduğu belirlenmiştir. En yaygın infüzyon cilt alanındaki komplikasyonun infüzyon süresi uzun olanlarda daha sık gelişen lipohipertrofi (26.1%) olduğu, pompa işlev bozukluğunun bireylerin %48'inde geliştiği, bazı hastalarda kilo alma (34%) ve kilo verme (15%) geliştiği belirlenmiştir *(*Pickup et al., 2014). Bangladeş'te ortalama insulin kullanım süresi 3.84 ± 4.05 yıl olan, ortalama günlük insulin dozu 41 ± 25 unite olan diabetik bireylerle yapılan bir anket çalışmasında, enjeksiyondan sonraki bekleme sürelerinin yeterli olmadığı hastaların %9.2'sinde enjeksiyon bölgesinde lipohipertrofi geliştiği, lipohipertrofi gelişen hastaların %38.5'inin enjeksiyonu lezyonun içine verdikleri belirlenmiştir (Kamrul-Hasan ve ark., 2020).

Pompa ile insulin verilen tip 1 diabetik hastalarının verileri retrospektif olarak incelenerek yapılan bir çalışmada, insülin pompasının etkinliği değerlendirilmiş ve pompa tedavisi kullanan hastaların %67,3'ünde pompa ile ilişkili en az bir komplikasyon geliştiği, hastaların %61,2'sinde infüzyon setinde tıkanıklık, %38,8'inde diyabetik ketoasidoz geliştiği belirlenmiştir (Yılmaz ve ark., 2021).

Yaş ortalaması 13.3 ± 3.5 yıl olan, pompa kullanılarak sürekli subkutan insulin tedavisi alan tip 1 diabetik toplam 50 genç bireyde dermatolojik sorunların ve pompa ile sürekli insulin infüze edilme süresi ile yaş, SC yağ dokusu kalınlığı, $HbA1_c$, insulin dozu, insulin markası, infüzyon seti veya bölgesi

arasındaki ilişkinin incelendiği çalışmada, 8 bireyde ultrason taraması yapılmış, ortalama şiddet puanı 6.3 ± 3.5 olarak bulunmuştur. Vakaların %94'ünde en yaygın görülen skarların <3 mm çapında olduğu, eritemlerin nodüllerle ilişkili olmadığı, %62'sinde subkutan nodül ve lipohipertrofi geliştiği belirlenmiştir. Hastaların %5'inden daha azında, ebeveynler ve hastaların deri sorunları nedeniyle sürekli subkutan insulin tedavisini yarıda bıraktıkları, ayrıca ultrason taraması sonuçları, sürekli subkutan insulin tedavisi bölgelerinde, dermis ve hipodermiste hafif artma olduğu sonucuna varılmıştır (Conwell ve ark., 2008).

Literatürde insulin tedavisine ilişkin cilt reaksiyonlarından lipodistrofi ve lipohipertrofi ile ilgili vaka örneklerine rastlanmıştır. Bu vaka örneğinde son 1 ve 3 yıldır subkutan insulin alan 51 ve 47 yaşındaki Tip 2 diabetik iki erkek hastada, son 6 aydır diyete ve insulin dozuna uydukları halde, kan glukoz düzeyinde değişimler ve beklenmeyen hipoglisemi atakları nedeniyle enjeksiyon bölgesinde yapılan incelemede, göbek çevresinfe iki lipohipertrofi ve iyi çevrelenmiş lipoatrofi görülmüştür. Hastalara bu bölgeleri enjeksiyon için kullanmamaları önerilmiş ve insulin dozu %10 azaltılmış, her iki vakada 3 ay sonra hem HgA1c azalmış hem de herhangi bir hipoglisemi görülmemiştir. Yazarlar bu iki vakada görülen komplikasyonun insulin kristallerine lokal immün reaksiyonun yanısıra aynı insulin iğnesinin sık kullanımının ve insulin yapılan bölgelerin rote edilmemesinin lipodistrofi gelişimiyle bağlantılı olduğu sonucuna varmışlardır (Mokta et al., 2013).

KOMPLIKASYONLARIN ÖNLENMESINDE HEMŞİRENIN ROLÜ

Sağlık çalışanları insülünin uygulanmasında önemli bir role sahiptir. Hastanın doğru enjeksiyon tekniğini uygulaması; iyi bir diabet yönetimi sağlar, emilimle ilgili değişkenliği azaltır ve en iyi ilaç etkisinin elde edilmesini sağlar**.** Insülinin kas içine verilmesinden kaçınarak, subkutan dokuya doğru enjeksiyon tekniği ile uygulanması ve lipodistrofi gibi sık görülen komplikasyonlardan kaçınılması önemlidir. Sağlık çalışanlarının hastaların insulin subkutan doku yerine yanlışlıkla kas için enjekte etmelerini önlemek, sızıntı ve diğer komplikasyonlarından kaçınarak hastaların kendilerine subkutan enjeksiyonları yapmalarına yardım etmek için, enjeksiyon bölgelerini anatomisini iyice anlamalıdırlar (Frid et al., 2010). Hemşire diabetik hastalara hem insulini uygulama hem de hastayı kendi kendine enjeksiyon tekniği, enjeksiyon bölgelerini rote etme, enjeksiyon bölgesindeki lokal komplikasyonları önleme ve diğer komplikasyon belirtileri hakkında eğitme sorumluluğuna sahiptir (Annersten ve Willman, 2005; Demir ve ark., 2022). Subkutan insülin enjeksiyonu, kapiller damarlanmanın görünmediği bir bölgeye yapılmalıdır, böylelikle kanama önlenebilir. Subkutan insülin enjeksiyonu bittikten sonra iğne 5-10 saniye kadar cilt altında bekletilmelidir veya uzun iğne kullanılmalıdır, böylece insülinin geri sızma olasılığı azaltılabilir (Dinççağ, 2011). Hipogliseminin erken tanınması için sık kan şekeri kontrolü yapılmalıdır. Şiddetli ketoasidoz gelişme riskini azaltmak için, hastalar günde en az kez 4 kez kan şekerlerini kontrol etmelidir (Lenhard ve Reeves, 2001). İnsülin pompa tedavisi ile kan şekeri ölçüm sayısı en az kalem insülin kullanımındaki kadar (günde en az 4-6 kez) sık olmalıdır (T.C. Sağlık Bakanlığı, 2020). Pompa kullanılarak sürekli insülin infüze edilen hastalarda kateter bölgesi her 2-3 günde bir değiştirilmelidir. Bu, deride enfeksiyon gelişme riskini azaltır. İnsülini subkutan yolla uygulama sırasında enjeksiyon yapılan bölgeler rote edilmelidir (Sayınalp, 2021). Kontakt dermatite yönelik olarak Aloa'lı krem, E vitamini, veya kortikosteroid yararlı olabilir. Kilo almayı önlemek için egzersiz yapılmalı ve kalori alımına dikkat edilmelidir, bu durum aynı zamanda gerekiyorsa kilo kaybını sağlayabilir (Lenhard ve Reeves, 2001). Pompa kullanılarak sürekli insülin infüze edilen hastaların asepsi ilkeleri konusunda eğitilmesi, ve tek kullanımlık kateterin kullanılması, enfeksiyon ve abse oluşumu engellenebilir (Tuncel, 2007). Hemşire hastayı bilgilendirmeli, hasta kontrole geldiğinde bu komplikasyonların gelişip gelişmediğini izlemeli (Mokta et al., 2013) ve bazı komplikasyonların belirtilerinin belirgin olmayabileceğini hatırlayarak hekimle ileri tetkik gerekip gerekmediği belirlenmelidir (Annersten ve Willman, 2005). Pompa kullanılarak sürekli insülin infüze edilen hastalarda diyabet ekibi insülin pompasının bilgisayarla bağlantısı yaptığı taktirde, kaydedilen veriler

gerektiğinde insülin pompa ayarlarını düzenlerken kullanılabilir (T.C. Sağlık Bakanlığı, 2020). Pompa kullanılarak sürekli insülin infüze edilen hastalarda cihaz arızalarında insülin kalemi tedavisine geçilip diyabet ekibi ve ilgili firma ile iletişime geçilmelidir (T.C. Sağlık Bakanlığı, 2020). Her yıl enjeksiyon bölgesinin rutin olarak lipodistrofi açısından muayene edilmelidir (Mokta et al., 2013). Lipohipertrofi riski açısından her gün doğru olarak saptanan enjeksiyon bölgeleri değiştirilmeli (Blanco ve ark., 2013; Mokta et al., 2013). Sağlık çalışanları diabetik bireyleri enjeksiyon yerlerini rote etmesi, doğru enjeksiyon tekniği, enjeksiyonların arasında iğne değiştirmesi veya enjeksiyon bölgelerini hypolipodistrofi varlığı açısından izlemesini öğretmelidir (Blanco ve ark., 2013) düzenli gözlem yapılmalı, subkutan enjeksiyon için kullanılan iğneler değiştirilmelidir (Demir ve ark., 2022). Lipohipertrofi sürekli aynı bölgeye enjeksiyon yapılması sonucu görülebildiği için, enjeksiyon bölgesini değiştirmek hem koruyucudur (Sayınalp, 2021) hem de lezyon tedavi edilir (Dinççağ, 2011). Lipoatrofi bir kez geliştiğinde, bölgenin kenarına insülin enjeksiyonu, deksametazonun insülinle birlikte uygulanması veya insülin uygulama şeklinin değiştirilmesi yarar sağlayabilir (Richardson ve Kerr, 2003).

SONUÇ: Sonuç olarak insülinin subkutan yolla verilmesi çeşitli komplikasyonlara yol açar ve bu komplikasyonlar hastalığın yönetimini ve prognozunu dolaylı olarak etkiler.

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EVALUATING THRESHOLD LEVEL UNCERTAINTY IN HYDROLOGICAL DROUGHT THROUGH THE STREAMFLOW DROUGHT INDEX (SDI)

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ABSTRACT

In monitoring drought events and characteristics, the literature reveals that standardized indices often employ specific threshold levels, such as 0, -0.5, -1.0, -1.5, and -2. Each of these thresholds corresponds to a certain probability level, statistically defined by the standard deviation of the index. In studies of meteorological drought, the -1.0 level is commonly used as the threshold between mild and moderate drought, often serving as the onset indicator of a drought event. For hydrological drought characterization, thresholds of -0.5 and -1.0 are typically preferred as the initiation levels. At the same time, in reservoir operations and water management, values of -1.5 and below are occasionally considered operational thresholds. Since hydrological processes exhibit delayed responses and vary considerably across regions, determining which threshold level to apply in hydrological drought studies is even more debatable. Moreover, the use of a single standardized threshold often proves misleading. The aim of this study is to evaluate statistically critical threshold levels from the perspective of water resources management and decision-support systems. For this purpose, the Streamflow Drought Index (SDI) was applied within the Konya Closed Basin at 6- and 12-month time scales, analyzing how thresholds of 0, -0.5, -1.0, -1.5, and -2.0 influence drought duration and intensity. This approach examines the extent to which threshold selection is critical for drought characteristics, under what conditions alternative thresholds are more appropriate, and in which cases a single standard threshold may lead to misinterpretation. The results demonstrate that threshold selection is crucial in identifying long-lasting and severe drought events. Findings highlight the necessity of using basin-specific, purpose-oriented calibrated thresholds in hydrological drought assessments. This study contributes to the systematic evaluation of threshold-related uncertainties in hydrological drought research, offering insights applicable to reservoir operations, irrigation planning, and early warning systems.

Keywords: Drought, Konya Closed Basin, SDI, Threshold Level Analysis, Water Resources Management, Hydrological Drought.

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CONTROVERSIES AND FACTS ABOUT DARK CHOCOLATE: QUO VADIS?

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ABSTRACT

Chocolate is one of the most attractive foods in the world, and many desserts involving chocolate as a versatile ingredient exist, such as ice creams, brownies, cakes, truffles, mousse, chocolate salami, and cookies. Statistics show that milk chocolate is a more common choice than dark chocolate due to its sweeter and creamier taste.

In recent decades, dark chocolate has gained increased interest for its potential health benefits and its classification as a potential functional food. However, there are some controversies related to dark chocolate and its therapeutic effects.

In this review, several aspects related to dark chocolate are presented and discussed as follows:

- *Antioxidant content and health benefits*

Dark chocolate contains flavonoids (catechin, epicatechin, and procyanidin) that act as antioxidants. These flavanols have been linked to several health benefits, such as: the synthesis of nitric oxide, which improves cardiovascular health, reduced risk of future cognitive decline, decreased inflammation, increased insulin sensitivity, diminished risk of skin cancer and improved skin health. One of the most important aspects highlighted in this article is related to flavanol content. The percentage of cocoa listed on chocolate packaging does not accurately reflect the amount of flavanols present. For this reason, the medical community advises shifting the focus from discussing the "darkness" of chocolate or its cocoa content to initiating a discussion about flavanol content.

- *Valuable source of minerals*

Dark chocolate is an excellent source of magnesium, iron, and manganese, and a good source of zinc and selenium.

- *Good source of fiber*

Dark chocolate, especially those with higher cocoa content, contains fiber, which is beneficial for gut health.

- *High in calories, fat, and sugar*

Dark chocolate is a high-calorie food (approximately 150–170 calories per ounce) and can contribute to weight gain if consumed in excess. It also contains saturated fats, which can raise cholesterol levels.

- *Heavy metal contamination*

Some dark chocolate products have been found to contain trace amounts of heavy metals such as cadmium and lead.

In recent years, to create a functional food with potential cholesterol-lowering effects, dark chocolate has been enriched with phytosterols (e.g., *ChocoNuvo™ 66% Cacao Mild Dark Chocolate*).

Keywords: flavanols, calories, heavy metal, cocoa.

EVALUATING THE TRENDS OF HYDROLOGICAL DROUGHT USING FREQUENCY INNOVATIVE TREND ANALYSIS METHODOLOGY (F-ITA) IN THE KONYA CLOSED BASIN, TÜRKİYE

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ABSTRACT

Analyzing drought trends is crucial for understanding the risks of long-term water scarcity, especially in arid and semi-arid regions such as the Konya Closed Basin in Türkiye. Although many statistical methods are used for trend analysis, most neglect the frequency of different drought categories, such as moderate, severe, and extreme drought. This study aims to apply the Frequency-Innovated Trend Analysis (F-ITA) method to the Streamflow Drought Index (SDI) to comprehensively assess hydrological drought trends during the study period. Most previous studies focused only on trend values (increase or decrease) using traditional methods such as Mann-Kendall, without considering the frequency of drought categories. This raises the research question: How can combining the frequency of drought categories with trend analysis improve our understanding of hydrological drought dynamics in closed basins? The study's main objective is to analyze the trend of hydrological drought with frequency using F-ITA within the Konya Closed Basin. The results showed that some stations showed an increase and some showed a decrease trend in SDI values. Still, there is an increasing trend in hydrological drought, particularly during the summer and fall seasons. The study highlights the importance of using F-ITA to detect hidden changes in drought patterns, providing deeper insights for decision-makers and policymakers in water resource management and climate change mitigation.

Keywords: Hydrological Drought, Konya Closed Basin, SDI, Trend Analysis, F-ITA, Water Resources Management.

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UNDERSTANDING THE DELICIOUS TASTE, FLAVOR AND DANGER BEHIND THE BARBECUE - A SIMPLE LESSON OF ORGANIC CHEMISTRY IN DAILY LIFE

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ABSTRACT

Organic chemistry is often perceived as a difficult subject by students. One of the most common complaints from students is that organic chemistry does not seem to have any connection, at least at first glance, to the real world. For the majority of students, organic chemistry appears to lack relevance to their everyday lives.

The aim of the present paper is to discuss the chemistry behind barbecuing and explain how some knowledge of organic chemistry can be useful in understanding and minimizing the dangers associated with this type of food preparation. The paper explains how Maillard reactions are responsible for the delicious taste and aroma of barbecue. However, barbecuing can pose health risks due to the myriad of chemical reactions that lead to the formation of hazardous compounds, as detailed below:

- *Heterocyclic Amines (HCAs)*

HCAs are synthesized from creatinine, amino acids, and carbohydrates when heated to temperatures between 125°C and 300°C. Recent studies confirm a causal relationship between the consumption of these heterocyclic amines and the incidence of colon, rectal, prostate, and pancreatic cancers.

- *Polycyclic Aromatic Hydrocarbons (PAHs)*

PAHs are formed from fats, proteins, carbohydrates, or compounds with a steroid structure (such as cholesterol) when heated to temperatures above 500°C. Many PAHs have been shown to possess mutagenic, carcinogenic, and teratogenic properties, making the ingestion of these substances potentially dangerous.

- *N-nitroso compounds*

Nitrites, which are commonly used as preservatives in cured meats, are a major source of N-nitroso compounds. Under thermal treatments such as grilling, roasting, or frying, the formation of hazardous nitrosamines can increase up to threefold.

The paper also lists several tricks to limit the formation of toxic compounds during the preparation of meat on the grill, including: a) preventing direct contact between the meat and the open flame; b) using a lower processing temperature; c) using harder wood to make the fire; d) using aluminum foil with small perforations to prevent fat from dripping directly into the flame (this avoids the formation of larger quantities of toxic compounds); e) using meat with a low-fat content; f) marinating the meat beforehand with various spices.

Keywords: heterocyclic amines, aromatic hydrocarbons, Maillard reaction.

UNDERSTANDING BRONSTED ACIDS AND BASES: BEYOND OF FIELD AND RESONANCE EFFECTS

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ABSTRACT

Brønsted acids and bases are key concepts in organic chemistry and are of paramount importance in predicting the reactivity of molecules in various circumstances, elucidating reaction mechanisms, facilitating organic synthesis, and understanding several concepts in biochemistry. When discussing the strength of acids and bases, two primary concepts are most often invoked: field effects and resonance.

Generally speaking, electron-donating groups that act through field effects increase basicity, while electron-withdrawing groups have the opposite effect. Resonance effects produce similar results as field effects.

The aim of this paper is to discuss some additional subtle effects that influence the strength of Brønsted acids and bases, as follows:

- *Steric effects*

The proton itself is small, and direct steric hindrance in proton transfer is unlikely. However, steric effects indirectly influence acid-base properties by altering resonance. Steric effects are also responsible for the unusually high basicity of 1,8-bis(dimethylamino)naphthalene, commonly known as the "proton sponge."

- *Hydrogen bonding*

Internal hydrogen bonding can significantly influence the acidity or basicity of various compounds.

- *Differential Solvation*

Solvents, such as water, can drastically alter acid-base properties through differential hydration. For example, the acidity of simple alcohols such as ethanol, isopropanol, and tert-butanol is completely reversed in aqueous solution compared to the gas phase.

- *Temperature*

  Temperature has a significant effect on acid-base properties.

- *Hybridization*

  The type of hybridization explains the relatively increased acidity of compounds such as hydrogen cyanide (HCN) and acetylene.

- *Statistical Effects*

  Statistical factors can also contribute to the observed acid-base behavior in certain cases.

All these effects are illustrated and clarified through a variety of specific examples. Based on relevant examples and analyses, the paper highlights that a common request from teachers—to arrange organic acids or bases in order of increasing acidity or basicity—can be very challenging. Inexperienced students often lack the background necessary to identify the predominant factors contributing to the acidity or basicity of a given compound.

Keywords: steric effects, hydrogen bond, solvation, temperature.

INORGANIC COMPOUNDS FROM WHO'LIST OF ESSENTIAL MEDICINES: A REVIEW

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ABSTRACT

The World Health Organization (WHO) Model List of Essential Medicines, first published in 1977, is a list that includes medications considered to be the most effective and safe for a basic healthcare system. It is frequently used by countries to help develop their own lists, prioritizing medicines based on evidence of effectiveness, public health relevance, safety, and cost-effectiveness. Most medicines on the WHO's essential list are organic compounds, ranging from small molecules to larger biological molecules such as enzymes. Many of these molecules are derived from natural sources or are inspired by natural compounds, but they are synthesized and modified by organic chemists to enhance their effectiveness and safety.

However, several inorganic compounds are also crucial for human health and are included in lists of essential medicines or nutrients. These essential inorganic compounds often include solid elements, minerals, gases, platinum-based complexes, and electrolytes. Examples include: potassium ferric hexacyanoferrate (II) - $2H_2O$ (Prussian blue), sodium thiosulfate, magnesium sulfate, potassium iodide (KI), arsenic trioxide, iron sulfate, selenium sulfide, potassium permanganate, calamine, coal tar, precipitated sulfur, barium sulfate, chlorine-based compounds, zinc sulfate, sodium selenite, cupric oxide (as a component of multiple micronutrient supplements), lithium carbonate, cisplatin, potassium chloride, oxygen, nitrous oxide, iodine, sodium hydrogen carbonate, glass ionomer cement (containing 25–50% silicate and 20–40% aluminum oxide). It is important to note that this list includes common substances, such as iron sulfate, which can be found in any student laboratory, as well as dangerous substances and real poisons, such as arsenic trioxide (As_2O_3).

For all the above-mentioned compounds, their structure, mechanism of action, formulation, and therapeutic indications are presented.

Keywords: inorganic compounds, safety, effectiveness, essential medicines.

WORK-LIFE BALANCE ISSUES EXPERIENCED BY REMOTE WORKERS DURING THE COVID-19 PANDEMIC

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ABSTRACT

The Covid-19 epidemic, which emerged in Wuhan, the capital of China's Hubei region, in 2019 and spread throughout the world in a short time, was declared a pandemic by the World Health Organization in March 2020. The pandemic had an impact all over the world until May 2022. With the measures taken during this period and intensive vaccination, it lost its impact, although it did not completely disappear. During the pandemic period, countries around the world implemented quarantine and lockdown measures after it was understood that the epidemic was spreading through human-to-human contact and air. These measures have begun to have negative effects on the functioning of national economies. In order to eliminate the effects on economies and reduce the damage, countries have switched to a remote working model in their labor markets. In the labor market, especially in the service sector, jobs have started to be done remotely. Advanced technological products have contributed to the implementation of this model. During this period, due to the pandemic, a type of remote working model, working from home, has been implemented. n this way, it was aimed to prevent the spread of the epidemic. Especially in developed countries, remote working rates in labor markets increased to 35% during these periods. This practice was applied all over the world, albeit at different rates. It is referred to as a great remote working experiment. At the end of this experiment, a very wide knowledge about the model has been formed. The transition from standard work activities to a previously unexperienced working model has created some challenges for employees. The effort to achieve work-life balance and to define the boundaries between the two has become a part of the employees' agenda. Standard (in-office) work carried out within a certain routine makes it easier for people who are used to it to maintain work-life balance. However, when the health problems caused by the pandemic are added to the isolation, employees working remotely from home are having difficulty maintaining a work-life balance. Especially married employees with children and parents have started to mix work and private life. Our study addresses the work-life balance problems experienced by employees who were forced to work remotely from home for the first time due to the pandemic.

Keyword: Covid-19, Remote Work, Standard Work, Work Life Balance

AI-DRIVEN DRUG DISCOVERY AND COMPUTATIONAL MODELING TO TARGET SDHB/SDHD MUTATIONS LINKED TO CANCER AND RARE DISORDERS

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ABSTRACT

Mutations in *SDHB* and *SDHD*, essential components of the succinate dehydrogenase (SDH) complex, drive tumorigenesis in pheochromocytomas, paragangliomas, renal cell carcinoma, and gastrointestinal stromal tumors. These mutations impair mitochondrial function, leading to succinate accumulation, metabolic dysregulation, and epigenetic reprogramming. Succinate acts as an oncometabolite, inhibiting prolyl hydroxylase enzymes (PHDs), which stabilizes hypoxia-inducible factors (HIFs) and induces a pseudohypoxic state that promotes malignancy. Additionally, succinate inhibits DNA and histone demethylases, altering gene expression and driving tumor progression. This study focuses on drug discovery strategies to target SDH-deficient tumors through precision medicine. Therapeutic approaches include HIF-2α inhibitors (e.g., belzutifan) to counteract hypoxia-driven oncogenesis, metabolic modulators (e.g., metformin, mitochondrial inhibitors) to restore metabolic balance, and epigenetic drugs (e.g., DNA methyltransferase and histone deacetylase inhibitors) to reverse transcriptional dysregulation. Furthermore, immunotherapy is emerging as a promising avenue for enhancing anti-tumor responses in SDH-mutant cancers. Advancements in AI-driven drug discovery, multi-omics profiling, and high-throughput screening are accelerating the identification of novel small molecules tailored to SDH-deficient malignancies. Computational modeling and machine learning-based approaches facilitate the design of targeted therapies that selectively exploit metabolic vulnerabilities.

This research underscores the importance of translational oncology in bridging fundamental discoveries with clinical applications. The development of precision-targeted therapeutics holds immense potential to improve patient outcomes, particularly in rare and aggressive malignancies. By integrating innovative drug discovery methodologies, this work aims to drive the next generation of therapies for SDH-deficient cancers, offering personalized treatment strategies for enhanced efficacy and clinical success.

Keywords: SDH-deficient tumors, Drug discovery, Precision medicine, Metabolic reprogramming, HIF stabilization, Epigenetic therapy.

PEDAGOGICAL ANALYSIS OF REFORMS IN THE HIGHER MILITARY EDUCATION SYSTEM IN AZERBAIJAN

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ABSTRACT

The rapid changes taking place in the field of military security in the modern era and the changing geopolitical balance in the region necessitate the constant improvement of the structure and level of training of the Azerbaijani Armed Forces. In this context, the higher military education system is of particular importance. In order to train officers with high intellectual and professional skills, the army needs not only technical knowledge, but also flexible individuals with leadership skills formed through the application of modern pedagogical approaches.

In recent years, significant structural and methodological reforms have been implemented in the higher military education system in Azerbaijan. This article analyzes these reforms from a pedagogical perspective. The main emphasis is on updating teaching methods, changing the content of the curriculum, introducing simulation technologies, creating a student-oriented learning environment, and strengthening teacher training. At the same time, the development of social skills such as leadership, ethical behavior, and psychological resilience is also taken into account in the educational process.

The updated higher military education model applies interactive methods (problem-based learning, group work, simulation exercises, and analysis of combat scenarios) to develop students' analytical thinking and decision-making skills. These methods replace the traditional lecture format with more practical and participatory approaches. At the same time, curricula adapted to NATO and other international military education standards aim to train future military leaders with competencies based on international experience.

The analysis shows that curriculum reforms have made the higher military education system more flexible and dynamic, strengthening not only the technical, but also the moral and strategic aspects of military training. Also, the introduction of modern technologies, including electronic educational platforms and simulation tools, in the educational process has led to a qualitative change in officer training.

As a result, the reforms implemented in higher military education in Azerbaijan are not limited to structural changes, but also have a significant impact on the quality of education, the training process and the effectiveness of officer training from a pedagogical point of view. The sustainability of this process and its development in accordance with international standards will play a decisive role in the formation of the next generation of leaders of the Azerbaijani Army.

Keywords: Higher military education, pedagogical reform, curriculum, training methods, officer training, simulation, leadership

INTRODUCTION

Modern security challenges and geopolitical processes in the region have necessitated the introduction of new approaches in the field of defense and army building by the Republic of Azerbaijan. The preparation of educated, professional personnel with leadership and strategic thinking skills for the army

is directly related not only to military technical training, but also to a strong and dynamic higher military education system. In recent years, Azerbaijan has implemented serious reforms in the higher military education system, the purpose of which was to increase the professionalism of the officer corps and adapt the educational process to modern requirements. This article analyzes the reforms carried out in the higher military education system in Azerbaijan from a pedagogical perspective. The main topic of discussion is how the reforms are evaluated in the context of teaching methodology, curriculum content, pedagogical technologies applied in the educational process, and teacher-student relations.

METHOD

The first significant reforms in the field of higher military education in the Republic of Azerbaijan began to be implemented in the early 2000s. Within the framework of these reforms, the Heydar Aliyev Higher Military School of Azerbaijan was reorganized, new educational programs were developed, and the training and teaching base was strengthened. Also, the Azerbaijan Military Academy, established in 2022, constitutes the highest stage of officer training.

In the new structural models, pedagogical foundations, in particular the application of curricula based on learning outcomes and the creation of educational modules in accordance with NATO standards, were in the spotlight (Guliyev, 2021). These approaches are based on a student-oriented, practice-oriented, and goal-based educational philosophy. In contrast to the traditional military training system, this system prioritizes the development of students' analytical and situational decision-making skills.

The classical lecture and command-centered teaching methods applied in higher military educational institutions have gradually given way to interactive, activity-based learning methods. Within the framework of the reforms, simulation technologies, electronic learning platforms, group work and problem-based learning methods are widely used (Hajizadeh, 2022).

Modern military pedagogy emphasizes the development of the student not only as a recipient of knowledge, but also as an active learner, decision-maker and person who applies leadership skills. In this sense, the application of "role-playing" techniques in command training lessons, modeling of combat scenarios in the classroom environment and real-time analysis develop both technical and moral decision-making skills of students (Aliyev, 2023).

In addition, the pedagogical skills of the teaching staff should be constantly improved, and their adaptation to modern teaching methods should be ensured through methodological training. Although the "Training of Trainers" programs currently designed for military teachers partially meet this need, there is a need to implement more systematic and international experience-based courses.

Adapting the curriculum to modern challenges in higher military education is one of the main directions of the reforms. In addition to military-strategic disciplines, new curriculum models also devote a large amount of space to areas such as ethical leadership, psychological resilience, information security, and foreign languages. This integrative approach aims to shape future officers as leaders armed not only with technical knowledge, but also with social and moral values (UNESCO, 2018). At the same time, the curriculum requires the application of flexible and adaptive content. For example, the inclusion of real combat experiences in the curriculum, the analytical analysis of the Second Karabakh War and the use of its conclusions as teaching material ensure that students have a deeper approach to national security issues (Ministry of Defense of the Republic of Azerbaijan, 2021).

RECOMMENDATIONS

The reforms carried out in the higher military education system in Azerbaijan are commendable from a pedagogical point of view and correspond to the officer profile required by the modern era. Pedagogical analysis shows that structural changes, renewal of teaching methods and modernization of curricula have a positive impact on the quality of officer training.

However, there are also challenges ahead in this area: issues such as ensuring continuous development in teacher training, systematic integration of international experience and adaptation of new technologies to the educational process require additional measures. Only in these cases can the higher military education system become an effective support for a long-term security strategy.

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DIAGNOSIS OF PHENOLS AND ANTIOXIDANT ACTIVITY OF LEAVES IN SOME IRAQI MYRTACEAE'S GENERA BY HPLC

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ABSTRACT

Measurement of phenols and antioxidants activity were studied in this research, and the results showed the plants share Gallic acid, the highest concentration was in *Eucalyptus obliqua* was 692.929 µg/ml, *Melaleuca viminalis* plant contained nine phenolic compounds, the most compound which was Salicylic acid with 862.309 µg/ml a concentration, as it reached presence of a Catechol compound the lowest concentration was156.579 µg/ml, The *Eucalyptus obliqua* plant contained the lowest number of phenolic compounds there were eight, two of them shared with the rest of the plants, It was also distinguished by containing a compound Eucalptone that had the highest concentration was 1020.201µg/ml, while the Ferulic acid achieved the lowest concentration was104.835 µg/ml, distinguished *Myrtus communis* by superior to the presence of 11 phenolic compounds whose ratio ranged between Mericetin-3-O-rabinoside and Gallic acid, which recorded 1058.94 µg/ml, 60.525 µg/ml concentration respectively, and the rest of the compounds graded between these two limits. It is worth noting that eight compounds are characterized in the *Myrtus communis* plant that was not found in other plants, and this is an important chemical taxonomic isolation characteristic. Results showed that the scavenging activity by the DPPH technique in *Myrtus communis* extract at 200 µg/ml and above was 96.36 µg/ml compared to ascorbic acid. This result indicates that superior extract is an effective antioxidant. The results have drawn attention and give clear data on chemical classification to isolate genera. This paper aims to present the current situation to fill the gap, and a more understanding of some Iraqi plants and provide pharmaceutical and food health information.

Key words: phenols, antioxidant activity, Myrtaceae family, *Melaleuca viminalis*, *Eucalyptus obliqua*, and *Myrtus communis.*

INTRODUCTION

According to statistics, the Myrtaceae family is considered one of the woody flowering plants that occupy around 17 families' biodiversity within 144 genera and are classified as 5500 species. Myrtaceae family members are scattered in huge areas of Europe, Northern Africa, and Asia, particularly in the Mediterranean region and east and western Asia (Hennia *et al.*, 2018).

Melaleuca viminalis, also the old name referred to as *Callistemon viminalis* sometimes counts as a synonym of Melaleuca and it is commonly referred to as bottle brush due to its flower's cylindrical like traditional brush bottle (Dhiman *et al.*, 2012). *Melaleuca viminalis* is an important medicinal plant, commonly used for traditional healing like anticough diarrhea, gastroenteritis treatment, respiratory ills, skin infections, and stomachaches(Afrah, 2012) moreover is widely used in ornamental gardening (Salem *et al.*, 2013). Ghasemi *et al.*, (2014) reported that *Melaleuca viminalis* provides effective control of *Ephestia kuehniella* by exerting negative effects on its immune cells causing it to have antioxidant

activity. Over the years, many papers have indicated and analyzed scientifically that *Melaleuca viminalis* is a source of bioactive compounds with several medicinal characteristics (Gupta *et al.*,1997; Kumar *et al.,* 2007; Kim *et al.,* 2009; Firoz *et al.,* 2011; Dhiman *et al.,* 2012).

The genus *Eucalyptus* genus contains about 700 species, among them; more than 300 contain bioactive compounds in their leaves (Kesharwani *et al.,* 2018). Many *Eucalyptus* species are used in the cosmetics, food industries, pharmaceuticals, and toiletries (Marzoug *et al.,* 2011). Various species of *Eucalyptus* are cultivated, particularly in semi-tropical and tropical regions. *Eucalyptus obliqua* has a long history of folk usage because of its rich medicinal value. The plant has been reported to possess potent antiseptic, astringent, deodorant, diaphoretic, expectorant, inhalant, insect repellant, and suppurative (Javaid *et al.,* 2012)

Myrtus communis is endemic in Iraq and is described as a medicinal plant with strong antibacterial, anti-inflammatory, disinfectant drug, hypoglycemic agent, anti-hyperglycemic, and antioxidant activities (Vasconcelos *et al.,* 2017). Traditional methods of the local culture are a major public health system of healing common colds, hemorrhoids, lower blood glucose, past kidney stones, and wound healers. Despite its antimicrobial uses, the treatment of skin diseases causes microorganisms (Bouzabata *et al.,* 2016). Alkaltham *et al.,* (2021) inferred that dried myrtle fruit is a good source of antioxidant and phenolic compounds. Myrtle fruit can be effectively used for the recovery of bioactive compounds that have useful functional properties and can be employed in the development of functional foods and nutrients.

Chemotaxonomy data may provide reliable evidence to other lines such as morphological and anatomical studies, it can give us a solid foundation for a taxonomic decision and can be a good chemotaxonomy tool to solve morphological problems, and it has been possible to diagnose and serve as a classifying tool to separation species and taxa (Al-Anbari *et al.,* 2017).

The abiotic and biotic ingredients may change or modify gradually or straighten the plant growth and production giving rise to changes of secondary metabolism and change of secondary compounds concentration. Secondary metabolism plays a remarkable part in the adaptation of plants to the environment and overcoming stress conditions. (Russo et al, 2015). High amounts of polyphenols which act as potent antioxidants (Alkaltham *et al.,* 2021). The present review will focus on the phenols compounds and antioxidant and anti-activity in some Myrtaceae family genera.

MATERIAL AND METHOD

1. Sample Preparation

Fully-expanded leaves of *Melaleuca viminalis* (Sol. ex Gaertn.) Byrnes, *Eucalyptus obliqua* L'Hér. 1789, *and Myrtus communis* L. (Fig.1) were collected from one-year-old plants grown in containers and supplied twice a week during September. The main vein was excised from the leaf lamina and the tissue was rapidly quenched in liquid nitrogen and stored at 4ºC before proceeding with the analysis. A pestle under liquid nitrogen the leaf material was then ground in a mortar.

2. Extraction and Purification Procedures

The leaf tissue (1-2 g) was extracted with 4 x 80 mL of 70 % EtOH. The raw ethanolic extract was then concentrated under a vacuum (Rotavapor 144R, Btchi, Switzerland) and rinsed with ultrapure water (Milli Q System, Waters Co., Milford, MA, USA) to reach a final volume of 100 ml. The solution was then extracted with 4 x 50 mL n-hexane to completely remove lipophilic compounds. The ethanolic extract was concentrated under reduced pressure and rinsed with water (pH 2 by HCOOH) to 10 mL final volume, the protocol previously reported by Romani *et al.,* (1999). According to Obouayeba *et al.,* (2014) the result from 1g of dry leaves samples which were crushed into small pieces in pastel-

mortar followed by suspending fine-crushed samples into 200 ml of HPLC grade methanol and deionized water (80:20mv/v), the sample were shaking, the extraction of phenolic compounds were subjected to ultra-sonication (Branson sonifier, USA) at 60 % duty cycles for 25 min at 25oC followed by centrifugation at 7,500 rpm for 15 mins. The clear supernatant of each sample was subjected to evaporation under vacuum (BuchiRotavapor Re Type). The produced dried samples were re-suspended in 1ml HPLC grade methanol by vortexing, the mixture was passed through a 2.5 µm disposable filter, the extract was tightly closed and stored in the dark at 4oC for further analysis, then20 µl of the sample was injected into HPLC system according to the optimum separation condition.**3-HPLC**

3. Separation of phenolic compounds from plant extract

The main compounds were separated on the FLC (Fast Liquid Chromatographic) column under the optimum condition. Column: nucludar C18-DB, 3um particle size (50 x 2.0 mm I.D) column, Mobile phase: linear-gradient of, solvent A 0.05% trifluoro acetic acid (TFA acid) in deionized water: solvent B was 0.05% TFA in methanol, PH, 2.5. Linear Gradient program from 0%B to 100%B for 18 minutes Flow rate 1.0 ml/min. Detection: UV at 280 nm. The Calculation was the Concentration of sample=Area of sample ug/ml / Area of standard x conc. of standard x dilution Factor. The separation occurred on liquid chromatography Shimadzu 10 AV-LC equipped with binary delivery pump model LC-10A shimadzu, the eluted peaks were monitored by UV-Vis 10 A- SPD spectrophotometer. All chemicals used were at least analytical grade, trifluoroacetic acid, and phenolic acids standards were purchased from Sigma-Aldrich (Steinheim, Germany).

4. Antioxidant Activity

The radical scavenging activity of isolated extract from plant leaves depends on its capacity to scavenge DPPH free radicals. The 2,2- Diphenyl-1-picryl-hydrazyl (DPPH) radical scavenging activity was evaluated according to the method described by Thai pong *et al.,* (2006) with some modifications. A total of 2.62 mg of DPPH was dissolved in 50 mL methanol and 7 concentrations of dry plant extract (2.5-300 ug/mL) were prepared. Then 1 mL of each concentration of plant extract was added to 1 mL of DPPH solution, agitated and maintained for 30 min at room temperature in the dark. The absorbance was measured at 517 nm using a UV-visible spectrometer (Shimaduz UV-1605, Japan). The DPPH scavenging capacity was calculated from the following equation: DPPH scavenging ability (%)[(Absorbance of control- Absorbance of sample)/Absorbance of control] x 100. Ascorbic acid was used as a reference positive control according to the above method. Each value represents the average of three independent experiments.

RESULTS AND DISCUSSION

- **Identification and Quantitation of phenols compounds**

The Gallic acid compound participated presences in all plants under study, the highest concentration was in *Eucalyptus obliqua* 692.929 µg/ml but it achieved the lowest percentage in *Myrtus communis* 60.525 µg/ml, as the Ellagic acid compound was present in each of *Melaleuca viminalis* and *Myrtus communis*, while the Rutin compound recorded presence in *Eucalyptus obliqua* and *Myrtus communis*. This outcome agree with Aldrwesh and Al-Anbari (2021)

From the tables, it is clear that *Myrtus communis* has been superior to the presence of 11 phenolic compounds, whose ratio ranged between Mericetin-3-O-rabinoside and Gallic acid, which recorded 1058.94 µg/ml, 60.525 µg/ml concentrations respectively, and the rest of the compounds graded between these two limits. Martin *et al.,* (1990) studied the polyphenols in *Myrtus communis* and they showed an important contribution of myricetin, hesperidin, and esculin to the composition. In 1999 Romani et al. reported there are three main phenolic compounds in *Myrtus communis* extracted from leaves, antioxidant stability and activity were high observed in myrtle after a storage period of three

months (Montoro *et al.,* 2006). It is worth noting that eight compounds are characterized in the *Myrtus communis* plant that were not found in other plants, and this is an important chemical taxonomic isolation characteristic.

A *Melaleuca viminalis* plant contained nine phenolic compounds, the most compound which was Salicylic acid with 862.309 µg/ml a concentration, as it reached the presence of a Catechol compound the lowest concentration was156.579 µg/ml, the *Melaleuca viminalis* separate from its peers by containing seven unique compounds. This result indicates that using methanol alone was efficient for extracting polyphenols from Callistemon leaf extract. Our findings agree with Fayemi *et al.,* (2019) which confirm the suitability of phenolic extraction.

The *Eucalyptus obliqua* contained the lowest number of phenolic compounds there were eight, two of them shared with the rest of the plants, but it was isolated by the presence of 6 compounds, It was also distinguished by containing a compound Eucalptone had the highest concentration was 1020.201µg/ml, while the Ferulic acid achieved the lowest concentration was104.835 µg/ml, the rest of the compounds were graded between these two limits. Our phenols do not agree with Conde *et al.,* (1996) and Eyles *et al.,* (2003) who found myricetin 3-O-rhamnoside, quercetin 3-glucoside, quercetin 3-glucuronide but the ellagic acid is the main compound present in the extract. Indeed, all these compounds typically occur in the bark, leaves, or needles of *Eucalyptus obliqua* and have demonstrated antioxidant capacity (Moure *et al.,* 2001; Xavier *et al.,* 2017).

In the literature, Barboni *et al.,* (2010) showed that the geoclimatic factors and genetic and/or environmental factors could be considered to affect the quantitative composition of plant extracts and irrigation affected the concentration of many compounds, plant part localization as well as the extraction method (Bouaoudia-Madi *et al.,* 2017). Phenolic acid, polyphenolic compounds, and simple phenol derivatives are present in many plant sources and can act as natural antioxidants for various uses (Moure *et al.,* 2001). Many researchers have reported the presence of low molecular weight phenolics compounds with demonstrated antioxidant capacity (gallic, ellagic, sinapic, syringilic, and vainillic acids) in different parts of plants, especially in eucalyptus species (Conde *et al.,* 1996, Eyles *et al.,* 2003).

Results showed (table 4) that the scavenging activity of *Melaleuca viminalis* extract even at 300 µg/ml is lower than that of ascorbic acid reference antioxidant, but it increases with concentration, while the scavenging activity of *Eucalyptus obliqua* and *Myrtus communis* extract at 50 µg/mL is lower than that of ascorbic acid were 81.33 and 84.52 µg/ml sequentially but it became almost the same for both compounds at 200 µg/ml and above were 95.95 and 96.36 µg/ml sequentially. These results indicate that extract is an effective antioxidant compared to ascorbic acid. This outcome agrees with Bouaoudia-Madi *et al.,* (2017) who pointed out that the efficient process of antioxidant activity depended on plant part localization as well as the extraction method.

Fundamentally, Differences in antioxidant activity can be attributed not only to the amounts of phenols but also to their structures, according to the authors, nevertheless, no study was performed by them to clarify this statement (Snoussi *et al.,* 2021). Our finding is in harmony with Alkaltham *et al.,* (2021) that confirmed Myrtle fruit can be effectively used for the recovery of bioactive compounds which play an important role in functional qualities and can be utilized in the development of functional foods and nutrients.

CONCLUSION

This chemotaxonomy study demonstrates the variation of phenols in plants by HPLC, and it was shown that Myrtle's leaves extract contains more percentages and therefore can reduce free radicals more efficiently than the rest of the plants under study measured bythe DPPH technique.

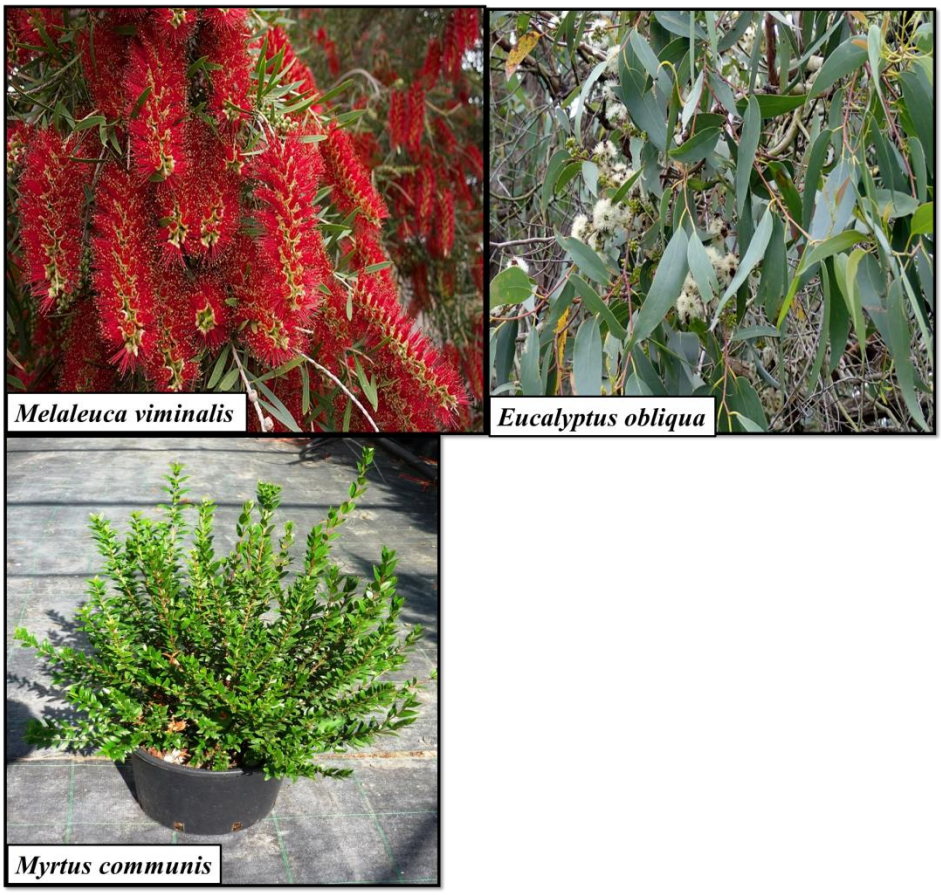


Figure 1: the form of the plant under study.

TABLE 1. The phenolic compounds from *Melaleuca viminalis* plant

Se q	Subjects	Retention time	Area uv	Concentration 10 ug/ml each
1	Betalinic acid	10.82	58168	288.612
2	Catechol	4.32	56820	156.579
3	Cinnamic acid	10.01	47202	295.284
4	Coumaric acid	6.42	53711	165.643
5	Ellagic acid	2.74	68136	236.675
6	Ferulic acid	5.50	44787	359.149
7	Gallic acid	1.85	5047	404.694
8	Salicylic acid	7.77	57594	862.309
9	Urosolic acid	8.66	56376	331.517

TABLE 2. The phenolic compounds from *Eucalyptus obliqua* plant

Se q	Subjects	Retention time	Area uv	Concentration 10 ug/ml
1	Caffeic acid	4.58	67159	635.136
2	Chlorogenic acid	7.74	59354	750.037
3	Eucalptone	8.83	60323	1020.201
4	Ferulic acid	5.67	65034	104.835
5	Gallic acid	3.0	91117	692.929
6	Genistic acid	6.75	71573	758.498
7	Rutin	10.19	65104	759.273
8	Tannic acid	1.99	68130	542.700

TABLE 3. The phenolic compounds from *Myrtus communis* plant

Se q	Subjects	Retention time	Area uv	Concentration 10 ug/ml
1	Catechin	4.55	139970	175.65
2	Ellagic acid	2.60	137389	82.39
3	Epicallocatechin	6.70	122882	669.12
4	Epicatechine-3-gallate	5.44	120893	136.72
5	Gallic acid	1.68	151026	60.525
6	Kaemperol	13.86	125763	521.25
7	Merecetin	11.76	239012	288.36
8	Mericetin-3-O-calactoside	7.80	143880	1001.13
9	Mericetin-3-O-rabinoside	9.19	150672	1058.94
10	Quercetin	12.64	195516	241.365
11	Rutin	14.67	140262	275.840

TABLE 4. Calculated DPPH radical scavenging activity % of plants extracted at different concentration compared with ascorbic acid.

Compounds	Concentration µg/ml								
	0.0	2.5	5.0	10.0	25	50	100	200	300
C. viminalis	0.0	11.67	27.0	33.57	41.6	53.35	67.15	72.26	81.75
E. sp.	0.0	31.37	37.90	55.29	68.62	81.33	95.42	95.95	95.95
M. communis	0.0	31.44	35.50	47.93	68.55	84.52	94.32	96.36	96.36
Ascorbic acid	0.0	42.70	68.22	90.10	95.83	96.01	96.01	96.01	96.01

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BİLGİ ÇAĞINDA HABERCİLİĞİN DÖNÜŞÜMÜ: SÜRÜKLEYİCİ GAZETECİLİK ÖRNEĞİ

THE TRANSFORMATION OF JOURNALISM IN THE INFORMATION AGE: THE CASE OF IMMERSIVE JOURNALISM

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ÖZET

Endüstri toplumundan bilgi toplumuna geçiş sürecinde yaşanan yenilikler, toplumların hızla entegrasyonlarına neden olmuştur. Aynı paralelde gazeteciliğin değişim ve dönüşümü matbaanın bulunuşundan bu yana büyük bir hızla gelişen teknolojiye bağlı olarak bilgisayarların devreye girmesiyle okurların ilgilerindeki değişiklikleri de beraberinde getirmiştir. Sonunda sayısal bilginin elektronik ortamlara aktarılmasıyla çok daha önemli değişimler yaşanmaya başlamıştır.

Dijital devrim, dünyanın her yerinde olduğu gibi Türkiye'de de gazeteciliğin yeniden gözden geçirilmesine, haber üretim ve toplama süreçleri, haberlerin sunumu ve tüketimi gibi tüm aşamaların değişim ve dönüşümlerine neden olmuştur. Bireylerin bilgi kaynakları artık basılıdan dijitale evrilmiştir. Teknolojinin bu hızlı değişimi haberciliğin ve okur profillerinin değişimine neden olmuştur. Gazeteciler de bu değişimlere ayak uydurarak, içerik üretimi ve tüketimi süreci boyunca yeni nesil gazetecilik türleri olarak veri gazeteciliği, robot gazetecilik, drone gazeteciliği, sanal gerçeklik gazeteciliği, artırılmış gerçeklik gazeteciliği, blokzincir gazeteciliği ve sürükleyici gazetecilik gibi yeni boyutlarıyla mesleklerini yürütmüşlerdir. Sürükleyici gazetecilik, haber raporlarında ve belgesel filmlerde anlatılan olayların veya durumların birinci şahıslar tarafından deneyimlenmesini sağlayan, 3D oyun ve sürükleyici teknolojileri kullanan, sanal gerçeklik teknolojileri ve 360 derece video kullanarak birinci şahıs deneyimleri yaratan ve izleyicileri olayların içine sürükleyip deneyimlemelerini sağlayan bir gazetecilik üretim biçimidir. Çalışmanın amacı, bilgi çağını yaşadığımız bu dönemde yazılı basında, iletişim teknolojilerinde devrim niteliğinde yaşanan yeniliklere entegre olarak yaşanan değişimlerin bir sonucu olarak gelişen sürükleyici gazeteciliği literatür tarama yöntemi kullanarak incelemektir.

Anahtar Kelimeler: Sürükleyici gazetecilik, bilgi çağı, dijital devrim, yeni nesil gazetecilik

ÖZET

The innovations experienced in the process of transition from the industrial society to the information society have led to the rapid integration of societies. In parallel, the change and transformation of

journalism has brought about changes in the interests of readers with the introduction of computers due to the technology that has developed rapidly since the invention of the printing press. Finally, with the transfer of digital information to electronic media, much more significant changes have begun to take place.

The digital revolution has led to a rethinking of journalism in Turkey, as it has everywhere else in the world, and to changes and transformations in all stages such as news production and gathering processes, presentation and consumption of news. Individuals' sources of information have now evolved from print to digital. This rapid change in technology has led to changes in journalism and reader profiles. Journalists have kept pace with these changes and practiced their profession with new dimensions such as data journalism, robot journalism, drone journalism, virtual reality journalism, augmented reality journalism, blockchain journalism and immersive journalism as new generation journalism types throughout the content production and consumption process. Immersive journalism is a form of journalism production that enables first-person experiences of events or situations described in news reports and documentary films, using 3D gaming and immersive technologies, creating first-person experiences using virtual reality technologies and 360-degree video, and immersing the audience in the events and allowing them to experience them. The aim of the study is to examine immersive journalism, which has developed as a result of the changes in print media as a result of the changes integrated with the revolutionary innovations in communication technologies in this period when we live in the information age, using the literature review method.

Keywords: Immersive journalism, information age, digital revolution, new generation journalism

INFLUENCE OF NAOH and Na_2SiO_3 ACTIVATOR SYSTEMS ON 3D PRINTABILITY OF FLY ASH-SLAG BASED GEOPOLYMER MORTARS

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ABSTRACT

The development of sustainable and printable construction materials is essential for progress and is gaining significance in three-dimensional (3D) printing and additive manufacturing. Geopolymer mortars and concrete produced from fly ash and slag byproducts are extensively employed and offer a low-carbon substitute for traditional Portland cement-based materials. This preliminary study investigates the pumpability and extrudability of fly ash and slag-based geopolymer mortars for 3D printing, focusing on the impact of varying dosages and compositions of alkali activators. Alkali activator dosages of 8%, 10%, and 12% of binder mass using liquid and solid forms of Na_2SiO_3 and NaOH were evaluated on the geopolymer mortars with FA/GGBS ratio of 1:1, sand-to-binder ratio of 1:1.5, and water-to-binder ratio of 0.3. All materials were locally sourced in Turkey. Experimental tests included workability by flow table test, open time, setting time, pumpability through screw-driven extrusion, extrudability, shape retention, buildability (up to 2 layers), and visual inspection. Results showed that workability for all mixes ranged between 135–230 mm. Open time and setting times were influenced by both the type and concentration of the alkali activator. NaOH-activated mortars showed superior open and setting time behavior, with open time and initial setting time around 20 and 50 minutes, respectively. In contrast, solid Na_2SiO_3 significantly affected workability, open time, and setting time, adversely affecting pumpability and extrudability at all concentrations. NaOH-activated mortars and liquid Na_2SiO_3/NaOH exhibited better printability overall. Increasing activator concentration improved cohesion and extrudability; however, very low or high concentrations caused issues such as nozzle blockage and poor filament definition. This study offers preliminary insights into using fly ash–slag geopolymer mortars in extrusion-based 3D printing and highlights the key role of alkali activator composition in fresh properties. It establishes a foundation for future research on rheology, strength, interlayer bonding, and life cycle assessment.

Keywords: pumpability, extrudability, 3D-printing, alkali activators, geopolymer.

EVALUATION THE EFFECTIVENESS OF EXISTING HEALTH PROMOTION STRATEGIES AND PROGRAMS IN GEORGIA

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ABSTRACT

Background: Worldwide, as well as in Georgia, morbidity and mortality caused by non-communicable diseases fall on cardiovascular diseases, cancers, chronic respiratory diseases and diabetes. The universal health care program currently implemented in Georgia includes access to quality health services.

The priority of the Georgian healthcare system is to carry out preventive measures and implement various health promotion programs. Specialized program financing continues in Georgia today.

The aim of the study is to assess the existing interventions in the country in the direction of health promotion and strengthening, their effectiveness, as well as existing challenges.

Methods: To achieve the goal, a qualitative study was conducted. A mixed (open and closed) questionnaire was used as a research tool. 10 experts in the field were interviewed within the framework of the study. The survey was conducted in accordance with all the requirements characteristic of qualitative research. The interview was pre-agreed with the experts in a comfortable and acceptable environment, taking into account the time frame. The interview was recorded on a dictaphone. The questionnaire was divided into parts.

The first demographic part of the questionnaire included the following questions: gender, age, place of work, work experience;

The second, third and fourth parts of the survey included the following questions: What interventions exist in the country to promote health? How do you assess the existing interventions, are the existing interventions effective or not? What recommendations would you give regarding these interventions and this problem in general?

Results:

Of the respondents, 4 were women and 4 were men. Their average age was 54 years, and their average work experience was 14 years. As we learn from the experts' answers, their views and opinions on the questions asked are practically similar, there are no mutually exclusive answers and no conflicts of interest. Their views on the effectiveness of existing medical interventions and programs in the country are unambiguous, but, as almost all experts note, there are certain problems, the solution of which requires further refinement of health promotion and interventions, full coverage of the population, targeted use of finances, sharing the experience of leading, developed countries in the world, familiarization with already proven methods and innovative approaches, and transferring them to the reality of the Georgian healthcare system as much as possible.

Conclusions: Despite the fact that there are and are numerous intervention programs/services in the country, both in the prevention and treatment of various non-communicable diseases, we still face many problems and challenges, for example, insufficient professional resources, low qualifications and responsibility, low wages, the virtual absence of protective mechanisms for medical personnel, excessive and irrational prescription and use of medications, and a high rate of self-medication by patients. Today, Georgia still offers a limited profile of medical services to the population, unable to fully cope with the above-mentioned problems in the prevention of non-communicable diseases related to tobacco smoking and air pollution. Strengthening mass media and tele-communication channels in terms of promoting a healthy lifestyle; Raising awareness of the population on a healthy lifestyle and other issues related to health promotion.

Keywords: non-communicable diseases, health promotion programs, qualitative study.

RECENT EVIDENCES IN THE DIRECTION OF STIMULATING WOUND HEALING WITHOUT THE DEVELOPMENT OF PATHOLOGICAL SCARRING

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ABSTRACT

Wound healing, tissue repair, and regeneration are biological processes essential for restoring tissue integrity following injury. Disorders in these processes can lead to complications and the formation of scars, impacting both physical and psychological well-being.

This review synthesizes recent advancements in understanding of the molecular and cellular mechanisms governing these processes. We explore the sequential phases of wound healing, the key cellular and molecular players involved, factors influencing healing outcomes, and emerging therapeutic strategies. Special emphasis is placed on novel biomaterials, cell-based therapies, gene therapies, and physical modalities.

Modern therapeutic approaches aim to accelerate healing while minimizing complications such as scarring, infection, or chronic inflammation. Among the commercially available topical agents, Dermatix Ultra, Epicyn, Flosteron, and Contractubex are widely used and studied. This review provides a contemporary analysis in the context of wound healing, tissue repair, and scar management, with an evidence-based comparison of these agents, focusing on their composition, mechanisms of action, clinical applications, and a comparative perspective on their efficacy in improving scar outcomes.

This review aims to provide clinicians and patients with an up-to-date understanding of these treatments to facilitate informed decision-making in scar management. Finally, we discuss current challenges and future directions in the field, highlighting the potential for personalized medicine and translational research.

Keywords: Wound healing, Tissue Repair, Regeneration, Scar Management.

DETERMINATION OF THE RHEOLOGICAL PARAMETERS OF THE MATERIAL BY AN IMPROVED METHOD ON THE EXAMPLE OF THE CREEP PROCESS UNDER TORSIONAL DEFORMATION

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ABSTRACT

In this work, we discuss an improved methodology for determining the parameters of rheological functions in materials with elastic-plastic properties, using the creep process under torsional deformation as an example. This approach is based on the theory of inheritance, where the parameters of the rheological functions (A, α, and β) are determined by combining graphs. Traditionally, these graphs are matched through visual alignment of manually drawn curves, which is prone to significant human error. The updated methodology presented in this work involves the precise matching of graphs using various computer programs, with their alignment performed using a least-squares approach.

During the research process, we utilized an existing database of theoretical graphs of rheological functions and values displayed in tabular form, which, although important, contains insufficient information. To expand this database, specific programs were developed using "Maple," and a methodology was created for the simplified calculation of complex mathematical expressions through numerical methods by transitioning to the complex plane.

Based on experimental data from the torsional testing of composite materials, the improved matching method was used to calculate correction coefficients that determine the accuracy of graph alignment, and the percentage differences were estimated.

Keywords: Composite material, rheology, creep, influence function, torsional deformation.

EPILEPTIC HEART SYNDROME: CARDIAC COMPLICATIONS IN CHRONIC EPILEPSY

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ABSTRACT

Epilepsy, impacting over 50 million individuals globally, poses a substantial risk of sudden unexpected death, with SUDEP. Notably, a history of epilepsy is associated with a 21% incidence of heart disease, significantly higher than the 12% observed in those without epilepsy. Heart disease is 2.4 times more prevalent among epilepsy patients aged 18-44 years, reaching 25.6% compared to 11.5% in those without epilepsy. Research into the "Epileptic Heart" syndrome reveals structural and autonomic changes in the heart linked to chronic epilepsy, leading to increased susceptibility to fatal arrhythmias. Studies using electrocardiography (ECG) and heart rate variability (HRV) assessments have identified significant abnormalities, including elevated QTc and QTd values, particularly among refractory epilepsy patients, suggesting heightened SUDEP risk in this subgroup. Autonomic dysfunction, characterized by sympathetic overactivity, has been implicated in cardiac fibrosis and arrhythmogenesis, contributing to cardiovascular complications in epilepsy.

The concept of an "ictal-Heart Syndrome" is supported by data showing that nearly 9% of epilepsy patients experience cardiovascular events (CVEs) within 30 days following ictal episodes, with rates varying across age groups. Those who suffer early CVEs face elevated long-term risks of hospitalization and mortality compared to individuals without epilepsy-related CVEs. Moreover, individuals with epilepsy have a 2–3 times higher risk of premature death, with SUDEP accounting for 2–18% of epilepsy-related deaths.The integration of routine cardiac evaluations, including resting 12-lead EKG and ambulatory EKG patch recording, into epilepsy management is crucial for detecting and managing cardiac issues associated with seizures. This multidisciplinary approach aims to optimize outcomes and reduce premature mortality by addressing cardiac comorbidities in epilepsy patients. These findings underscore the urgent need for comprehensive care strategies tailored to mitigate cardiovascular risks and improve long-term prognosis in this vulnerable population.

Keywords: Epilepsy, SUDEP, Cardiovascular disease, Ictal-Heart Syndrome, Autonomic dysfunction, Sudden cardiac death, Electrocardiography (ECG), Heart rate variability (HRV), Cardiac evaluation, Multidisciplinary care.

PRE-STRESSED SEISMIC-RESISTANT SUSPENDED SPATIAL STRUCTURAL SYSTEM FOR HIGH-RISE BUILDINGS

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ABSTRACT

This work presents an innovative seismic-resistant suspended spatial structural system featuring a central rigidity core. The proposed system consists of a reinforced concrete central core with a circular or rectangular cross-section, which ensures the overall lateral stiffness of the structure. At the uppermost level of this core, a spatial cantilever structural beam is installed, serving as the primary load-bearing element. The floor slabs are suspended from this beam using pre-stressed vertical hangers, which are rigidly or articulately connected to the central core.

A key advancement of this system over conventional designs is the incorporation of inclined pre-stressed hangers, which continuously traverse the structural framework in two orthogonal directions, forming an integrated, uninterrupted load-bearing system. These inclined cables are arranged in a cross-bracing pattern at each floor level, significantly improving the building's lateral load resistance and increasing its fundamental frequency of vibration. This design enhancement results in superior seismic performance compared to traditional suspended structural solutions.

The principal advantage of the proposed pre-stressed seismic-resistant suspended framework lies in the combined action of inclined and vertical pre-stressed hangers. This approach enhances the load-bearing capacity of the entire structure, ensuring high seismic resilience. Additionally, it facilitates a technologically efficient and structurally optimized installation of floor slabs and connection nodes between the core and hangers. The introduction of inclined hangers not only reinforces the central core but also enhances the rigidity and stability of the inter-floor slabs and the overall spatial framework.

Compared to conventional suspended structures, this system enables the construction of additional suspended floors, while simultaneously reducing material consumption and construction time, making it a cost-effective and high-performance solution for high-rise buildings in seismic-prone regions.

Keywords: Pre-stressed spatial framework, seismic-resistant structure, central rigidity core, spatial cantilever beam, pre-stressed hangers.

EVALUATION OF THE ELECTROMYOGRAPHIC ACTIVITY OF MASTICATORY MUSCLES IN ADULT WOMEN AFTER HYALURONIC ACID APPLICATION IN THE MANDIBULAR ANGLE REGION

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ABSTRACT

Objective: To investigate the electromyographic (EMG) activity of the masseter and temporalis muscles in adults women undergoing hyaluronic acid injection in the mandibular angle region. Methods: This is a preliminary longitudinal study, approved by the Research Ethics Committee of the Ribeirão Preto School of Dentistry, University of São Paulo, Brazil (protocol no. 79298124.2.0000.5419). Six healthy volunteers, aged between 20 and 45 years, with normal occlusion and no signs of temporomandibular dysfunction, were evaluated. EMG activity was recorded from the masseter and temporalis muscles during various mandibular tasks: rest, protrusion, right and left laterality, and dental clenching in maximum voluntary contraction. A Delsys system was used for signal acquisition. Assessments were performed at three time points: before the hyaluronic acid injection, and 15 and 30 days after the procedure, which followed Medical Device (MD) guidelines. Results: Statistical analysis, conducted using repeated-measures ANOVA with Bonferroni correction ($p < 0.05$), indicated a significant change in the EMG activity of the left masseter muscle during dental clenching in maximum voluntary contraction ($p = 0.03$). A reduction in the electrical activity of this muscle was observed 15 days after the intervention, followed by a possible functional compensation at 30 days. Conclusion: Preliminary results suggest that hyaluronic acid injection in the mandibular angle region may impact the functional activity of the masseter and temporalis muscles during mandibular movements.

Keywords: hyaluronic acid; mandibular angle; electromyography; masticatory muscles

$AG_2ZNP_2O_7$: A NOVEL APPROACH TO ENHANCING PHOTOCATALYTIC ACTIVITY FOR ENVIRONMENTAL APPLICATIONS

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ABSTRACT

Wastewater from various industries, including the textile sector, significantly contributes to environmental pollution due to its complex and harmful impurities, including carcinogenic azo dyes. Traditional treatment methods have proven inadequate for these persistent organic pollutants. This study reviews primary dyes and other organic pollutants and evaluates both conventional and advanced purification methods, particularly advanced oxidation processes (AOPs) and phosphate-based photocatalysts.

The objective of this work is to enhance photocatalytic activity through morphology control and material integration. Phosphate-based materials with tailored morphologies and properties were synthesized using the solid-state reaction method to improve photocatalytic efficiency. The synthesis involved precise preparation methods and extensive characterization to determine crystal structure, morphology, and optical properties. The $Ag_2ZnP_2O_7$ photocatalyst phase was developed.

Characterization techniques, including X-ray diffraction (XRD), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), Fourier-transform infrared spectroscopy (FTIR), and UV-Vis spectroscopy, confirmed the successful synthesis and desirable properties of these materials. The photocatalysts demonstrated enhanced degradation efficiencies for organic pollutants. The $Ag_2ZnP_2O_7$ photocatalyst showcased impressive degradation prowess, achieving an astounding degradation rate of 99.8% for MO and 72.4% for MB after a full exposure cycle of 112 minutes.

This study highlights the potential of phosphate-based photocatalysts in the treatment of wastewater containing persistent organic pollutants, emphasizing the need for further research to address challenges such as self-photo corrosion in Ag_3PO_4/TiO_2 photocatalysts.

Keywords: persistent organic pollutants, photocatalysts, advanced oxidation processes, phosphate-based materials.

FUNCTIONALIZATION OF MOROCCAN GHASSOUL CLAY FOR ENHANCED ADSORPTION OF REFRACTORY POLLUTANTS

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ABSTRACT

Water pollution remains a critical challenge in the 21st century, driving global efforts to develop efficient, cost-effective, and eco-friendly wastewater treatment technologies. This doctoral research explores innovative treatment processes based on modified clays, particularly organophilic clays enhanced through cation exchange. Moroccan ghassoul clay, known for its high adsorption capacity for cationic dyes due to its negatively charged surface, serves as the foundation of this study. Our goal is to enhance its efficiency by functionalizing its surface to improve interactions with anionic dyes. The study began with the purification and chemical activation of ghassoul, followed by modification using cationic surfactants. Advanced characterization techniques, including X-ray diffraction (XRD), X-ray fluorescence (XRF), zeta potential analysis, thermogravimetric analysis (TGA), scanning electron microscopy with energy-dispersive X-ray analysis (SEM/EDX), and BET microporosity, confirmed the successful functionalization. This transformation from hydrophilic to hydrophobic properties expands its potential for wastewater treatment. In the next phase, an alternative adsorbent was developed by incorporating a different surfactant to capture a highly toxic non-ionic and hydrophobic pollutant. Characterization techniques validated the intercalation and cation exchange efficiency, demonstrating the material's ability to retain this pollutant through hydrophobic and π-π interactions. These results highlight the potential of modified ghassoul clays as versatile and sustainable solutions for wastewater treatment, effectively removing both anionic and cationic contaminants.

Keywords: Organophilic clays, Cation exchange, Adsorption, Anionic dyes, Hydrophobic compounds.

IN-SITU UNIFORM GROWTH OF POLYPYRROLE ON MAGNETIC Fe_3O_4@NiMgAl-LDH: APPLICATION IN THE ADSORPTIVE REMOVAL OF DICHLORPROP-P HERBICIDE FROM WASTEWATER

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Abstract

The widespread use of hazardous pesticides has emerged as a critical environmental concern due to their significant adverse effects on human health. In this study, a novel magnetic layered double hydroxide (LDH) composite doped with Polypyrrole (Fe_3O_4@NiMgAl LDH-PPy) was successfully synthesized using a straightforward coprecipitation method, followed by mechanical stirring and in-situ polymerization. This composite was designed for the efficient removal of the herbicide Dichlorprop-P from wastewater. Comprehensive characterization techniques including Fourier-transform infrared spectroscopy (FT-IR), scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDS), X-ray diffraction (XRD), Raman spectroscopy, and Brunauer–Emmett–Teller (BET) surface area analysis was employed to investigate the composite's crystallinity, morphology, porosity, and structural features. The effects of various operational parameters, such as adsorbent dosage, contact time, pH, initial herbicide concentration, and temperature, were systematically evaluated. Adsorption studies revealed that the process closely followed pseudo-second-order and Elovich kinetic models, as well as the Langmuir, Sips, and Temkin isotherm models. Thermodynamic analysis indicated that the adsorption process was spontaneous and endothermic. Additionally, the composite showed strong potential for treating simulated wastewater containing pharmaceutical and dye pollutants, highlighting its promise as an effective adsorbent for environmental remediation applications.

Keywords: Adsorption mechanism, Dichlorprop-P herbicide, Layered double hydroxide, Polymerization, magnetic LDH.

PERFORMANCE-ENHANCING DRUGS AND THEIR EFFECTS ON HUMAN PHYSIOLOGY

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ABSTRACT

Performance-enhancing drugs (PEDs) encompass a range of substances used to improve physical strength, endurance, and overall athletic performance. While often associated with competitive sports, their physiological impact extends far beyond performance gains. This abstract explores the effects of common PEDs—such as anabolic steroids, stimulants, human growth hormone (HGH), and erythropoietin—on various systems within the human body. These substances can significantly alter muscular development, hormonal balance, cardiovascular function, and neurological processes. Although short-term benefits may include increased muscle mass, reduced fatigue, and improved recovery time, long-term use often leads to serious health complications, including liver and kidney damage, heart disease, infertility, and psychological disorders. By examining the mechanisms through which PEDs interact with human physiology, this study underscores the importance of awareness, regulation, and education to mitigate their harmful consequences.

Keywords: performance-enhancing drugs, human physiology, muscle growth, health risks

COMPARATIVE EVALUATION OF SONOCHEMISTRY AND THE FENTON REACTION FOR THE TREATMENT OF ANTIBIOTIC FAMILIES: INVESTIGATING THEIR SYNERGISTIC POTENTIAL

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ABSTRACT

Antibiotics constitute a broad class of pharmaceutical compounds. However, even at trace concentrations, their presence in water resources contributes significantly to the emergence and spread of antibiotic-resistant bacteria[1].

Antibiotics, due to their persistent nature, are often inadequately removed by conventional wastewater treatment methods such as coagulation, flocculation, sedimentation, and filtration [2]. In contrast, advanced oxidation processes (AOPs), which generate highly reactive hydroxyl radicals (•OH), are recognised as among the most effective techniques for degrading stable organic contaminants in wastewater. Notably, combining different AOPs has been shown to significantly enhance treatment efficiency [3]. For instance, the integration of Fenton's reaction with acoustic cavitation commonly referred to as the Sono-Fenton or US/Fenton process can substantially improve the mineralization of organic pollutants [4].

This study evaluates the effectiveness of this combined method by assessing the degradation rates of two antibiotic families, sulfonamides and fluoroquinolones. The primary focus is to understand the potential improvements in pollutant removal when ultrasound and the Fenton process are applied simultaneously compared to their independent applications. By comparing the treatment efficiency across these two distinct antibiotic families, the research aims to highlight the influence of molecular structure on degradation behaviour. This study also seeks to gain insights into this advanced treatment technique's operational parameters, synergetic effects, and environmental benefits.

Keywords: Pollution, Degradation, Antibiotics, Ultrasounds, Fenton

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EXPLORING STRUCTURAL, ELECTRONIC, OPTICAL, AND PHOTOCATALYTIC PROPERTIES OF NOVEL DOUBLE PEROVSKITES CS_2INSBX_6 (X = F, CL) UNDER STRAIN

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ABSTRACT

Inorganic and organo-lead halide perovskites have garnered significant attention as promising materials for next-generation solar cells due to their exceptional light-absorption properties. However, concerns about their long-term stability and the environmental hazards associated with lead toxicity remain unresolved. Antimony, a non-toxic element with electronic properties similar to lead, offers a sustainable alternative. This study investigates the potential of Cs_2InSbX_6 (X = F, Cl) double perovskites for optoelectronic and photocatalytic applications. Using Density Functional Theory (DFT) calculations, we analyze the effect of strain on their electronic and optical properties. The unstrained structures of Cs_2InSbF_6 and $Cs_2InSbCl_6$ exhibit band gaps of 1.20 eV and 2.06 eV, respectively. Strains ranging from -5% to +5% were applied to evaluate their impact. The results reveal that negative strain significantly enhances photocatalytic performance by improving light absorption and quantum efficiency while reducing the band gap. These findings position Cs_2InSbX_6 materials as promising candidates for photocatalytic applications. Additionally, their strong visible light absorption and relatively high refractive indices make them suitable for a range of optical device applications.

Keywords: Cs_2InSbX_6; DFT calculation; Strain engineering; Quantum efficiency; Optoelectronic properties; Photocatalytic properties

PRODUCTION OF *Vicia faba* INTERSPECIFIC HYBRID THROUGH *In vitro* PROPAGATION TECHNIQUE

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ABSTRACT

An embryo rescue of the hybrid derived from two *Vicia faba* lines (ILB 1270, Giza Blanca ILB 1814) was studded under I*n vitro* conditions. Four protocols (A, B, C, and D) were used for inducing embryonic structures. The results indicated that the most effective response was recorded by using protocol (B), which recorded the highest number of new embryonic structures. Furthermore, the results confirmed that adding Kinetin to MS medium with B5 Vitamins (MS basal salts supplemented with B_5 Vitamins + 2.3 mg/l Kinetin + 20 gm/l sucrose and 8 gm/l Agar) encourages shoot proliferation and elongation. *In vitro,* flowering was achieved by producing large numbers of flowers when cultured in DKW medium supplemented with 1 gm/l MES, 30 gm/l sucrose, and 2 gm/l gelrite. Finally, the results revealed that 5% of the regenerated shoots were able to form roots by using half strength of MS medium salts + 2.5 mg/l of ascorbic acid + 1.0 mg/l PVP + 15 gm/l sucrose + 2 gm/l phytagel.

Keywords: Vicia faba; Micropropagation; Organogenesis; TDZ, Kinetin.

INCREASING THE FLIGHT SAFETY OF RESCUE DRONES AND HELICOPTERS WITH A DEVICE TO PREVENT BIRDS FROM GETTING INTO THE ENGINES

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ABSTRACT

The implementation of the presented project is important because it will be possible to create a product that ensures the safety of aircraft used in search and rescue operations. This product will be innovative for the aviation field, which will bring significant financial benefits to our country.

There are many vacation spots on the coast of Georgia, and the number of visitors is increasing every year. Many rescue and search operations are carried out in such regions. A number of such operations are planned and carried out using drones and helicopters. In the future, the involvement of various types of drones in rescue operations of this type will increase even more. This is evidenced by the great interest of leading foreign countries in the multi-purpose use of drones.

According to statistics, worldwide demand for search and rescue helicopters and drones has increased significantly. In the recent past, many different types of search and rescue operations were carried out in our country. Unfortunately, some of them did not succeed because the crew members had problems trying to save people's lives because the operation involved high risks. These risks are significantly due to the increased probability of birds getting into aircraft engines.

To avoid the above-mentioned accidents, the only correct way is to protect the motors with special devices. Many manufacturers have begun equipping search-and-rescue helicopters and drones in maritime regions with protective equipment. However, it is worth noting that these nets are made of simple metal constructions that do not provide adequate protection, especially in such biodiversity-rich regions as Georgia. Moreover, the sizes of these meshes are relatively large and cannot stop small birds from crashing, while a smaller size mesh may cause a significant reduction in airflow and thus result in a deterioration of the engine's power characteristics.

Keywords: Drone,Helicopter,Engine,Nets.

INFLUENCE OF SUNSHINE (IN HOURS) ON THE DEVELOPMENT OF STROKES AMONG THE POPULATION IN SOUTHERN KYRGYZSTAN

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ABSTRACT

This study aims to analyze acute cerebrovascular accidents (ACVA) occupy priority ranking positions in the structure of neurological pathologies. The differences and incidence of stroke may be due to climatic conditions that differ in different regions of Kyrgyzstan.

The purpose of the article is to study the risk of developing cerebral strokeover 4 years under the influence of meteorological factors for the timely adoption of preventive measures.

Solar activity - a set of phenomena and processes associated with the formation and decay in the solar atmosphere of strong magnetic fields. Solar spots are areas on the surface of the Sun, which are darker than the photosphere surrounding them, since in them a strong magnetic field suppresses plasma convection and reduces its temperature by about 2000 degrees.

One of the most common indicators of solar activity is the number of wolf. The number of wolf ("international number of solar spots") is a numerical indicator of the number of solar spots. The number of wolf for this day is calculated according to the formula W = k (F+10G), where W the number of wolf, f is the number of observed spots, G is the number of groups of observed spots, k is the normalizer coefficient. The normalizing coefficient K is displayed for each observer and telescope, which allows you to jointly use the wolf numbers found by different observers.The main outcoming result which we aim to get is the list of different ways of the prevention of cerebral strokeover in Kyrgyzstan.

Key words:strokeover,phenomenon,solar,climatic conditions,prevention.

EFFECT OF SURFACE MODIFICATION ON THE MECHANICAL AND BIOLOGICAL PROPERTIES OF 3D-PRINTED DENTURE BASE RESIN

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ABSTRACT

The aim of this *in vitro* study was to assess the effect of different surface treatments (Polishing and Coating) on samples obtained by 3D printing on the roughness, topographical analysis, cytotoxicity, and biofilm formation of *Candida albicans*. Initially, discs of 3D-printed resin (NextDent Base) with a diameter of 14 mm and a thickness of 1.2 mm were fabricated. The samples were randomly divided into four groups: U: Untreated (control group); POL: Polishing; COAT: Coating; COAT + POL: Coating + Polishing. The POL group samples underwent a polishing protocol using sandpapers with grit sizes of 220, 400, 600, and 1200, respectively. The COAT group was coated with a layer of unpolymerized resin, followed by curing under UV light, whereas the COAT + POL group underwent coating followed by polishing. Roughness measurements (n=9) were conducted using a profilometer, and topographical analysis was performed using scanning electron microscopy (SEM) (n=2). Cytotoxicity was assessed using the AlamarBlue assay after exposing L929 cells in monolayer culture to resin extracts (n = 9). For microbiological analysis, *C. albicans* biofilms were cultured on the samples and evaluated by colony counting (n=9). Data were analyzed using one-way ANOVA followed by Tukey's post hoc test ($p < 0.05$). All experimental groups showed a significant reduction in surface roughness and increased material smoothness, as observed by SEM, compared to the untreated group. All groups were considered non-cytotoxic for L929 cells. There was no difference in colony counting compared to the control group. It was concluded that all treatments were effective in reducing surface roughness, were biocompatible, but did not reduce the formation of *C. albicans* biofilm.

Keywords: 3D printing, Denture Base, Surface Roughness, Cytotoxicity tests, *Candida albicans*

CALCULATING OPTIMAL SOLAR PANEL AND BATTERY CONFIGURATIONS FOR A 3 MW SOLAR POWER SYSTEM

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ABSTRACT

In recent years, our major objective of this research is to get the best arrangement of solar panels and batteries for a 3 MW system because we are focusing on the parameters that are crucial for our calculations including panel power, sunshine hours, battery voltage, and battery capacity. So, in the first step, we have to compute the daily energy production of a solar panel through its power capacity and average daily sunshine hours. Then, secondly, we define the total number of solar panels used for this system.

Subsequently, besides addressing the battery requirement for storing extra energy, which is generated during sunny hours, it is required that the storage capacity of batteries should be enough to accumulate this surplus electrical energy and hence can be used during non-sunny hours or during the night. By undertaking this study, therefore, our findings add more knowledge towards how solar energy systems can be efficiently designed and optimized based on sustainable utilization of renewable resources, hence supporting global energy sustainability goals.

Furthermore, the study takes into account environmental factors that can affect solar energy production, such as seasonal variations in sunshine hours. Analyzing these factors will help refine the estimation of both the required number of panels and battery storage capacity, ensuring that the system functions optimally throughout the year. The ultimate goal is to create a blueprint for renewable energy systems that are not only efficient but also scalable and adaptable to different regions, making them a viable solution for future energy needs across the globe.

Keywords: Solar Energy System; Solar Panel Configuration; Battery Storage Optimization; Energy Production Calculation; Sunshine Hours; Renewable Energy Design; Solar-Battery Integration; Sustainable Energy Utilization; 3 MW Solar Power; Solar Power System Efficiency

THE ROLE OF PHYSICAL ACTIVITY TO MITIGATE ACADEMIC BURNOUT AMONG MOROCCAN ADOLESCENTS

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ABSTRACT

The current study explores the potential mediating effects of body mass index (BMI) in the impact of physical activity on academic burnout. **Materials and Methods :** A total of 1197 participants from public secondary school students from RabatSale-Kenitra Region (Morocco) with a mean age of 17.15 years (SD=1.328), including 59.1% of girls, responded to an Arabic version of the Maslach Burnout Inventory-Student Survey (MBISS), a short from the International Physical Activity Questionnaire (IPAQ-sf), and standardized questions to calculate BMI. The IBM SPSS statistics 26.0 and Amos 24 were used to analyze the data. **Findings:** The findings indicated a detrimental association between school burnout, BMI, and physical activity levels. An inverse correlation was observed between physical activity and this mental disorder, with BMI functioning as a mediating factor in this dynamic. Regular physical activity mitigates academic burnout by achieving a healthier BMI. **Conclusion:** These findings can be explored to propose suitable strategies for mitigating academic burnout in secondary school. Keywords: Academic burnout, Secondary school, Physical activity.

Keywords: Academic burnout, Secondary school, Physical activity.

ASSESSING KNOWLEDGE AND PREVENTIVE PRACTICES REGARDING BREAST CANCER AMONG FEMALE POPULATIONS: A QUANTITATIVE ANALYSIS

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ABSTRACT

Early detection of breast cancer is essential for improving patient survival.

This study aims to assess women's knowledge about breast cancer, screening practices, perceived barriers, and access to healthcare facilities in the Elbasan district. Methodology. It is a simple cross-sectional study that included women from the Elbasan district. The study was carried out between December 2024 and February 2025. Appropriate stratified random sampling was used to determine the study sample from each area. The acquired data were analysed using SPSS version 27.

Results. Overall, 14.3% of respondents experienced breast-related problems. The average knowledge score was 5 out of 6, with an overall correct response percentage of 86.4%. However, only 57.3% of participants identified heredity as a risk factor for breast cancer. Women in urban areas and with a family history of breast cancer showed significantly higher knowledge scores ($p<0.001$). 14.3% of participants reported having a family history of breast cancer (mother, aunt, sister or grandmothers). Notably, 67.8% of women had never been to a healthcare facility for breast-related concerns. In terms of breast imaging, 31.6% of individuals had had three or more examinations, whereas 68.3% (n=272) had never had any radiological screening.

Conclusion. The study showed a satisfactory level of knowledge related to breast cancer but low rates of breast visits and imaging examinations. Intervention programs, particularly in rural areas, must be implemented to raise awareness of the importance of regular breast cancer screening visits and examinations.

Keywords: breast cancer, knowledge, risk factors, imaging examinations, women.

KEY CHALLENGES IN THE DEVELOPMENT OF GEORGIA'S CAPITAL MARKET AND STRATEGIES FOR ITS ENHANCEMENT

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ABSTRACT

Georgia's capital market has experienced significant development in recent years. Notably, the local corporate bond market has expanded substantially, increasing from $205 million in 2018 to $800 million by the end of 2023. This growth reflects increasing confidence in bonds as an alternative source of financing. The expansion is supported by the positive development of Georgia's economic landscape. However, despite this progress, significant challenges to capital market development persist.

1. **Low liquidity:** Limited market liquidity discourages both investors and issuers, making it challenging to buy and sell securities efficiently.
2. **Restricted investor and issuer base:** The small number of market participants constrains competition and limits investment diversification.
3. **Insufficient transparency:** A lack of accessible and reliable information hinders informed decision-making by investors.
4. **Regulatory and compliance challenges:** Market participants face challenges in adhering to international standards and regulations, which impedes market development.
5. **Infrastructure deficiencies:** Enhancing market infrastructure and integrating modern technologies are essential for improving market efficiency.

Several measures can be taken to address the challenges facing the development of Georgia's capital market. These include expanding the number of market participants, enhancing information transparency, strengthening market infrastructure, enforcing regulatory standards, and promoting financial education and awareness.

Keywords: Capital, Market, Liquidity, Development, Infrastructure, Technologies.

THE AESTHETIC AND PERCEPTUAL CONSTRUCTION OF SPACE IN DIGITAL ART: AN ANALYSIS IN THE CONTEXT OF REFİK ANADOL'S ART PRACTICES

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ABSTRACT

Digital art fundamentally questions the interaction between humans and their environment, knowledge, and technology, as well as how this interaction affects the individual's experience of selfhood. In this context, as in conceptual art, the role of space and the diversity of meanings it embodies occupy a significant place in digital artistic expression. Especially for artists working with advanced digital tools such as artificial intelligence, data visualization, and machine learning, space is not merely a physical context but a perceptual and aesthetic experience that is reconstructed and redefined.

This study aims to analyze how space is redefined in digital art through Refik Anadol's works, including *Augmented Structures v1.1: Acoustic Formations / Istiklal Street*, *Machine Hallucinations*, *Melting Memories*, and *Quantum Memories*. Anadol's data-driven artistic production transforms space from a fixed and physical entity into a dynamic, fluid, and multi-dimensional perceptual experience.

The theoretical framework of this study is built upon Henri Lefebvre's conception of space as a socially produced practice, Gilles Deleuze's understanding of perception, Nicolas Bourriaud's notion of relational aesthetics, and Lev Manovich's approach emphasizing the algorithmic structure of digital art, data-driven production processes, and software as a new aesthetic form. Refik Anadol's artistic practices, shaped by artificial intelligence, data visualization, and algorithmic processes, are examined within this theoretical context to propose an original reading of how the relationship between art and space has transformed aesthetically, perceptually, and technically in the digital age.

In conclusion, Anadol's artistic practices demonstrate that within the context of digital art, space can be reconstructed not merely as content but also as a data-driven experience, a medium of memory, and an aesthetic form.

Keywords: Digital art, artificial intelligence art, data visualization, perceptual experience, algorithmic aesthetics

RESEARCH OF THE MECHANISM OF EMISSION GAS REDUCTION IN THE AVIATION FIELD

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ABSTRACT

The mechanisms and technologies for reducing emission gases in the aviation sector, which aim to reduce emission gases, as well as the role of the state in this global effort and current projects, are investigated. , because the release of exhaust gases in the aviation field is increasing day by day. The study also discusses the Carbon Offsetting and Reduction Scheme for International Aviation, CORSIA, which sets out the industry's approach to reducing emissions on a global scale. The aviation industry's long-term goal is to halve greenhouse gas emissions by 2050 from 2005 levels. A significant effect of reducing emissions is achieved by developing new aircraft technology and using sustainable aviation fuel. Sustainable aviation fuel can be up to 80% less carbon and is already commercially available.

Keywords: Aviation; Emission; Sustainable.

ENHANCING PHOTOCATALYTIC EFFICIENCY OF PHOSPHATE-BASED MATERIALS FOR EFFECTIVE DEGRADATION OF PERSISTENT ORGANIC POLLUANTS

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ABSTRACT

Wastewater from various industries, including the textile sector, significantly contributes to environmental pollution due to its complex and harmful impurities, including carcinogenic azo dyes. Traditional treatment methods have proven inadequate for these persistent organic pollutants. This study reviews primary dyes and other organic pollutants and evaluates both conventional and advanced purification methods, particularly advanced oxidation processes (AOPs) and phosphate-based photocatalysts.

The primary objective of this study was to enhance photocatalytic activity through morphology control and material integration. $Ag_4Ti(P_2O_7)_2$ materials with tailored morphologies and properties were synthesized using the solid-state reaction method to improve photocatalytic efficiency.

The initial phase confirmation using X-ray Diffraction (XRD) analysis laid a solid foundation for further characterizations. Scanning Electron Microscopy (SEM) revealed the formation of nanoparticle agglomerates, indicating a high surface area conducive to photocatalytic reactions. Energy-Dispersive X-ray Spectroscopy (EDS) and Fourier Transform Infrared Spectroscopy (FTIR) validated the successful synthesis of the desired compound, while UV-Visible spectroscopy highlighted reduced band gaps, which are critical for enhanced photocatalytic potential. The increased surface area, due to porosity and agglomeration, coupled with favorable optical properties, positioned these materials as promising candidates for effective and sustainable photocatalysis

This research underscores the effectiveness of phosphate-based photocatalysts in treating wastewater containing resilient organic contaminants.

Keywords: persistent organic pollutants, photocatalysts, advanced oxidation processes, phosphate-based materials. .

PRELIMINARY ELECTROMYOGRAPHIC ANALYSIS OF MASTICATORY AND FACIAL MUSCLES AFTER MIDFACE LIFTING THROUGH SUPRAPERIOSTEAL HYALURONIC ACID FILLER IN THE ZYGOMATIC ARCH IN ADULT WOMEN

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ABSTRACT

Objective: To analyze the effects of supraperiosteal hyaluronic acid filler, applied posterior to the osteocutaneous ligament lines in the zygomatic arch, on the electromyographic activity of masticatory and facial muscles in adult women. Methods: This is a preliminary longitudinal study involving five women (aged 30–50 years) with no temporomandibular disorders, normal occlusion, and natural dentition. The study was approved by the Research Ethics Committee of the Ribeirão Preto School of Dentistry, University of São Paulo, Brazil (protocol #83183924.1.0000.5419). Electromyographic evaluation (μV) was performed using a Delsys electromyograph, both before the procedure and 45 days after. The muscles analyzed were the right (RM) and left (LM) masseter, right (RT) and left (LT) temporalis, right (ROO) and left (LOO) orbicularis oculi, and the right (RZR) and left (LZR) zygomatic regions. The tasks evaluated included rest position, right and left laterality, protrusion, dental clenching (maximum voluntary contraction), upper lip elevation (facial expression of disgust), and eye closure (maximum contraction). Supraperiosteal filler in the zygomatic arch was performed using 1 ml of hyaluronic acid, injected at specific points of the arch and zygomatic eminence following the MD Codes® technique. The procedure was performed by a specialist in orofacial harmonization. Statistical analysis was conducted using a repeated measures test ($p < 0.05$). Results: An increase in electromyographic activity was observed in nearly 100% of the tasks, with significant differences for the right masseter (RM) at rest ($p=0.02$) and during protrusion ($p=0.05$), right temporalis (RT) during protrusion ($p=0.02$), right orbicularis oculi (ROO) during protrusion ($p=0.05$), right zygomatic region (RZR) during left laterality ($p=0.00$), and left zygomatic region (LZR) during dental clenching ($p=0.05$). During dental clenching, a reduction in masseter muscle activity was noted, although not statistically significant, suggesting functional redistribution following the filler procedure. Conclusion:

Supraperiosteal hyaluronic acid filler modifies muscle dynamics by increasing the activity of facial and masticatory muscles, reflecting a functional adaptation to the new tissue support, with an integrated aesthetic and functional impact.

Keywords: supraperiosteal filler, zygomatic arch, hyaluronic acid, electromyography, facial muscle, masticatory muscle

RECALL OF CARBOMER-CONTAINING EYE GELS IN THE UNITED KINGDOM: AN EVALUATION FROM A PHARMACOVIGILANCE AND PUBLIC HEALTH PERSPECTIVE

BİRLEŞİK KRALLIK'TA KARBOMER İÇERİKLİ GÖZ JELLERİNİN GERİ ÇEKİLMESİ: FARMAKOVİJİLANS VE HALK SAĞLIĞI AÇISINDAN BİR DEĞERLENDİRME

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ABSTRACT

Drug safety depends on the careful completion of all stages of development and continuous post-marketing follow-up. Concerns about drug safety have increased in recent years. In November 2023, some eye gels were recalled in the United Kingdom due to suspected microbiological contamination, and this incident was reported in the media. This study aims to examine the incident. This descriptive study includes characteristics of pharmacovigilance and public health evaluation. Data for the study was obtained from the UK government website (gov.uk), as well as from the websites of the newspapers The Daily Mail, The Telegraph and The Independent. The keywords 'eye gel' and 'recall' were used in the search. On 24 November 2023, the UK government issued a notice stating that carbomer-containing eye gels manufactured by Indiana Ophthalmics under the brands Aacarb, Aacomer and Puroptics were being recalled. The reason for the recall was cited as microbiological contamination. Of those affected by the outbreak, 52 were confirmed cases and six were suspected cases. The first confirmed case was diagnosed on January 16, 2023, and the last on February 12, 2024. However, most cases occurred in October, November and December 2023. Of the cases, 38 were patients currently receiving intensive care treatment, 30 were male, and the median age of those affected was 59 (range 0–91). Examining the clinical characteristics of the cases revealed a range of conditions, from eye infections to respiratory tract infections and sepsis. One of those affected by the outbreak lost their life. The antibiotic-resistant causative agent of the outbreak, Burkholderia cenocepacia, was isolated from patient samples and eye gels. This evaluation has once again emphasised the crucial importance of drug safety and pharmacovigilance systems for public health. Preventing healthcare from becoming a cause of illness is important in terms of maintaining trust in the healthcare sector.

Keywords: drug safety, drug recall, adverse reaction, United Kingdom, eye gel.

ÖZET

İlaç güvenliği tüm geliştirme aşamalarının hassasiyetle tamamlanması ve post-marketing takiplerin sürekliliği ile ilişkilidir. Son yıllarda ilaç güvenliğiyle ilgili endişeler artmaktadır. Kasım 2023'te Birleşik Krallık'ta bazı göz jelleri mikrobiyolojik kontaminasyon şüphesiyle geri çekilmiş ve bu olaya ilişkin detaylar basına da yansımıştır. Bu çalışmada bu olayın incelenmesi amaçlanmıştır. Çalışma tanımlayıcı türde olup farmakovijilans ve halk sağlığı değerlendirmesi özelliği taşımaktadır. Araştırmada kullanılan verilere Birleşik Krallık hükümetine ait web sayfasına (gov.uk) ek olarak Daily Mail, The Telegraph ve Independent gazetelerinin online adreslerinden ulaşılmıştır. Tarama için 'eye gel' ve 'recall' anahtar kelimeleri kullanılmıştır. 24 Kasım 2023 tarihinde Birleşik Krallık hükümeti tarafından Indiana Ophthalmics'in ürettiği Aacarb, Aacomer ve Puroptics markalarına ait karbomer içerikli göz jellerinin geri çağrıldığına dair bir bildirim yayımlandı. Bu geri çağırmanın nedeni

mikrobiyolojik kontaminasyon olarak gösterildi. Bu salgından etkilenenlerden 52'si doğrulanmış ve altısı olası vakaydı. İlk doğrulanmış vaka 16 Ocak 2023'te ve son doğrulanmış vaka 12 Şubat 2024'te tanı aldı. Bununla birlikte vakalar Ekim, Kasım ve Aralık 2023'te yoğunlaşmaktaydı. Vakaların 38'i halihazırda yoğun bakımda tedavi gören hastalardan oluşuyordu, 30'u erkekti ve etkilenenlerin yaş ortancası 59 (0–91)'du. Vakaların klinik özellikleri incelendiğinde göz enfeksiyonundan solunum yolu enfeksiyonuna ve sepsise varan olgular söz konusuydu. Salgından etkilenenlerden biri yaşamını yitirdi. Salgının etkeni olan antibiyotiklere dirençli Burkholderia cenocepacia hem hastalara ait örneklerden hem de göz jellerinden izole edildi. Bu değerlendirme, ilaç güvenliği ve farmakovijilans sistemlerinin halk sağlığı açısından kritik rolünü bir kez daha gözler önüne sermiştir. Sağlık hizmetinin hastalık nedeni olmasının önüne geçmek sağlık sektörüne olan güvenin korunması açısından önemlidir.

Anahtar kelimeler: ilaç güvenliği, ilaç geri çağırma, advers reaksiyon, Birleşik Krallık, göz jeli.

OPTIMIZATION OF TRANSPORTATION ROUTES USING AI ALGORITHMS

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ABSTRACT

The optimization of transportation routes constitutes a significant challenge in supply chain and logistics management nowadays, as organizations continuously seek to reduce delivery costs, time, and their associated carbon footprint. But using inefficiently designed transportation routes creates high operational costs, delayed deliveries, and environmental issues, underscoring the need for more advanced solutions.

This study illustrates artificial intelligence (AI) algorithms that enhance transportation and way finding, demonstrating the degree of benefit that logistics systems may reap through AI approaches. It demonstrates the use of AI methodologies and applications, ranging from least-cost path machine learning, genetic algorithms and deep reinforcement learning, to identify the optimal (in this case diverted to avoid high car traffic or extreme environment) in near real-time and facilitate data-driven decision support. This enables businesses to maximize their efficiency, reduce fuel consumption and improve their customer satisfaction through timely and efficient deliveries.

This research applies a mixed-methods approach through coupling data-intensive modeling with real-world logistics and e-commerce case studies. This allows for a comprehensive assessment of the benefits and costs associated with the implementation of AI in transportation routing. The findings underscore the advantages of AI, including higher operational efficiency, cost saving, and environmental sustainability. AI-enabled systems such as route management can effectively minimize fuel consumption when deliveries are carried out, directly cutting down carbon emission and costs.

Nevertheless, the study also reveals a few downsides of the kind of AI technologies with avatars that are part of transportation logistics, and thus a significant barrier to widespread adoption of such technologies still exists. This encompasses the computational complexity of AI algorithms, dependency on high-quality data and resistance to organizational structure. In addition to that, many firms, in particular SMEs with limited resources, face the challenge that their AI systems have to interoperate with other legacy infrastructure.

These are indeed pressing matters, therefore, in this paper; we will propose some concrete solutions to overcome these barriers: gradually implemented approach, personnel training, and scalable technologies, such as BaaS, which can help better unify and so provide comprehensive data. Coupled with other technologies—including the Internet of Things (IoT)—the potential of AI is amplified, enabling real-time data inputs and predictive analytics that can optimize operations. AI is quickly being heralded as the game changer in supply chain management.

Keywords: Artificial intelligence, logistics, operational efficiency, route optimization, supply chain.

PROBIOTICS FOR ORAL HEALTH - A META-ANALYSIS

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ABSTRACT

Probiotics are instrumental in maintaining oral health by modulating the oral microbiome, promoting beneficial bacteria, and reducing pathogens. Their effects improve gingival health by reducing inflammation and preventing periodontal diseases, and help control dental plaque formation, minimizing cavities and gum infections. To assess consequences of probiotics on dental plaque, gingival health and oral microbiological environment in patients suffering from plaque-induced gingivitis, a meta-analysis was conducted. The systemic search involved the electronic exploration of PubMed and Google Scholar for English language studies published between 2009-24. This review included two published non-randomized studies and eleven published randomized clinical trials; enrollment equalling 321 patients with plaque-induced gingivitis with no other systemic diseases. Risk of bias across the studies was assessed using the Cochrane Risk of Bias tool via Revman, evaluating the quality of the studies. For statistical analysis, the RevMan Cochrane Collaboration Network software was used. This meta-analysis included a total of 13 studies: two non-randomized studies and eleven randomized control trials, encompassing 321 participants. Through this meta-analysis, it was demonstrated that probiotics influenced oral microbial ecology in both favorable and unfavorable ways. Gingival Index scores were reported in nine studies with 242 participants. Probiotics showed statistically significant effects on GI scores (WMD=.27, 95% CI=.02 to .52, p=.04, I2=98%). However, no significant difference was observed in Plaque Index scores, reported in nine studies with 227 participants (WMD=-0.11, 95% CI=-0.57 to 0.35, p=.64, I2=97%). No significant effects were found for Bleeding on Probing, (p=.92), IL-1β (p=.02) or microbial counts Prevotella intermedia (p=.37), Fusobacterium nucleatum (p=.11), Porphyromonas gingivalis (p=.13), Aggregatibacter actinomycetemcomitans (p=.16) and Gingival Crevicular Fluid (GCF) (p=.94). Differences in probiotic strains, delivery forms and dosage may result in various outcomes. Moreover, presence of high risk and unclear risk biases in included studies can compromise the evidence reliability. Overall, probiotic intervention had a substantial impact on gingival index score. These findings suggest the potential of oral microbiota in improving gingival health, offering adjunctive treatment for gingivitis and periodontal disease.

Keywords: Dental Plaque, Gingival Health, MicroBiological Environment

EFFECT OF POLYPHENOLS ON HAEMOSTASIS SYSTEM IN RATS WITH STREPTOZOTOCIN-INDUCED TYPE II DM

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ABSTRACT

Diabetes-related mortality is associated with thrombotic events, especially cardiovascular disease. Usually, patients with diabetes mellitus show signs of hypercoagulability and hypofibrinolysis. In type 2 diabetes mellitus (DM2), all haemostasis systems involved in blood coagulation, regulation of blood vessel tone, blood cell status, and plasma enzyme systems are activated. In DM, there is a correlation between haemocoagulation abnormalities and the degree of glycaemia. However, the mechanisms causing haemostasis abnormalities in diabetic patients are unclear. In this regard, it is an urgent problem to study this issue and search for new drugs that prevent further progression of type 2 DM and the development of its complications on the haemostasis system. This paper presents the study of polyphenolic preparations isolated from the plant Pistacia vera L. (ANK-1), Karelinia caspia (KCL-1), and Isatis tinctoria L. (ITL-2). Biochemical parameters and ADP-aggregation of platelets were studied through in vitro experiments on platelet-rich blood plasma in rats with experimentally modeled streptozotocin-induced type 2 diabetes mellitus. The obtained data showed that the actions of polyphenols ANK-1, KCL-1, and ITL-2 extract are associated with activation of adenylate cyclase, reduction of thromboxane formation, and influence on the mobilization of calcium ions from intracellular depots. Since these polyphenols inhibit the second wave of ADP- and adrenaline-induced platelet aggregation to a greater extent, the effects are due to the activation of thromboxane and an increase in the concentration of Ca^{2+} in the platelet cytoplasm. These polyphenols, by reducing intracellular calcium concentrations, inhibit platelet aggregation, prevent their binding to SIR and IGF-1, and inhibit phosphorylation of SIR and IGF-1 receptors and prostacyclin receptor expression.

Keywords: type 2 diabetes mellitus, streptozotocin, blood enzyme and plasma indices, fibrinogen, hemostasis system, polyphenol.

RHEOLOGICAL BEHAVIOR AND SHELF-LIFE CORRELATION OF FRESH QUINCE, APPLE, BLUEBERRY AND SEA BUCKTHORN JUICES

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ABSTRACT

This study investigates the rheological properties of cold-pressed fresh juices obtained from quince (Cydonia oblonga), apple (Malus domestica), blueberry (Vaccinium myrtillus), and sea buckthorn (Hippophae rhamnoides), with a focus on their evolution during storage under refrigerated conditions. The aim is to evaluate how flow behavior correlates with shelf-life indicators relevant for physico-chemical stability and microbial safety. Rheological measurements were performed using a rotational rheometer with cone-plate geometry, in controlled shear rate mode. Apparent viscosity, flow curves, and thixotropic behavior were analyzed on days 0, 7, 14, and 21 of storage at 4 °C. Complementary analyses included pH monitoring, total phenolic content, enzymatic activity, and sensory evaluation. The results revealed clear differences among the juices: quince juice exhibited the highest initial viscosity and strong thixotropic loops, indicating a structured colloidal matrix that degrades significantly after 14 days. Blueberry and sea buckthorn juices showed pronounced shear-thinning behavior and high polyphenol content but presented rapid structural changes during storage. Apple juice demonstrated a near-Newtonian flow profile and maintained good sensory quality and microbial stability up to 21 days, though a moderate decrease in bioactive compounds was noted. Rheological signatures proved useful as non-destructive indicators for predicting the onset of physical destabilization and quality loss in unpasteurized fruit juices. These findings support the use of rheological profiling in quality control and shelf-life optimization of minimally processed fruit products.

Keywords: rheology, fresh fruit juice, shelf-life, cold-pressed, viscosity, thixotropy

LIPID PANEL AND APOPTOTIC BIOMARKERS IN HIGH-RISK POPULATIONS FOR ISCHEMIC HEART DISEASE

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ABSTRACT

Ischemic heart disease (IHD) remains one of the leading causes of death today, making early diagnosis and risk factor assessment critically important [1-4]. This study investigated lipid metabolism indicators and apoptosis biomarkers — specifically caspases-related Granzyme B and caspase-independent mitochondria-associated apoptosis-inducing factor (AIF) — in individuals with IHD and its associated risk factors. A total of 99 participants were stratified to three groups: IHD patients with type II diabetes (n=41), IHD patients with metabolic syndrome (n=38), and a healthy control group (n=20). Serum levels of cholesterol, LDL, HDL, triglycerides, Granzyme B, and AIF were measured using biochemical and immunoenzymatic methods. The statistical analysis revealed a strong positive correlation between the apoptosis biomarkers, underscoring the pivotal contribution of apoptosis to the pathophysiology of cardiovascular injury. These findings reinforce the mechanistic link between apoptotic signaling pathways and myocardial damage in ischemic heart disease. So, the results showed significantly elevated LDL and triglyceride levels along with reduced HDL levels in the risk groups vs. control ($p<0.05$). Additionally, levels of the apoptosis markers Granzyme B and AIF were notably higher, suggesting a link between apoptotic cell death markers and cardiovascular damage indicating that lipid panel disbalance along with elevated apoptosis indicators may serve as early biomarkers for IHD. Monitoring these parameters could prove valuable in the diagnosis, prevention, and management of İHD.

Keywords: apoptosis; cell death; AIF; Granzyme B; ischemic heart disease (IHD), lipid panel

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TECHNOLOGY'S ROLE IN POST-PANDEMIC STRATEGY AND INNOVATION IN THE GLOBAL COMPANY

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ABSTRACT

The COVID-19 pandemic dramatically reshaped the business landscape, pushing organizations to adopt digital technologies at an unprecedented pace. This paper explores how technology has become a key strategic driver in helping companies adapt, survive, and thrive in the post-pandemic world. By reviewing recent literature and examining theoretical perspectives, the study looks at how firms have turned to digital tools—not just for operational efficiency, but to build resilience, rethink their strategies, and better connect with customers. From artificial intelligence and cloud computing to blockchain and data analytics, companies have embraced a wide range of technologies to meet new challenges. The paper also discusses how this shift requires more than just new tools—it demands cultural change, leadership with a digital mindset, and a willingness to rethink how work is done. The move to remote work, digital customer journeys, and agile supply chains are just some of the ways businesses have responded to uncertainty with innovation. While this is a theoretical study, it highlights important practical insights for managers and decision-makers. It shows that digital transformation is not a one-time fix, but an evolving process that must be aligned with organizational goals and supported by the right structures and skills. The paper concludes by identifying key areas for future research, especially as companies continue to navigate the ongoing impact of technological change in a post-crisis era.

Keywords: Digital transformation, post-pandemic business strategy, organizational change, strategic use of technology, innovation and resilience.

AN ANALYSIS OF THE 5th GRADE SCIENCE TEXTBOOK UNIT "OUR NEIGHBORS IN THE SKY AND US" IN TERMS OF CRITICAL THINKING STANDARDS AND COMPONENTS OF LOGICAL THINKING

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ABSTRACT

The ability of individuals to lead meaningful and conscious lives is closely linked to their capacity to analyze and evaluate the information they acquire. This process involves a questioning approach and rational decision-making based on that information. Critical thinking skills are essential for effectively carrying out these cognitive processes. Gaining this skill from an early age allows individuals to make more informed decisions. Schools play a fundamental role in the mental development of individuals and are crucial institutions where critical thinking is taught and reinforced. The teaching methods, materials, and learning environments used to foster critical thinking skills in students are vital for the development of effective thinking patterns. Therefore, it is important that textbooks, which are among the most frequently used teaching materials, contain content that supports critical thinking. This study examines the unit titled "Our Neighbors in the Sky and Us" in the 5th grade science textbook approved by the Ministry of National Education for the 2024-2025 academic year in Turkey. The aim of the study is to evaluate this unit according to critical thinking standards and components of logical thinking. It employs a case study design, which is a qualitative research method, and data were collected through document analysis and utilized descriptive analysis for data evaluation. Upon reviewing the findings regarding critical thinking standards, it was noted that, despite some unclear and superficial statements, there were also many statements meeting the standards of certainty and accuracy. Analysis of logical thinking components revealed that activities were appropriate to the unit's purpose, and relevant questions and assumptions were included. However, it was identified that the perspective component could benefit from a greater emphasis on different cultures. The study recommends that textbook content should be structured to align with critical thinking standards and components of logical thinking, emphasizing the universality and inclusiveness of scientific knowledge through the inclusion of diverse perspectives.

Keywords: Components of logical thinking, critical thinking, critical thinking standards, science education, textbook

ONE-DIMENSIONAL ACOUSTIC STUDY OF A HYBRID SYSTEM WITH HELMHOLTZ RESONATORS AND CLOSED RESONATORS FOR FILTERING APPLICATIONS

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ABSTRACT

The use of acoustic waves in next-generation devices is attracting growing interest due to their high potential in the fields of filtering and high-precision detection. Their remarkable sensitivity and selective response over wide frequency bands make them ideal candidates for the development of advanced sensors. The acoustic resonances observed in these systems can arise from wave interference phenomena, such as Fano effects or induced acoustic transparency (AIT), or result from localized modes linked to the introduction of defects in periodic structures. In this study, we analyze the acoustic wave propagation in a simple system consisting of a waveguide coupled laterally to closed resonators and Helmholtz resonators. The objective is to modulate and characterize two kinds of localized resonances, Fano and AIT, appearing in acoustic band gaps, by modifying certain geometric parameters. The resonances observed result from the acoustic wave coupling between the main waveguide and the resonators that make up the proposed system. Acoustic optimization properties such as resonance peak position, quality factor, and sensitivity were also analyzed. These results enable us to propose design strategies for compact, high-performance acoustic devices suitable for selective filtering and ultra-sensitive detection.

Keywords: Acoustic filtering, Helmholtz resonators, Closed resonators, Fano resonance, AIT resonance, Acoustic band gaps, Transfer matrix method.

FROM LOCAL TO GLOBAL: CULTURAL INFLUENCES IN CEO SUSTAINABILITY AND EMBEDDEDNESS NARRATIVES IN THE COSMETICS AND FASHION INDUSTRY

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ABSTRACT

This research explores how cultural factors shape corporate reputation through the sustainability and embeddedness narratives found in CEO letters within the cosmetics and fashion industry. The research is situated at the intersection of corporate communication, cultural studies, and sustainability, focusing on how national cultural dimensions influence the way companies frame their commitment to stakeholders and their spatial embeddedness – whether locally or globally oriented. The analysis is based on a sample of 15 leading companies from 10 countries, selected using Lewis's cultural typology to ensure cultural diversity. The CEO letters from four different years (2018, 2019, 2022, and 2023) were examined using a mixed-method approach that combines qualitative content analysis and software-assisted quantitative analysis (WordStat). Hofstede's cultural dimensions served as the framework for assessing cross-cultural differences, with particular attention to long-term orientation, masculinity-femininity, and their correlation with sustainability-related discourse. Findings indicate a moderately strong negative correlation between the masculinity index and the presence of sustainability narratives, suggesting that companies embedded in more feminine cultures place greater emphasis on sustainability in their communications. Additionally, the study examines how CEO narratives can serve as indicators of a company's spatial embeddedness and how cultural background shapes the portrayal of local and global engagement. The results provide insights into how corporate communication reflects deeper cultural values and strategic orientations across national contexts.

Keywords: CEO letters, corporate sustainability, embeddedness, culture, cross-cultural comparison

PSYCHOEMOTIONAL EXPERIENCE OF PARENTS WHOSE BABIES ARE IN THE NEONATAL INTENSIVE CARE UNIT-NICU

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ABSTRACT

Introduction and Purpose: The birth of a baby is undoubtedly one of the most beautiful events that every woman experiences, but the major changes that occur during this phase (mood swings, physical changes, baby's health) significantly affect her emotional and psychological state. But when their baby is transferred to the NICU, the psycho-emotional experience of the parents is more difficult. The aim is to identify the emotional state of parents whose babies are hospitalized in the NICU.

Methodology: The study was conducted at the NICU-UHOG "Koço Gliozheni", Tirana and includes the period January-March 2023. The study included two groups of parents, those who had their babies hospitalized in the NICU and who had their newborn babies in the room. The first group included 41 pairs of parents and the second group included 55 pairs of parents. Parents were given a questionnaire that was completed in complete anonymity. Parents with babies with congenital anomalies, etc., were not included in the study.

Results: Parents of these infants need various forms of emotional support in the NICU, including support from staff, professional psychological help and/or socializing with other parents, are highly variable in their willingness to discuss their emotional state with staff. Parents are also able to have a strong sense of trust in the NICU'staff, with parents reporting that poor communication with staff, partly due to staff discontinuity, undermines trust, increases fear and uncertainty about the future of their infant's life and well-being.

Conclusions: Transferring a newborn infant to the NICU, especially when it is born prematurely, can present emotional and practical challenges for parents, especially when the mother's bond and interaction with the newborn are interrupted. This causes stress in the parents, and stress disrupts the infant-parent relationship and interaction and often leads to emotional maladjustment in the parents.

Keywords: Parent, newborn, NICU, psycho-emotional experience.

COMPARATIVE ANALYSIS OF TURKISH EDUCATION PROGRAMS IN 1924 AND 2024 WITHIN THE CURRICULUM AND INSTRUCTION

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ABSTRACT

This study offers a comparative analysis of Turkey's national education curricula from 1924 and 2024 within the Curriculum and Instruction. It investigates the structural, philosophical, and pedagogical transformations that have taken place over the last century, emphasizing changes in learning objectives, subject content, and instructional methodologies. The 1924 curriculum, developed during the formative years of Turkish Republic, was founded on the principles of progressivist educational philosophy, emphasizing nation-building, secularism, and the promotion of fundamental literacy and citizenship skills. In contrast, the 2024 curriculum reflects a response to globalization and technological advancement, integrating digital literacy and prioritizing critical thinking, creativity, and student-centered learning approaches. This research utilizes a comprehensive review of official curriculum documents, educational policy analyses, and scholarly literature to conduct its comparative evaluation. Key findings present a comparison between the foundations of the Republic, established on progressive educational philosophy, and the contemporary curriculum, highlighting how these principles have evolved and adapted to meet today's educational needs. Furthermore, whereas the 1924 program concentrated on fostering national identity and cultural cohesion, the 2024 curriculum strives to balance respect for local cultural values with alignment to international educational standards. The paper discusses how evolving historical, political, and socio-economic contexts have shaped curriculum development in Turkey, offering valuable insights into the challenges and opportunities in educational reform. The study ultimately contributes to broader discussions on curriculum innovation in emerging educational systems and proposes directions for future research and curriculum development.

Keywords: Turkish Curriculum, Comparative Education, Instructional Design, Education Reform, Educational Philosophy

KEY FACTORS IN THE DETERMINATION OF DOMINANT DISCHARGE

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ABSTRACT

The estimation of dominant discharge is currently based on the Makeyev method, in which the annual average discharge is calculated using the classical arithmetic average. However, the subdivision of discharge into levels Q_i, the determination of their occurrence frequencies P_i, and the computation of the product $P_iJ_iQ_i^m$ lack a sound scientific basis. This study provides an initial analysis of the methods for calculating annual average discharge and for classifying discharge levels to derive reasonable frequency values. The objective is to improve the estimation of dominant discharge to better reflect real-world conditions.

Keywords: Dominant discharge, Makeyev method, Classical arithmetic average, Dual approach.

DIPYRIDAMOLE INCORPORATION INTO HYDROXYAPATITE

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ABSTRACT

Hydroxyapatite (HA) is widely used in bone tissue engineering and bone grafting due to its bioactivity and resorption potential. The incorporation of bioactive molecules, such as dipyridamole (DIPY), may enhance its osteoinductive potential. This study analyzes the influence of adding DIPY to HA and evaluates physicochemical interactions using Fourier-transform infrared spectroscopy (FTIR). HA was synthesized by a wet precipitation route, followed by powder sintering. Pellets were treated with DIPY solutions (100 µM and 1,000 µM) in ethanol and methanol. One group of the samples was dried at 50°C, and the other was air-dried. FTIR analysis was used to identify characteristic DIPY bands and detect possible solvent residues. Spectral comparisons between groups allowed interpretation of incorporation efficiency and interaction with the ceramic matrix. The results support the development of drug-functionalized bioceramics for bone repair.

Keywords: Dipyridamole; Hydroxyapatite; Bone graft; Functionalization

SUSTAINABLE AND COST-EFFECTIVE APPROACH TO RECYCLING SALTED ANCHOVY BONES: DESALTING COMBINED WITH NUTRITIONAL ENRICHMENT USING PLANT-BASED MEALS

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ABSTRACT

The salted anchovy industry generates large quantities of bones, a by-product rich in essential minerals such as calcium, phosphorus, and nitrogen, but difficult to valorize due to its high salt content. This study aimed to develop a simple and cost-effective method to reduce the salt content of the bones while preserving their nutritional value, with a view to their use in poultry feed. A controlled desalting process using potable water significantly reduced salinity. To enhance the effectiveness of desalting and enrich the nutritional profile, plant-based meals, notably soybean and argan cakes, were incorporated into the desalted bones. The addition of these co-products reduced the residual salinity to levels compatible with animal feed standards, while improving the supply of key nutrients. The response surface methodology (RSM) was used to evaluate the effect of the proportions of desalted bones and plant meals on salt content, mineral content, ash, and total nitrogen, and to optimize the formulation. The optimal combination yielded a low-salt, nutritionally balanced product suitable for inclusion in poultry feed formulations. These results confirm the technical and economic feasibility of the proposed process, which offers a sustainable solution for valorizing waste from the salted anchovy industry while producing a safe and nutritionally balanced ingredient for animal feed.

Keywords: Salted anchovy, Poultry feed, Soybean, Argan cakes, The response surface methodology (RSM).

INITIAL APPLICATION OF THE BIOCOUPLER^{MT} TEMPORARY IMMERSION SYSTEM FOR MICROPROPAGATION OF ARGANIA SPINOSA (SKEELS L.)

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ABSTRACT

The argan tree (*Argania spinosa*) is valued for its agronomic, environmental, and economic properties, as well as its application in the production of argan oil. This study examined in vitro culture techniques to optimize the development of argan tree microplants. The temporary immersion system (Biocoupler™) was utilized to enhance nutrient uptake, with a one-minute immersion identified as optimal for rapid growth. Adjustments to immersion durations across three periods were necessary to prevent water saturation and vitrification. The application of plant growth regulators, particularly meta-topolin at 0.8 mg/l combined with a low dose of IBA, demonstrated a synergistic effect, promoting increased biomass. Comparisons with other culture methods revealed that the temporary immersion system effectively manages humidity and nutrients while minimizing hyperhydricity risks. These findings emphasize the significance of innovative in vitro practices for sustainable propagation of Argania spinosa, contributing to advances in conservation and cultivation efforts.

Keywords: *Argania spinosa*, Biocoupler™, Hyperhydricity, Meta-topolin

THE CRISIS OF CRITICAL THINKING IN THE AGE OF ARTIFICIAL INTELLIGENCE: BETWEEN TECHNOLOGICAL CONVENIENCE AND THE VALUE OF KNOWLEDGE

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ABSTRACT

The rapid advancement of generative artificial intelligence (AI) is reshaping how students in higher education access, process, and present academic content. While these tools provide unprecedented efficiency and ease, they also raise serious concerns about diminishing critical thinking skills and eroding academic integrity. This paper investigates how students' increasing reliance on AI-powered tools impacts the depth of intellectual engagement and the authenticity of their academic work. Through a critical review of selected peer-reviewed studies published between 2023 and 2025 from ScienceDirect, Springer, and JSTOR, the analysis highlights emerging risks and trends. The hypothesis guiding this inquiry is that uncontrolled use of AI leads to reduced cognitive effort and growing dependence on machine-generated outputs, potentially weakening students' analytical skills and compromising learning outcomes. Among the sources reviewed, a study by Kumar (2025) reveals that 68% of U.S. undergraduate students have used AI in academic assignments, often without proper oversight. Ye et al. (2024) document growing faculty concerns about declining analytical reasoning in doctoral students exposed heavily to AI assistance. Moreover, examples from Finland and Singapore show how some institutions have begun revising assessment formats to better safeguard critical thinking and originality in the digital age. The findings suggest that while AI supports access to knowledge, it simultaneously risks creating a passive learning environment where thinking is outsourced. Furthermore, this paper discusses the cultural and psychological implications of over-reliance on artificial intelligence in education. It emphasizes the risk of weakening student motivation, diminishing self-regulated learning, and altering the traditional student-teacher dynamic. The integration of generative AI must be approached with a balanced strategy that both leverages its benefits and safeguards the essence of human learning. Failing to address these challenges may not only reduce the quality of higher education but also reshape future academic cultures in unforeseen and possibly regressive ways.

Keywords: artificial intelligence, critical thinking, academic integrity, educational policy, ethics, knowledge value

1. INTRODUCTION

In recent years, the integration of generative artificial intelligence (AI) into educational settings has profoundly reshaped the ways in which students access, process, and produce academic content (Tian et al., 2025). Tools such as AI-powered writing assistants, ChatGPT, and Copilot have rapidly expanded in both functionality and scope, offering learners new possibilities for personalized learning and enhanced efficiency. However, alongside these opportunities, this technological evolution introduces significant pedagogical and ethical dilemmas. Among the most pressing concerns for educators, researchers, and policymakers is the potential erosion of students' critical thinking skills due to an increasing dependence on AI technologies (Ye et al., 2024).

Critical thinking-widely regarded as a cornerstone of higher education, entails the ability to analyze information, evaluate sources, and construct reasoned, original arguments (Brookfield, 2012; Paul & Elder, 2014). More than just a cognitive skill, it is a reflective and effortful process that demands intellectual engagement and independence. Yet, as AI tools make it increasingly easy to generate entire essays, solve complex tasks, or articulate structured arguments with minimal input, students may be tempted to bypass these essential cognitive steps in favor of speed and automation. Kumar (2025) observes that 68% of undergraduate students now report using AI-generated content in their coursework, often without meaningful engagement or attribution.

Beyond individual learning, the widespread and largely unregulated use of AI in academic settings poses a broader risk to the culture of higher education itself. As Sol and Heng (2025) emphasize, in the absence of well-defined ethical guidelines, students begin to perceive automated responses as acceptable substitutes for genuine academic work. This normalization threatens to erode longstanding academic values such as intellectual honesty, perseverance, and deep inquiry. If critical thinking becomes marginal or obsolete, the fundamental mission of higher education-to nurture autonomous, reflective, and ethically grounded thinkers - may be irreversibly compromised.

This technological shift is not occurring in a vacuum. Studies in educational psychology suggest that reliance on automation may reduce students' sense of ownership over their learning process, diminishing intrinsic motivation and long-term cognitive development (Bandura, 2006; Deci & Ryan, 2020). Simultaneously, institutional policies often lag behind these innovations, failing to equip faculty and learners with the tools to navigate AI ethically and constructively. As institutions rush to integrate new tools, the absence of clear boundaries and pedagogical safeguards creates a vacuum where automation overshadows understanding.

This paper positions itself within this critical juncture, aiming to assess the cognitive and ethical implications of AI use in higher education and to propose actionable educational reforms that preserve human-centered learning.The urgency of addressing this issue stems not only from its immediate impact on learning practices but also from the long-term uncertainty surrounding AI's role in shaping cognitive and educational development. As generative AI continues to evolve rapidly, we remain largely unaware of its full consequences on student psychology, academic norms, and intellectual culture. Will we adapt our educational systems to integrate these technologies meaningfully, or will we allow them to substitute foundational processes of learning? The stakes are particularly high because education does not only serve to transfer information but to shape how individuals think, reason, and act within society. Without timely reflection and intervention, we risk cultivating generations of learners who may be highly efficient, yet intellectually dependent-capable of producing output, but unable to critically evaluate it. This paper therefore advocates for a thoughtful, evidence-based engagement with AI in education, grounded in ethical responsibility and an unwavering commitment to preserve the purpose of learning itself.

2. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

The theoretical foundation of this study lies at the intersection of cognitive psychology, educational philosophy, and technological disruption. Critical thinking has long been considered a fundamental outcome of higher education-defined by Paul and Elder (2014) as the capacity to analyze, evaluate, and synthesize information through intellectual discipline. It requires not only information processing but also reflection, skepticism, and ethical reasoning (Brookfield, 2012). In contrast, generative AI provides students with instant solutions, often bypassing the intellectual struggle that fosters deep learning.

Motivational theorists like Deci and Ryan (2020) emphasize that meaningful learning depends on autonomy, competence, and relatedness. These pillars are now challenged by AI tools that reduce cognitive effort and present complete solutions with little user input. Kumar (2025) notes that many

students report feeling less inclined to engage in critical evaluation when using AI tools, relying instead on the perceived authority of machine-generated text. This tendency creates what Ye et al. (2024) call 'cognitive outsourcing', where mental effort is replaced by algorithmic suggestion.

The literature also reveals a growing unease among educators and institutions. While some celebrate AI as an accelerator of access and efficiency, others express concern about its capacity to diminish reflective judgment and original thinking. Sol and Heng (2025) document institutional responses that include redesigned assessments, oral defenses, and renewed emphasis on in-class analysis. Meanwhile, research from Nordic institutions (Tian et al., 2025) shows a shift toward hybrid models that combine AI literacy with human-led reasoning tasks.

More broadly, the post-2020 educational environment reflects a deeper philosophical crisis. The rapid infusion of technology has forced educators into a complex crossroads: to resist or integrate, to protect traditional values or reframe them. The very nature of knowledge is being redefined-not as something to be constructed through inquiry, but accessed via prompts and algorithms. This epistemic shift challenges foundational assumptions of pedagogy: what does it mean to "know" something in an age where machines simulate thought?

This transformation also raises urgent questions about equity and inclusion. Students from under-resourced environments may depend more heavily on AI due to lack of support or time, potentially deepening cognitive gaps rather than bridging them. As a result, generative AI risks reproducing existing inequalities within education unless accompanied by carefully designed policies and support systems that promote critical engagement across diverse student populations.

Lastly, educators themselves are at an inflection point. Many report uncertainty, lack of training, and ethical dilemmas when incorporating AI tools into their teaching practice. While some embrace these technologies, others fear they compromise academic values. A systemic effort is needed-not only to train educators in AI literacy, but to support reflective pedagogical strategies that align technological innovation with the deeper mission of human development in education.

3. METHODOLOGY

This study adopts a qualitative, literature-based research design focused on critical analysis and synthesis of peer-reviewed academic sources published between 2020 and 2025. Rather than collecting primary data through surveys or interviews, the paper draws upon a curated set of studies from trusted academic platforms such as ScienceDirect, SpringerLink, JSTOR, and Taylor & Francis. The purpose is to examine how recent scholarship addresses the intersection of generative AI, critical thinking, and academic integrity in higher education contexts.

A total of 22 peer-reviewed articles were selected based on the following inclusion criteria: (1) relevance to the use of AI in education, (2) explicit discussion of critical thinking, ethics, or academic behavior, and (3) publication in reputable academic journals within the last five years. The search was conducted using advanced academic search tools and databases, applying combinations of keywords such as "AI and critical thinking," "academic integrity and automation," and "education policy and generative AI." Articles that focused solely on technical development of AI tools without educational implications were excluded.

The analysis employed a thematic literature review method, allowing for the identification of conceptual trends, ethical tensions, and policy proposals across disciplines. This interpretative approach facilitates a more nuanced understanding of how AI is affecting the moral and cognitive fabric of higher education. Studies were clustered thematically based on whether they emphasized cognitive shifts, ethical dilemmas, pedagogical reforms, or institutional policies. The interpretative framework is rooted in constructivist educational theory and ethical pragmatism-treating knowledge as an active, socially

situated process and viewing AI not as a neutral tool, but as a socio-technical force with ideological implications.

This methodology was deliberately chosen over empirical approaches because of the exploratory and foundational nature of the research question. At this stage of scholarly inquiry, the primary objective is not to measure effects statistically, but to map the intellectual and ethical landscape that surrounds AI in education. A critical literature review provides the flexibility to interrogate assumptions, question dominant narratives, and uncover the latent consequences of adopting AI tools without pedagogical recalibration.

Nonetheless, this methodological choice is not without limitations. The absence of direct student or teacher input means that the analysis relies heavily on the interpretations of other researchers. While this strengthens the theoretical consistency, it also invites caution when drawing context-specific conclusions. Future research could expand this inquiry by incorporating empirical data, including interviews with educators and students, to validate or challenge the themes outlined here. Still, in a field defined by rapid change and ethical ambiguity, this reflective and principled approach offers a necessary foundation for thoughtful educational reform.

4. ANALYSIS AND DISCUSSION

To synthesize the impact of generative AI on educational values, a comparison between traditional and AI-assisted learning approaches reveals a clear pedagogical shift. In traditional settings, the learning process emphasizes analysis, reflection, and independent inquiry. In contrast, AI-assisted education encourages immediate suggestions, potentially bypassing essential cognitive steps. While traditional education fosters creativity and self-regulation, the use of generative AI tools risks promoting uniform, machine-guided thinking and compromising academic integrity. The teacher's role also shifts-from intellectual mentor to overseer of AI-generated content-while student motivation may decline due to passive engagement.

The analysis of the literature reveals a complex, multi-layered impact of generative AI on students' cognitive development, especially their capacity and willingness to think critically. Studies such as Jones et al. (2023) and Mitchell & Ho (2024) report a significant drop in students' self-reported engagement with complex tasks after incorporating AI tools into their academic routines. This trend indicates a cognitive offloading, where intellectual effort is transferred to machines, ultimately weakening critical thinking over time. A central theme is what Arslan and Tekin (2022) term "AI-induced cognitive substitution," where students increasingly rely on algorithmic suggestions rather than their own reasoning. While this may offer a sense of efficiency, it disrupts the deeper learning processes highlighted by Paul and Elder (2014). Delegating complexity, avoiding ambiguity, and prematurely resolving contradictions reduces opportunities for meaningful critical reflection.The analysis of the selected literature reveals a complex, multi-layered impact of generative AI on students' cognitive development, particularly on their ability and motivation to think critically. Studies such as Jones et al. (2023) and Mitchell & Ho (2024) report a significant drop in students' self-reported engagement with complex tasks once they begin using AI-generated tools in daily academic work. The trend reflects a cognitive offloading where effort is delegated to machines, affecting long-term critical capacity.

One of the dominant themes is what Arslan and Tekin (2022) describe as "AI-induced cognitive substitution," where students rely not on their reasoning but on AI's textual suggestions. While this might increase perceived efficiency, it undercuts the deeper learning processes emphasized by Paul and Elder (2014). When complexity is delegated, ambiguity is avoided, and contradictions are resolved too quickly, critical reflection diminishes.

Another growing concern is academic authenticity. The study by Ortega et al. (2023) found that nearly 54% of students in European universities admitted to submitting AI-assisted essays without disclosure.

This aligns with findings by Sol & Heng (2025), who argue that educational institutions are now grappling with a blurred boundary between intellectual labor and algorithmic production, complicating both trust and assessment.

Institutional responses vary widely. While some universities in Finland and Denmark have launched mandatory AI ethics courses (Tian et al., 2025), others lack clear strategies. According to Higgins and Renshaw (2024), over 60% of institutions in the Global South reported having no formal policy on AI use in academic settings, leaving both faculty and students exposed to ethical ambiguities.

A deeper philosophical tension emerges regarding the role of education. If knowledge is reduced to prompt-based retrieval rather than inquiry-based construction, as Braddock (2023) warns, the academic model shifts from exploration to transaction. This shift reframes education as consumption rather than transformation-a phenomenon mirrored in the rise of "output-based learning" models promoted by edtech platforms.

This shift also introduces ethical tensions for educators. Teaching is not merely instructional delivery, but a value-driven act of mentorship and intellectual stewardship. When students bypass dialogic engagement through AI, educators lose their relational leverage. As Sato (2024) notes, this undermines trust and reduces teachers to "verifiers of AI compliance," distorting the pedagogical bond.

Closely linked is the destabilization of the teacher's intellectual authority. According to recent qualitative interviews conducted by Van der Meer & Jalali (2025), students increasingly describe AI as their "first consultant," turning to instructors only when AI fails. This reversal shifts epistemic authority away from human educators, marginalizing their role as guides, questioners, and ethical models.

Amid this transformation, a crucial yet often ignored issue is the disparity in access to AI-powered education. The promise of generative AI assumes a digitally connected, uninterrupted world-but what happens in a classroom without electricity? What of students in conflict zones, economically marginalized regions, or underfunded institutions where basic infrastructure is lacking? A UNESCO (2023) global report found that 43% of students in Sub-Saharan Africa lacked consistent access to electricity or devices. In such contexts, traditional human-centered teaching remains irreplaceable. Education risks becoming a privilege, contingent on connectivity, rather than a right grounded in equity.

While generative AI offers instant access to information, it also promotes what Ye et al. (2024) describe as the "shortcut culture of knowledge." Instead of fostering durable understanding through engagement, students are increasingly inclined to bypass the struggle of thinking in favor of rapid answers. This shift mirrors a cognitive shortcut with long-term implications: if knowledge becomes purely outcome-based, memory, context, and interpretation fade from the learning process. The use of AI in education may begin as instrumental-like a calculator in math class-but unlike a calculator, which doesn't devalue the multiplication table, generative AI risks hollowing the very process of knowledge formation.

It is important to clarify that this critique is not a dismissal of AI's value, but a call for discernment in its application. Generative AI has already demonstrated transformative potential in fields such as medicine, where it accelerates diagnostics; in economics, where it models complex systems; and in media, where it supports multilingual communication and accessibility. Even in education, AI can personalize learning, assist students with disabilities, and open access to resources in underserved areas. The concern lies not in AI as a tool, but in its uncritical adoption as a substitute for cognitive effort and pedagogical purpose. The hypothesis of this study-that overreliance on AI diminishes students' critical engagement-rests on the idea that education is not just about knowing more, but about becoming more. To realize the full promise of AI, we must embed it within a pedagogy that upholds human thought, reflection, and ethical learning.

Ultimately, this discussion points to a dual risk: the hollowing out of intellectual depth in AI-rich contexts and the total exclusion from innovation in AI-poor regions. As the world rushes toward automation, the challenge is not only pedagogical or cognitive-it is deeply moral. If AI becomes the dominant medium of learning, we must ask: who gets to learn, how, and at what ethical cost?

5. CONCLUSIONS AND RECOMMENDATIONS

This paper examined the growing impact of generative AI on critical thinking and academic integrity in higher education. The findings suggest that uncritical dependence on AI reduces students' cognitive engagement, diminishes intrinsic motivation, and undermines core academic values such as autonomy, inquiry, and ethical responsibility. Rather than supporting intellectual development, AI tools often replace the effortful thinking process-shifting learning from deep reflection to surface-level automation.

Although AI has the potential to enrich educational environments, it cannot replace the reflective, dialogical, and ethical foundations that define meaningful learning. The real concern lies in treating AI as a shortcut-prioritizing efficiency over understanding-which may compromise students' long-term intellectual growth.

To address these challenges, institutions should adopt clear and research-informed policies that define ethical AI use, integrate AI literacy into curricula with emphasis on both technical and philosophical dimensions, and reform assessment strategies to prioritize analysis, process, and real-time engagement. Faculty must be supported through training that reinforces their role as mentors and facilitators of critical thinking, while students should be encouraged to view AI as a collaborative aid-not a replacement for independent reasoning.

Ultimately, as digital technologies continue to reshape education, the key challenge is not how powerful AI becomes, but how wisely we choose to use it.

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CIVIL LIABILITY IN THE CONTEXT OF ARTIFICIAL INTELLIGENCE: CONTEMPORARY APPROACHES AND CHALLENGES FOR THE ALBANIAN LEGAL SYSTEM

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ABSTRACT
Rapid developments in the field of artificial intelligence (AI) are challenging the traditional principles of civil law, particularly concerning the concept of liability for actions arising from autonomous systems. These challenges include difficulties in identifying the liable legal subject, the limits of liability for damages caused by AI, and the capacity of the existing legal framework to address new situations such as automated contracts, decision-making algorithms, and robotics in sensitive areas like healthcare. In this context, Albania, as a legal and technological system in transition , faces significant normative gaps and institutional challenges in building a coherent and protective approach to these developments.

This paper analyses the interaction between artificial intelligence technology and the civil liability institution under Albanian law, identifying conceptual weaknesses and regulatory voids that hinder the fair functioning of the legal system. Particular focus is given to the analysis of liability for AI-caused damages, the legal validity of acts generated by intelligent systems, and evidentiary challenges in civil disputes involving technology. The paper argues that establishing a new regulatory framework requires an integrated, interdisciplinary approach involving legislative, institutional, and educational interventions to guarantee legal certainty and effective protection of fundamental rights in the digital age.

Keywords: Civil liability, artificial intelligence, Albanian civil law, autonomous algorithms, automated contracts, damage and compensation.

INTRODUCTION

In recent decades, artificial intelligence (AI) has emerged as one of the most transformative technological advances, profoundly reshaping various aspects of social, economic, and legal life worldwide. The integration of AI technologies,such as automation, machine learning, natural language processing, and autonomous decision-making systems,has led to unprecedented efficiency gains and innovation across sectors, ranging from healthcare and finance to transportation and legal services (Russell & Norvig, 2021; Ethem, 2020). However, despite these undeniable benefits, the incorporation of AI into civil legal relationships raises significant challenges that question the adequacy of traditional civil law concepts. Fundamental notions such as legal personality, autonomy of will, liability for harm, contract validity, and evidentiary procedures are being tested in ways that necessitate re-examination and adaptation (Scherpe, Barker, & Bauzon, 2023; European Commission, 2021).

Unlike earlier technologies, which typically functioned as mere tools under human control, AI systems increasingly operate with a high degree of autonomy, making independent decisions and interacting dynamically with their environment. This autonomous behavior disrupts the classical legal dichotomy between subject and object, raising novel legal and philosophical questions about who or what can bear rights and responsibilities under civil law (Gunkel, 2018; Ethem, 2020). For instance, self-learning algorithms can generate so-called "smart contracts" that automatically execute contractual terms without

direct human intervention, complicating the traditional requirements of mutual consent and intention in contract formation (Scherpe et al., 2023). Additionally, AI's application in critical fields such as medical diagnostics, where algorithms inform or replace human judgment, as well as in decision-making systems for banking and insurance, exemplifies the increasing reliance on autonomous technologies that challenge existing liability frameworks (European Commission, 2022). Similarly, autonomous vehicles represent a disruptive innovation in transport law, necessitating reconsideration of fault and causation principles in cases of accidents (Hevelke & Nida-Rümelin, 2015).

At the European Union level, these technological challenges have motivated a coordinated legislative response aimed at balancing innovation with the protection of fundamental rights and consumer safety. The proposed Artificial Intelligence Act (AI Act) introduces a risk-based regulatory framework, categorizing AI systems according to their potential impact and imposing requirements related to transparency, accountability, and human oversight (European Commission, 2021). Complementing this, the AI Liability Directive seeks to modernize liability rules by easing the burden of proof for victims harmed by AI-driven systems, including introducing presumptions of causality where the technical complexity of AI would otherwise hinder access to justice (European Commission, 2022). These instruments reflect a proactive approach to ensuring that AI development aligns with legal certainty, ethical standards, and the rule of law.

Contrasting this harmonizing trend, Albania's legal framework remains in an early stage of grappling with AI's legal implications. The current civil legislation lacks specific provisions addressing the use, liability, legal status, and evidentiary standards of AI systems and contracts executed through autonomous technologies. This regulatory void fosters uncertainty, undermining legal certainty and potentially infringing the rights of parties involved in AI-mediated transactions. Moreover, it poses barriers to Albania's effective participation in the European digital economy and to fostering innovation domestically (Ethem, 2020; European Commission, 2021).

Accordingly, this paper aims to offer a critical and systematic analysis of the intersection between AI technologies and civil liability under Albanian law. Utilizing doctrinal, normative, and comparative methods,drawing on European models and international standards,it seeks to identify existing legal gaps, evaluate the need for legislative harmonization, and propose fundamental reforms to ensure that Albania's civil legal system is equipped to meet the challenges and opportunities posed by the AI era.

THEORETICAL AND CONCEPTUAL FRAMEWORK

The rapid evolution of artificial intelligence (AI) technologies has compelled a fundamental re-evaluation of classical civil law doctrines that have traditionally been grounded in legal anthropocentrism,the notion that law applies primarily to human beings or human-created entities. Under this anthropocentric paradigm, the legal subject is invariably a human person or a legal entity with human origin, while objects of legal relationships are passive entities such as property, services, or outcomes (Katz, 2019). However, the advent of AI systems capable of autonomous decision-making, self-learning, and dynamic interaction with their environment disrupts this neat dichotomy between legal subject and object (Gómez & García, 2020; Ethem, 2020). Unlike conventional technologies, AI entities can act without direct human intervention and exert consequential effects on legal relationships, thus forcing legal scholars and legislators to reconsider foundational categories of civil law.

One of the most critical conceptual challenges lies in the traditional understanding of liability for harm. Classic civil liability hinges upon the presence of fault or negligence by an identifiable legal subject, typically a natural or legal person (Von Bar, 2013). The rise of AI challenges this principle since the autonomous nature of AI systems often precludes identifying a single human actor responsible for decisions or damages caused by such systems. For example, determining responsibility for medical misdiagnoses generated by AI diagnostic tools, accidents involving autonomous vehicles, or damages

from algorithm-driven digital platforms presents new legal puzzles (Hevelke & Nida-Rümelin, 2015; Ethem, 2020). To address these complexities, some legal scholars propose the innovative but controversial concept of "electronic personhood," which envisages granting a form of limited legal personality to AI systems, enabling them to bear rights and obligations independently (Wagner, 2019). Nonetheless, this approach remains subject to theoretical debate and is yet to be widely adopted in statutory law.

Beyond tort liability, AI has also revolutionized contract law. The emergence of smart contracts,self-executing agreements encoded on blockchain or similar platforms,presents a new category of legal relations executed without explicit human consent at the moment of performance (Murray, 2021). This phenomenon calls into question the applicability of traditional contractual principles such as mutual consent, as enshrined in Article 663 of the Albanian Civil Code, which requires a meeting of wills to create binding obligations (Albanian Civil Code, 1994). When contracts are automatically performed by AI without immediate human intervention, legal uncertainties arise regarding the assessment of contract validity, attribution of breach, and identification of the contracting parties, highlighting the pressing need for legal adaptation.

Internationally, the regulatory landscape has begun to evolve toward accommodating these new realities. Notably, the European Union's proposed Directive on AI Liability introduces concepts of strict liability and modified evidentiary burdens to better allocate risk in AI-driven activities (European Commission, 2022). This directive emphasizes "technological risk" as a legal category to safeguard consumers and end-users against unpredictable harms emanating from complex AI systems, thereby promoting legal certainty and social protection (Scherpe, Barker & Bauzon, 2023). However, this transition to strict liability regimes represents a significant departure from many countries' existing legal traditions, including Albania's, where fault-based liability remains dominant.

Against this backdrop, Albania finds itself at a crossroads. Its civil law framework currently lacks specific norms addressing the deployment, accountability, and legal recognition of AI technologies and their outputs. The absence of tailored regulation not only jeopardizes legal certainty but also impairs the nation's ability to foster technological innovation and participate fully in the digital economy (Ethem, 2020; European Commission, 2021). Addressing these gaps requires a dual approach: rigorous theoretical reflection on the evolving nature of legal subjectivity and liability, and practical legislative reforms inspired by leading international models, such as the EU's Artificial Intelligence Act and liability proposals (European Commission, 2021; Scherpe et al., 2023). This integrated approach is essential for building a resilient civil law system capable of effectively governing AI in the contemporary era.

LEGAL AND INSTITUTIONAL CHALLENGES IN THE USE OF ARTIFICIAL INTELLIGENCE IN ALBANIAN CIVIL LAW

The increasing adoption of artificial intelligence (AI) technologies across various sectors of Albania's social and economic landscape,including e-commerce, healthcare, finance, and transport,has exposed significant deficiencies in the existing legal framework to effectively address the novel challenges posed by these technologies within civil law relationships. Despite the rapid technological integration, Albanian legislation remains devoid of explicit provisions in its Civil Code, Code of Civil Procedure, or relevant sector-specific laws that directly govern the deployment, liability, contractual validity, or legal status of AI systems (Ethem, 2020).

Within the sphere of civil liability, the Albanian legal system primarily follows the classical fault-based (culpa) model, which predicates responsibility on the identification of a human actor who has manifested intent or negligence. However, AI systems, with their autonomous decision-making capabilities, disrupt

this model by functioning without direct human intervention, creating a lacuna in the attribution of responsibility for damages stemming from their operations. This gap poses particular risks in high-impact sectors such as autonomous transportation (driverless vehicles), healthcare diagnostics reliant on AI algorithms, and financial services that utilize automated decision-making processes for credit approvals or insurance underwriting. The lack of established mechanisms to identify causal liability and enforce accountability in these domains leaves affected individuals vulnerable and legal actors without clear guidance (European Commission, 2022; Ethem, 2020).

Moreover, Albanian law does not currently provide a regulatory framework for emerging contractual modalities such as smart contracts,self-executing agreements triggered by pre-programmed algorithmic conditions,nor does it clarify the legal validity of acts autonomously generated by AI systems. The foundational contractual principle of valid consent, as articulated in Articles 663,668 of the Albanian Civil Code, presupposes mutual agreement expressed through human will. The automation of contractual acts without explicit human consent challenges this principle, generating legal uncertainty for investors, businesses, and consumers seeking to leverage these technologies in commercial transactions and civil interactions (Scherpe, Barker & Bauzon, 2023).

In the realm of evidence law, the absence of explicit legal recognition of data, decisions, and records produced by autonomous AI systems complicates judicial proceedings. Courts currently face difficulties in accepting such outputs as admissible evidence due to the lack of defined standards for their probative value. This evidentiary gap undermines the core judicial principles of fairness, transparency, and efficiency in adjudication processes, potentially delaying justice and weakening trust in the legal system (Scherpe et al., 2023).

Institutionally, Albania suffers from the absence of a specialized supervisory authority dedicated to the oversight of advanced AI technologies. This void contributes to a fragmented regulatory environment and impedes the development of a coherent and sustainable legal infrastructure for AI governance. Contrastingly, several European Union member states have proactively established national AI task forces or integrated AI governance within their digital strategies to coordinate regulation, ethical standards, and innovation policies. Albania's lack of a comprehensive national strategy on AI regulation,spanning technological, ethical, and legal dimensions,further complicates efforts to modernize its legal system in line with global advancements (European Commission, 2021).

The failure to enact civil law reforms that introduce provisions for strict liability applicable to high-risk AI activities and clear standards for the legal validity of algorithm-driven contracts risks consigning Albania to a prolonged state of legal ambiguity. Such uncertainty undermines the protection of fundamental rights, restricts economic growth, stifles innovation, and limits the country's ability to integrate effectively within international technology and innovation networks. Urgent legislative and institutional measures aligned with international best practices are essential for Albania to navigate the transformative era of artificial intelligence successfully (European Commission, 2021; Ethem, 2020).

COMPARATIVE INTERNATIONAL MODELS: THE EXPERIENCE OF THE EUROPEAN UNION, ITALY, AND ESTONIA IN ADDRESSING ARTIFICIAL INTELLIGENCE IN CIVIL LAW

To effectively navigate the challenges posed by artificial intelligence (AI), it is imperative for Albania to draw lessons from the diverse legal frameworks and policy responses adopted by member states of the European Union. These comparative models offer critical insights for constructing a coherent civil law system that balances the safeguarding of individual rights with the encouragement of technological innovation and economic growth.

At the supranational level, the European Union has been at the forefront of establishing a comprehensive and forward-looking regulatory regime tailored to AI technologies. The Artificial Intelligence Act (AI Act), proposed in 2021, represents a landmark legislative initiative aiming to unify regulatory approaches across the EU. It introduces a risk-based classification of AI systems,ranging from minimal to unacceptable risk,and imposes graduated obligations on developers, deployers, and users, with particular attention to AI applications that directly impact human rights and safety. The AI Act's provisions emphasize transparency, human oversight, data governance, and robustness, seeking to mitigate risks while fostering trust in AI adoption (European Commission, 2021).

Complementing the AI Act, the proposed AI Liability Directive of 2022 targets the reform of tort law principles applicable to AI-induced harm. Recognizing the difficulties victims face in proving causation and fault when harm results from autonomous algorithms, the Directive proposes shifting the burden of proof and establishing a presumption of causation in favour of claimants. This essentially introduces an element of strict liability for operators of AI systems, addressing a significant regulatory gap prevalent in many jurisdictions, including Albania (European Commission, 2022). By doing so, the Directive strengthens consumer protection and legal certainty while incentivizing responsible AI deployment.

At the national level, Italy's approach reflects a pragmatic adaptation of existing legal doctrines to the challenges of AI, without yet adopting bespoke legislation. Italian civil law doctrine has classified AI as a "dangerous instrument" (strumento pericoloso) under Article 2050 of the Civil Code, thereby enabling the application of strict liability in cases where AI systems cause harm, even in the absence of fault. Italian courts have begun cautiously admitting evidence generated by AI in judicial proceedings, fostering the integration of technological evidence within principles of transparency and judicial efficiency. Institutionally, Italy contributes to the EU's AI Watch initiative and has published guidelines for the ethical use of AI in public administration, providing normative references that could extend into the private sector, thus laying groundwork for comprehensive AI governance (Scherpe, Barker & Bauzon, 2023).

In contrast, Estonia exemplifies a highly advanced and digital-first model, embracing AI not only at the legislative level but through practical, systemic implementation. Estonia's digital judiciary incorporates "virtual judges" to resolve low-value economic disputes, leveraging automation to enhance access to justice and judicial efficiency. Its legal framework explicitly recognises the validity of acts generated automatically by AI systems and supports robust data infrastructures that enable continuous monitoring and auditing of AI processes. Estonia's Digital Services Act imposes direct liability on entities managing AI systems regardless of human oversight, reflecting a forward-looking stance on responsibility and governance. This pragmatic and comprehensive approach demonstrates how civil law can adapt to technological realities while safeguarding legal certainty and public trust (European Commission, 2021; Scherpe et al., 2023).

In summary, these international experiences underline that recognizing AI as merely an innovative tool is insufficient. Legal systems must develop clear, operational frameworks that provide mechanisms for liability allocation, protect individual rights, and preserve stability in civil relations. For Albania, this translates into an urgent need for harmonising domestic laws with European standards, not only by adopting dedicated AI legislation but also through revisiting foundational civil law principles,such as those governing liability, contract validity, and personal data protection,to ensure the legal system is well-equipped to meet the demands of the digital era.

DISCUSSION

In an era characterised by accelerated technological transformation, artificial intelligence (AI) has fundamentally reshaped the fabric of legal and economic relationships, challenging the traditional paradigms of civil law. AI's capacity to act autonomously, learn from data, and interact with its environment has blurred the lines between tools and legal agents, thereby raising complex questions regarding civil liability, legal personality, contract formation, and evidentiary mechanisms. These developments call for a comprehensive re-evaluation of the foundational principles of civil law,particularly in jurisdictions like Albania, where the legal system remains largely anthropocentric and unprepared for these technological disruptions (Ethem, 2020; Scherpe, Barker & Bauzon, 2023).

One of the most pressing challenges is the absence of a normative framework defining the legal status and liability mechanisms for AI systems. In the Albanian civil law tradition, grounded in fault-based liability (culpa), responsibility for damage is typically attributed to a natural or legal person who has acted negligently or intentionally. However, this model proves inadequate in the context of AI-driven actions where there may be no clearly identifiable human actor or where harm arises from machine learning outcomes not directly programmed by humans. Such scenarios generate legal uncertainty, undermining the principle of foreseeability and the protection of parties affected by AI-driven decisions (European Commission, 2022).

Internationally, multiple legal systems have begun to confront these challenges through innovative legislative and interpretative strategies. At the European level, the Artificial Intelligence Act (2021) and the AI Liability Directive (2022) aim to introduce a harmonised legal framework that ensures both accountability and innovation. The proposed rules advocate for a risk-based classification of AI systems and introduce mechanisms such as the presumption of causality and strict liability in high-risk contexts. These legal tools are designed to shift part of the burden of proof onto AI operators, thereby enhancing victim protection in cases where proving fault is technically or factually impossible (European Commission, 2021; 2022).

The Italian legal experience offers another interpretative pathway. While Italy has not yet adopted specific legislation on AI in civil law, its courts and legal scholars have invoked Article 2050 of the Italian Civil Code,concerning dangerous activities,to justify the application of strict liability to certain uses of AI. This pragmatic approach enables the imposition of responsibility without requiring proof of fault, especially when AI systems are used in sensitive fields such as healthcare, autonomous transport, or financial services. Moreover, Italian courts have started accepting algorithmically generated evidence, demonstrating an incremental but meaningful adaptation of judicial practice to technological realities (Scherpe et al., 2023).

In contrast, Estonia presents a more technologically embedded model. The Estonian judiciary has adopted AI-driven systems for adjudicating low-value claims and recognises the legal validity of automatically generated acts. Its decentralised digital infrastructure allows for real-time auditing and oversight of AI processes, enhancing transparency and accountability. Estonia's Digital Services Act includes provisions that directly assign legal responsibility to operators of AI systems, regardless of human intervention levels, reflecting a future-oriented legal design that integrates innovation with public trust (European Commission, 2021).

In light of these international models, Albania's legal system must undergo structural reform to meet the demands of the AI age. This includes not only legislative adjustments to civil liability norms, contractual formation principles, and evidentiary rules, but also institutional transformations such as the creation of a national AI oversight body and the development of specialised legal training programs. Capacity building among jurists, regulators, and policymakers is essential to ensure a nuanced understanding of the legal, ethical, and technological dimensions of AI.

Beyond the technicalities of liability and regulatory oversight, the rise of AI invites a broader philosophical reflection on the evolving relationship between humans and machines. It raises fundamental questions about the role of law in an automated society, the protection of human dignity, and the normative boundaries between autonomy, agency, and accountability. Addressing these questions requires interdisciplinary dialogue among legal scholars, ethicists, technologists, and social scientists, as well as public engagement to define socially acceptable uses of AI.

In conclusion, civil liability in the context of artificial intelligence is not merely a matter of adapting old rules to new phenomena,it is a transformative legal challenge that demands bold, forward-looking solutions. For Albania, this means embracing a model of legal modernisation that is both rooted in European best practices and responsive to the specific socio-economic and institutional realities of the country. Only through such an integrated and adaptive approach can Albania ensure legal certainty, uphold fundamental rights, and foster a climate of responsible technological innovation.

CONCLUSIONS

The incorporation of artificial intelligence (AI) into the sphere of civil law represents one of the most significant contemporary challenges for legal systems worldwide, and particularly for Albania. This challenge is not limited to technical-legal questions; rather, it encompasses broader social, institutional, and economic implications that affect the coherence, functionality, and credibility of the legal order. In the absence of a comprehensive and responsive legal and institutional framework, Albania risks not only a growing disjunction between law and technology, but also a deterioration of legal certainty, reduced investor confidence, and stagnation in the development of its digital economy.

At the core of this normative vacuum lies the lack of clear provisions defining the legal personality, liability, and evidentiary relevance of actions carried out by AI systems. The absence of a recognised legal status for smart contracts and algorithmically generated obligations further exacerbates the gap between technological innovation and traditional civil law constructs. This misalignment hinders the adequate treatment of legal issues arising from the use of autonomous technologies,such as assigning liability for harm caused by AI, determining the validity of machine-executed contracts, and assessing the probative value of digital records in court.

Responding effectively to these challenges requires an integrated and multidimensional approach. Reforming the Albanian Civil Code and related legislation is a necessary starting point, but not a sufficient one. Legal reform must be accompanied by the establishment of institutional mechanisms capable of supervising the ethical, legal, and operational aspects of AI implementation. In this regard, the creation of a specialised regulatory authority,tasked with overseeing the development and use of advanced technologies,would represent a major step toward strengthening institutional capacity and building public trust.

Additionally, the reform process must include the development of expertise within the judiciary, legal profession, and public administration. Training programs, interdisciplinary collaboration, and the integration of technology-focused curricula in legal education are essential for enabling legal actors to interpret and apply new legal norms effectively. Without such capacity building, any legislative change may remain symbolic and ineffective in practice.

Equally important is the modernisation of evidentiary standards to accommodate the growing prevalence of digital and machine-generated evidence. The establishment of clear rules on the admissibility, authenticity, and reliability of such evidence would significantly improve judicial efficiency and fairness in disputes involving AI systems.

Crucially, Albania must look beyond its borders and draw on the experiences of countries that have pioneered legal responses to AI, particularly within the European Union. The EU's Artificial Intelligence Act and the AI Liability Directive offer valuable models for designing a balanced regulatory framework that fosters innovation while ensuring accountability and protection of fundamental rights. Likewise, national strategies such as those adopted in Italy and Estonia illustrate diverse yet pragmatic approaches to the legal integration of AI.

In conclusion, integrating AI into Albanian civil law is not an optional innovation, but a legal imperative. To safeguard legal certainty, protect individual rights, and enable technological progress, Albania must urgently reform its civil legal infrastructure in line with European and international standards. Only through a coordinated strategy that combines legislative innovation, institutional reform, capacity building, and international cooperation can Albania build a civil law system that is modern, resilient, and fit for the digital age.

RECOMMENDATIONS

In light of the multidimensional challenges posed by the integration of artificial intelligence (AI) into the Albanian civil law system, it is imperative to undertake a series of concrete, systematic reforms aimed at establishing a coherent, future-oriented legal and institutional framework. These recommendations are designed to provide strategic direction for aligning Albania's legal system with emerging technological realities while ensuring the effective protection of fundamental rights and fostering a dynamic environment for innovation and economic growth. Their implementation is essential for bridging existing normative gaps and for facilitating Albania's harmonisation with European and international standards.

1. Harmonisation with European Legal Standards

The foundational step in addressing the regulatory challenges posed by AI is the alignment of national legislation with European legal instruments. The adoption and transposition of key EU proposals,such as the *Artificial Intelligence Act* (2021) and the *AI Liability Directive* (2022),would establish a robust framework for regulating high-risk AI systems, defining liability standards, and ensuring transparency and accountability in automated decision-making processes. Without such harmonisation, any national initiative risks remaining fragmented and insufficient to respond to cross-border technological risks.

2. Defining the Legal Status and Accountability of AI Systems

A critical priority is the formal recognition of AI systems within the legal framework. The current ambiguity regarding their legal personality or functional status hampers the attribution of liability for autonomous actions. Developing a legal definition or classification of AI systems,possibly through a functional legal status, akin to the debated concept of "electronic personhood",would facilitate the allocation of responsibility between developers, users, and deployers, particularly in cases involving harm or contractual default. This step would reduce legal uncertainty and provide a normative foundation for adapting civil liability doctrines to new realities.

3. Regulation of Smart Contracts and Automated Transactions

Smart contracts, as self-executing agreements based on pre-programmed algorithms, represent a disruptive force in contract law. Albania must introduce provisions within its Civil Code or commercial legislation that define the legal nature, validity, enforceability, and limitations of such contracts. Their formal recognition as legally binding instruments would support the growth of digital commerce, strengthen legal security in online transactions, and reduce reliance on litigation by enabling transparent and automated enforcement of contractual obligations.

4. Establishment of a Specialised Supervisory Authority

The dynamic nature of AI technologies demands ongoing monitoring, evaluation, and enforcement of legal standards. To this end, Albania should create a dedicated national supervisory body or empower an existing agency with specific competence in AI oversight. This body should be responsible for certifying compliance with ethical and legal standards, coordinating with EU bodies, providing guidance to stakeholders, and overseeing high-risk AI applications across sectors such as health, finance, and transportation.

5. Capacity Building and Interdisciplinary Education

Successful legal reform requires investment in the human capital necessary to interpret, implement, and oversee AI-related regulations. Targeted training programs for judges, lawyers, public officials, technologists, and legislators are essential to foster a shared understanding of legal-tech interfaces. Furthermore, law schools and professional bodies should incorporate interdisciplinary modules on AI ethics, digital evidence, algorithmic accountability, and emerging technologies into their curricula to prepare future legal professionals for a digitised legal landscape.

6. Legal Recognition and Standards for Digital Evidence

Given the increasing role of AI systems in generating, processing, and storing data, Albania must adopt specific rules regarding the admissibility, authenticity, and probative value of digital evidence. Clear legal standards should govern the evaluation of data generated autonomously, including metadata, algorithmic decisions, and blockchain-based records. Such standards would enhance procedural fairness and efficiency in civil litigation, particularly in cases involving smart systems or cross-border digital platforms.

7. Strengthening International Cooperation and Comparative Legal Research

Albania's legal modernisation efforts must be framed within a broader context of international collaboration. Active participation in EU initiatives (such as *AI Watch*, *Digital Europe Programme*, and *Eurojust AI working groups*), regional dialogue, and bilateral cooperation with countries that have developed advanced AI regulatory strategies,such as Italy and Estonia,will accelerate the development of a responsive and competitive legal framework. Comparative research and continuous legal benchmarking should inform domestic reforms, ensuring Albania avoids regulatory isolation. The findings of this study underscore that Albania must urgently address existing normative and institutional voids by pursuing an integrated strategy that embraces innovation while safeguarding core legal values. A coordinated, interdisciplinary, and internationally aligned approach is the only viable path to ensuring legal certainty, protecting fundamental rights, and enabling Albania to become a credible actor within the European and global digital economy. This transformation must be supported not only through legislation, but also through education, institutional empowerment, and sustained political commitment.

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RETHINKING GROWTH AND INNOVATION: THE ROLE OF ARTIFICIAL INTELLIGENCE IN EUROPE'S INDUSTRIAL TRANSFORMATION

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ABSTRACT

In a global economic environment characterized by interdependence, structural transformations, and increasingly intense competitive pressures, the ability of economic systems to generate, sustain, and capitalize on research, development, and innovation (RDI) has become a key performance indicator. Artificial intelligence (AI), a strategic component of the Fourth Industrial Revolution, exerts a profound impact on the economic architecture and operational mechanisms of contemporary societies. While AI offers innovative solutions with high potential to support socio-economic progress, it also poses significant regulatory and ethical challenges. This study employs a mixed-methods approach, consisting of a review of the relevant scholarly literature and a quantitative analysis using a multiple regression econometric model to examine the main determinants of the variable "AI software development. Very High-impact AI projects (%)", based on data from the EU27 member states during the 2017–2022 period. The findings contribute to the existing literature and provide valuable insights for policymakers, investors, and industry leaders in designing effective strategies to accelerate technological progress and maximize the economic and social benefits of AI. At the same time, the study highlights the need for coherent and harmonized regulatory frameworks at the global level to address the risks associated with AI deployment - an issue that could serve as a basis for future research.

Keywords: Artificial Intelligence (AI), Industrial transformation, R&D, Multiple regression, Public policy.

1. INTRODUCTION

Technological transformations have historically been fundamental catalysts for economic, social, and institutional change. From the first industrial revolution of the 18th century - marked by the mechanization of production through the use of steam - to the massive digitalization of today, each stage of technological disruption has redefined the paradigms of economic organization and the way of interaction between the factors of production.

The five industrial revolutions, which followed at an accelerated pace over the last centuries, are summarized in the table below.

Table 1. Evolution of Industrial Revolutions

Industrial Revolution	**Major features**
Industrial Revolution 1.0 (end XVIII - dry start. XIX)	Mechanization, steam force, textile industry
Industrial Revolution 2.0 (end XIX - dry start. XX)	Electricity, serial production, steel, and chemistry
Industrial Revolution 3.0 (1970-2000 years)	Computers, automation, Internet
Transition period from Revolution 3.0 to 4.0 (2000-2010)	The Internet and digital globalization have paved the way for IoT, big data, AI, etc.
Industrial Revolution 4.0 (after 2010 - present)	Smart technologies, advanced digitalization, IoT, robotics, Big Data, Cloud Computing, 3D, augmented reality, AI, ML, etc.
Industrial Revolution 5.0 (in progress, after 2020)	Human-technology collaboration, sustainability, personalization, and a human-centric economy.

At present, humanity is in the midst of the Fourth Industrial Revolution (Industry 4.0), marked by the integration of digital and autonomous technologies across all sectors of the economy. Artificial Intelligence (AI) emerges as the main driver of this transformation, with the capacity to reconceptualize the foundations of economic development: process automation, predictive analytics, adaptive learning, and algorithmic decision-making. Within the Industry 5.0 paradigm, AI does not replace but rather complements and amplifies human abilities, fostering a more adaptable and sustainable working environment.

Artificial Intelligence is not merely an extension of computational capacity but an interdisciplinary paradigm that brings together computer science, mathematics, cognitive sciences, and systems engineering. Officially introduced in 1956, AI has evolved exponentially, benefiting from advances in neural networks, sophisticated processing, and access to massive volumes of data. More recently, AI has become a central theme in national and regional industrial policies, regarded as a tool for strengthening competitiveness, digital sovereignty, and economic security. In practice, the shift has been from algorithms to intelligent industrial strategies.

In the academic literature, AI is associated with productivity growth through the reduction of marginal costs, the acceleration of innovation, and the creation of new business models. Moreover, AI contributes to better resource allocation, optimization of supply chains, and the improvement of public services through e-government solutions. However, these benefits are accompanied by risks: labor market polarization, the intensification of social inequalities, the erosion of trust in institutions, and the urgent need for regulations to safeguard fundamental rights.

Against this backdrop, the paper aims to investigate to what extent AI can be considered both a catalyst of a new industrial revolution and a driver of sustainable economic development in the European Union. Through a mixed theoretical and empirical approach, the study examines the key factors influencing the implementation of high-impact AI projects, offering a comprehensive perspective on Europe's economic future.

2. LITERATURE REVIEW

2.1. Artificial Intelligence Policies at the European Union level

In the context of the accelerated evolution of digital technologies and the global pressure for ethical and strategic regulation, the European Union has developed a distinct and evolving policy framework on Artificial Intelligence. The EU's approach is based on balancing innovation, the protection of fundamental rights, and the safeguarding of digital sovereignty.

Key elements of the EU's AI policy:

The European Union legislature adopted a comprehensive legal act on Artificial Intelligence, published in the Official Journal of the EU (2024). The AI Act is the world's first binding horizontal regulation on AI, establishing a common framework for the use and provision of AI systems within the EU. The new regulation provides a classification of AI systems with differentiated requirements and obligations, based on a risk-oriented approach: Unacceptable risk: prohibited systems (e.g., subliminal manipulation, social scoring) / High risk (biometric surveillance, critical systems in health, transport, justice) / Limited risk: conversational interactions or chatbots (obligation of transparency) and Minimum risk: general applications (without additional regulation). At the same time, the European AI Strategy launched in 2018 (EC, 2018), with its subsequent reviews, includes: Public and private investment in research and innovation / Supporting the ecosystem of innovative startups and enterprises / Equal access to data, / Forming digital skills among the population and employees. On the other hand, according to the European Commission (2025, June 13), the EU Code of Ethics and the Charter of Digital Rights promote the development of shared ethical principles, translated into citizens' rights and legal safeguards for users, following the seven key requirements for Trustworthy AI formulated by the European Commission's *High-Level Expert Group on Artificial Intelligence* (AI HLEG): Human supervision / Technical robustness and safety / Data privacy and governance / Transparency / Diversity, non-discrimination and equity / Societal and environmental welfare / Acountability.

2.2. Systematization of relevant literature

Artificial Intelligence in Industry 4.0 and Industrial Applications. The integration of AI into Industry 4.0 has been widely documented as a driver of automation, process optimization, and real-time decision-making. Berawi (2020) highlights the extended role of artificial intelligence in industrial automation, work transformation, and service improvement through technologies such as 3D printing, IoT, blockchain, and machine learning, emphasizing that the future value of products will depend more on intellectual property than on production costs. Javaid et al. (2021) underline that AI enables efficient data management through sensors and cloud computing, enhancing both creativity and industrial efficiency. Similarly, Zeba et al. (2021) analyze the application of AI in manufacturing in the context of Industry 4.0, noting the evolution of research between 1979–2019 and pointing out the rise of cyber-physical systems, smart manufacturing, deep learning, and real-time programming algorithms in production processes. Through the large-scale adoption of AI and machine learning, the industry is undergoing advanced digital transformations that improve decision-making, optimize processes and supply chains, support the discovery of new materials, and redefine the human role in future AI-integrated production environments (Chiang et al., 2020). Furthermore, Ahmed (2022) provides a detailed analysis of AI and XAI methods used for diagnosis, prediction, and interpretation—processes essential to critical industrial applications. Although industrial AI can help manufacturers address the challenges of Industry 4.0, adoption remains low due to unique challenges and unprepared organizations (Peres et al., 2020). Chen et al. (2023) analyze the essential role of AI in the context of Industry 4.0, highlighting both opportunities and challenges in its application to manufacturing and services.

In the manufacturing sector, Elyasi et al. (2025) show that AI is transforming production by optimizing assembly lines, enabling predictive maintenance, and managing the workforce. Tools such as the "AI matchmaker" support decision-making in equipment procurement and task allocation, especially in environments with frequent product changes. Challenges include data integration, scalability, and the transition from traditional processes. The authors stress the need for continuous employee training, customized AI solutions, and collaboration between industry, research, and developers.

In the European context, Mallik (2023) observes that AI supports the twin transition to digitalization and climate neutrality, with major European firms following the sustainability direction set by the European Commission. Buarque et al. (2020) highlight regional disparities in AI adoption, showing digital innovation clusters achieve higher productivity and patenting success. Segarra-Blasco et al. (2025) add that AI and robotics foster innovation, especially in dynamic firms, with adoption depending on internal and external factors. The authors note that public policies are essential to support digitalization and reduce the EU's gap with the United States.

AI for Sustainability and Green Innovation. AI contributes significantly to environmental sustainability and green innovation through energy forecasting, cost optimization, system efficiency, and the discovery of materials for green technologies (Necula, 2023). Studies show that AI improves resource efficiency, reduces long-term carbon emissions, and facilitates industrial modernization and renewable energy management, with government support playing a crucial role in enhancing green policy effectiveness (Han et al., 2024; Liu et al., 2025). China is no exception to the need for stronger environmental regulations and a shift toward green and sustainable development in manufacturing—a trend seen as inevitable. In this respect, Gao (2022) shows that AI acts as a mediator between environmental regulations and upgrading in global value chains, by increasing productivity, efficiency, and substituting low-skilled labor, thus contributing to industrial transformation and long-term competitiveness.

In the high-tech sector, AI promotes radical green innovations, although its impact is mediated by R&D intensity and organizational learning (Su et al., 2022). Calabrese et al. (2023), analyzing 1,501 sustainability reports, find that although Industry 4.0 technologies contribute to innovation and operational efficiency, their use as a primary driver of sustainability remains limited, with marked regional differences. Finally, the convergence between industrial AI (INAI) and green finance (GNF) supports sustainable industrialization; in this regard, Kuang et al. (2024) show positive effects in major economies, with variations in Canada and Italy, and recommend supportive policies, incentives, and international cooperation.

AI as a General-Purpose Technology and Emerging Paradigms. AI is increasingly recognized as a general-purpose technology (Damioli et al., 2024), capable of transforming multiple sectors beyond ICT and stimulating innovation, particularly in small and young firms. Damioli also provides a telling table showing the percentage of patents for AI and non-AI innovations (Table 2).

Table 2. AI patent families by country of applicant, 2000-2016, source: Damioli et al., 2024

Country of AI innovator	% of AI patent families	% of non-AI patent families
China	37.1	13.4
Europe*	7.7	10.9
Japan	23.1	56.4
South Korea	16.6	5.2
United States	11.1	9.6
Other countries	4.4	4.5

Notes: Europe includes the European Union, Iceland, Liechtenstein, Norway, Switzerland, and the United Kingdom.

From the data presented, we see a particular interest of Chinese entrepreneurs in AI technologies.

Khosravy et al. (2024) propose Industry 5.0 as a human-centered evolution, where AI facilitates human-machine collaboration, mass customization, cyber security, and the integration of social value and sustainability into a smart industrial ecosystem. These developments suggest a paradigm shift, although data limitations restrict the assessment of long-term impacts.

AI in Decision-Making: Production, Services, and Business Processes. AI enhances data-driven decision-making and operational efficiency in various industries such as manufacturing, retail, and finance (Yaşar, 2024). Along the same lines, Mouzakitis et al. (2023) find that AI significantly improves decision-making processes in the energy sector and report that AI contributes to its digitalization and sustainability. However, challenges such as a lack of internal expertise, data interoperability issues, and unclear regulations limit adoption. In this context, the I-NERGY framework proposes an integrated approach for the development and implementation of AI services, connected with the European AI-on-Demand platform, to optimize the EPES value chain, particularly in support of SMEs and non-technological industries.

In healthcare, AI holds transformative potential for disease management and therapeutic interventions, yet adoption in Europe remains uneven due to policy and regulatory gaps, requiring a unified strategic framework (McKee & Marsella, 2024).

The European Commission promotes a profound transformation through the European Green Deal, with the sustainable food system at its core, as defined in the "farm-to-fork" strategy. This strategy requires a systemic approach integrating economic, ecological, and social aspects of food production and consumption. In this regard, Marvin et al. (2022) highlight the potential of digitalization and AI to overcome the challenges of building a sustainable food system. According to Zatsu et al. (2024), the food sector also benefits from AI-based monitoring, process and cost optimization, quality control, and food safety. On the other hand, AI fosters the servitization of China's manufacturing industry, mainly through increased productivity and workforce optimization, with a strong effect on integrated services and a weaker one on hybrid services (Chen et al., 2024). Rana & Daultani (2022) argue that firms in the manufacturing sector are adopting Industry 4.0 technologies to develop smart factories, which enable the rise of smart supply chains through digital transformation. Artificial intelligence and machine learning play a crucial role in cost optimization, profit growth, and service improvement. Their study analyzes 338 relevant works to highlight the unexplored potential of AI and ML in supply chain management.

AI and Labor Market Implications. The impact of AI on employment is heterogeneous. While some studies, such as Acemoglu (2022) for the U.S. industrial market, report negligible occupational effects,

other perspectives suggest that AI increasingly replaces humans in simple cognitive and social tasks—driven more by shareholder value maximization than social goals (Acemoglu et al., 2023). Similarly, Guarascio et al. (2024) emphasize regional disparities in Europe: high-tech and knowledge-intensive regions leverage AI for innovation, while labor-intensive regions face risks of job losses.

Economic Implications of AI. For instance, Rammer et al. (2022) find that the use of AI in German firms leads to increased product innovation and process improvements, contributing to approximately 6% of annual cost savings in the business sector. According to McKinsey, by 2030, about 70% of companies will use AI technologies, generating an estimated 1.2% annual increase in global GDP growth (Romania's National AI Strategy 2024–2027). Currently, only 13.5% of EU companies use AI (EC, 2025). On the other hand, the EU ranks second globally in high-impact AI projects (6–100 forks), but is significantly outperformed by the main competitors, the U.S. and China, in very high-impact projects (Spătaru et al., 2025).

Regulatory, Ethical, and Policy Considerations. AI governance varies significantly across regions. The EU prioritizes a rights-based, risk-oriented framework, while other countries emphasize regulatory flexibility to foster business development, such as Thailand (Netipatalachoochote & Pailler, 2025). The UN 2030 Agenda and global sustainability initiatives highlight the central role of AI in driving economic transformation toward inclusion and sustainability, while also calling for risk-aware approaches (Fernández-Aller et al., 2021). At the same time, the PAICE study shows that European citizens have limited knowledge about AI and EU policies, underscoring risks such as disinformation and educational inequalities (Scantamburlo et al., 2023). Consequently, the ethical, managerial, and policy framework is essential for mitigating risks related to data privacy, automation, and social equity (Balcıoğlu et al., 2024). Public policies are also particularly important for supporting digitalization and reducing the gap with the United States (Segarra-Blasco et al., 2025).

Challenges and Future Research Directions. Despite its transformative potential, AI adoption faces challenges such as high costs, limited expertise, interoperability problems, and ethical concerns (Peres et al., 2020; Zatsu et al., 2024; Mouzakitis et al., 2023). Future research should focus on integrating AI with sustainable practices, addressing regional and sectoral disparities in adoption, harmonizing regulations, and developing human-centered, optimized, and energy-efficient AI systems superior to earlier models (Ahmed et al., 2022; Wang et al., 2024). Moreover, the engineering architecture proposed by Wang (Fig. 1) optimizes computational efficiency and model size for IoT environments by integrating edge computing for rapid, localized data processing, reducing latency and bandwidth consumption, and ensuring security and privacy. This enables fast and precise real-time decision-making.

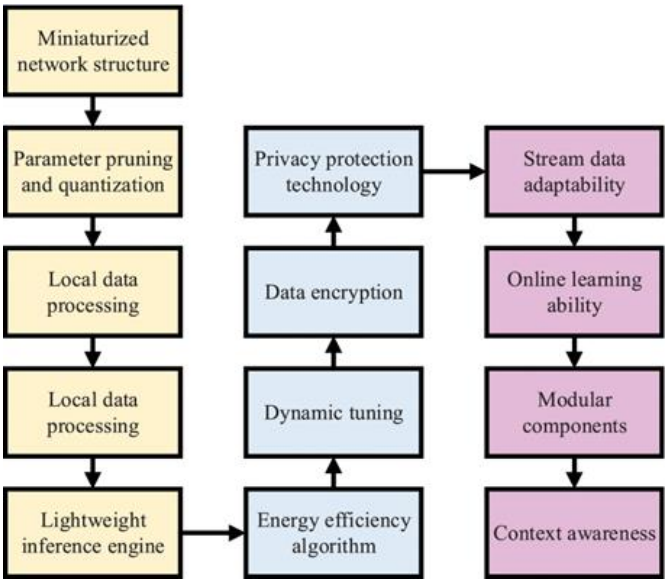


Figure 1. Optimized AI model architecture (engineering perspective), source: Wang et al., 2024

Bibliometric analysis, with its related limitations, provides a systematic review of AI and ML applications and identifies emerging topics in productivity, energy management, and cross-sectoral innovation (Espina-Romero et al., 2023; Cioffi et al., 2020).

Moreover, Espina-Romero offers us an eloquent graphic representation regarding the rise of AI implementation by sector, in the period 2018-2022 (Fig. 2). The accelerated dynamics are obvious.

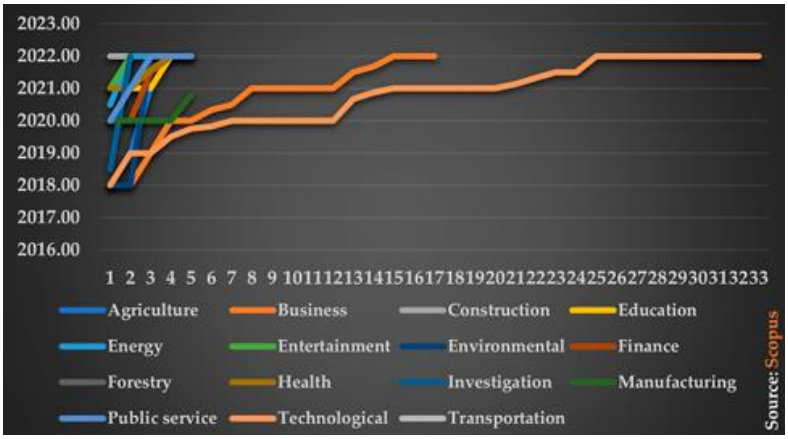


Figure 2. Ascension of AI implementation by sectors (2018-2022), initial source: Scopus

Elyasi et al. (2025) and Segarra-Blasco et al. (2025) emphasise the need to develop more sophisticated AI models, address ethical considerations, and stimulate innovation in SMEs through dedicated policies, infrastructure, and skills development initiatives.

3. METHODOLOGY

This study combines systematization of literature with a quantitative approach, utilizing statistical data analysis. Next, we propose to test the following research hypothesis:

Hypothesis of dependence (H1): "Available talents and the level of investment in research, development, and innovation significantly influence the scale of AI projects."

Analysis period: 2017 to 2022.

Number of observations = 28 (27 EU member states plus the EU average)

Presentation of variables subject to quantitative analysis:

- Dependent variable (**Y**): *AI software development. Very High-impact (>100 forks) AI projects (%),* (AI_Very High Impact Projects), source: OECD.ai.
- Independent variables (Xi):

(**X1**): *Total R&D expenditure, as percentage of GDP* (R&D %GDP), source: World Bank (WB) & EUROSTAT.

(**X2**)*: Venture capital investments in AI, % of GDP* (VC_invest), source: calculated by the authors based on OECD.ai & WB data.

(**X3**): *Total number of researchers in R&D per million people* (Researchers), source: World Bank.

(**X4**): *Global Innovation Index,* overall score: [0;100], (GII), source: WIPO.

Econometric model. In our case, **the multiple regression equation** can be expressed as:

$\mathbf{Y}i = \beta 0 + \beta 1(\mathbf{X1})i + \beta 2(\mathbf{X2})i + \beta 3(\mathbf{X3})i + \beta 4(\mathbf{X4})i + \varepsilon i$ (1)

Where: $\beta 0$ = intercept (constant), $\beta 1 \div \beta 4$ are regression coefficients, and Ɛ is residual error

Methods and Techniques of Data Analysis

- *Data Preparation and Cleaning* - We employed two approaches to handle predictors' missing data: calculating the average values (arithmetic mean neighboring values) and, in certain cases, utilizing Python-based predictive models for data imputation (linear regression or polynomial regression technique). Depending on the case, EU-level values were calculated as weighted averages based on population or GDP.
- *Data scaling/normalization*: Z-score
- *Correlation (Pearson)* – Measures the intensity of bivariate bonds (acceptable values: more than 20%; the closer it is to 1 (100%), the stronger the link between the variables)
- *Significance Testing* – p-value < 0.05 significant; p-value < 0.1 marginal significant. ANOVA validates the overall model (mandatory, p-value < 0.05).
- *Multiple Regression (OLS)* – Estimates effects; fit via R-square (R^2).

4. RESULTS AND DISCUSSIONS

Tables 3÷10 present the empirical results for 2017 and 2022, including correlation and regression analyses, and ANOVA statistics (Spătaru et al., 2025).

Observations and comments are provided at the end of the section.

Table 3. Matrix correlations_2017, Source: authors' elaboration

Pearson Correlations 2017	VC_Invest AI	R&D %GDP	Researchers	GII
AI_Very High Impact Projects	0.6532 (**65,32**%)	0.4287 (**42,87**%)	0.3245 (**32,45**%)	0.3102 (**31**%)

Table. 4. Regression coefficients_2017, Source: authors' elaboration

Variable	Coefficient	Standard error	t-statistic	p-value
Intercept	-0.0002	0.0876	-0.0023	0.9982
VC_Invest AI	**0.3876**	0.1132	3.4238	**0.0014** (< 0.01)

R&D %GDP	**0.2654**	0.1054	2.5183	**0.0156** (< 0.05)
Researchers	0.1432	0.0965	1.4838	0.1456
GII	0.0765	0.1187	0.6445	0.5231

Table. 5. Summary Model_2017, Source: authors' elaboration

R-squared	0.6932 **(69,32%)**	**F-statistic**	21.3245
Adjusted R-squared	0.6612	**Probability (F-**	**0.0000**

Table 6. Statistical ANOVA_2017, Source: authors' elaboration

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-statistic	p-value
Regression	8.1243	4	2.0311	21.3245	**0.0000**
Residual	3.5678	36	0.0991	-	-
Total	11.6921	40	-	-	-

Table 7. Matrix correlations_2022, Source: authors' elaboration

Pearson Correlations 2022	VC_Invest AI	R&D %GDP	Researchers	GII
AI_Very High Impact Projects	0.7624 (**76,24**%)	0.5203 (**52**%)	0.4118 (**41,18**%)	0.3946 (**39,46**%)

Table 8. Regression coefficients_2022, Source: authors' elaboration

Variable	Coefficient	Standard error	t-statistic	p-value
Intercept	-0.0001	0.0892	-0.0013	0.9990
VC_Invest AI	**0.4237**	0.1154	3.6721	**0.0009** (< 0.01)
R&D %GDP	**0.2918**	0.1076	2.7120	**0.0095** (< 0.01)
Researchers	0.1654	0.0987	1.6753	0.1022
GII	0.0932	0.1243	0.7496	0.4578

Table 9. Summary Model_2022, Source: authors' elaboration

R-squared	0.7243 **(72,43%)**	**F-statistic**	22.4568
Adjusted R-squared	0.6923	**Probability (F-**	**0.0000**

Table 10. Statistical ANOVA_2022, Source: authors' elaboration

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F-statistic	p-value
Regression	8.4521	4	2.1130	22.4568	**0.0000**
Residual	3.2198	36	0.0894	-	-
Total	11.6719	40	-	-	-

Interpretation of statistical results:

- The correlation results indicate weak to strong positive relationships between variables (values ranging from ≈ 31÷65% in 2017 and ≈ 39÷76% in 2022 (Table 3,7).
- The R^2 coefficient from regression analysis (Table 5,9, reveals that a significant portion of Government Effectiveness is explained by the independent variables, with ~69% (2017) and ~72% (2022).
- In regression analyses (Table 4,8), the dependent variable in 2017 was positively driven by *VC_invest AI* ($\beta = 0.39$, $p < 0.01$), and by *R&D %GDP* ($\beta = 0.27$, $p < 0.05$). In 2022, *VC_invest AI* ($\beta = 0.42$) and *R&D %GDP* ($\beta = 0.29$) remained statistically significant predictors ($p < 0.01$).

- The overall model was statistically significant (Sig. < 0.001); confidence level >99.9% (ANOVA – Table 6,10).
- The comparative analysis of the results reveals a marginal enhancement in 2022 when compared to 2017.

5. CONCLUSIONS

The empirical results confirm the initial dependency hypothesis (H1).

Thus, artificial intelligence is an essential catalyst of the industrial revolution and socio-economic progress, its success depending on investment in research and development and AI projects, respectively on the quality of the talents of the researchers involved in such projects. The EU has also provided an appropriate legislative framework to address opportunities and challenges and maximise the economic benefits of AI.

Following the literature synthesis, artificial intelligence emerges as a strategic driver of Europe's industrial transformation, reinforcing global digitalization, sustainability, and competitiveness across diverse sectors. Consequently, the key domains of AI's influence on European industry may be succinctly delineated (Table 11).

Table 11. Impact Areas of AI in European Industry, Source: authors' elaboration

Sector	**Main AI impact**
Manufacturing	Automation, optimization, human-machine collaboration
Energy	Efficiency, forecasts, smart grids
Sustainability	Emissions reduction, circular economy, and centric-human economy
Services	Personalization, behavioral analysis

In a context of successive crises, maintaining global competitiveness and strengthening strategic autonomy require the European Union to continue developing advanced digital infrastructure, innovative ecosystems, and digital skills, while intensifying international cooperation through exchanges of best practices in emerging technologies, including artificial intelligence. Stimulating investments and partnerships, especially public-private, is a key condition in this endeavour. The relevance of this direction is confirmed by the most recent press release of the European Commission (2025), which allocates EUR 200 billion to accelerate the development of AI on the continent, including the creation of at least 13 artificial intelligence factories based on the European supercomputing network and up to five gigafabrics through the *InvestAI* programme, which will mobilise investments of EUR 20 billion. Also, attracting elite AI experts and researchers will be achieved through initiatives such as the talent pool, the Marie Sklodowska-Curie action - *MSCA Choose Europe*, and dedicated AI scholarship programs. The empirical analysis was conducted based on these underlying realities, which served as the primary point of departure for the study.

The limitations of the study include its reliance on the current level of investments, the legislative framework, and the availability of AI talent in the EU, as well as the fact that the analysis focuses on overall sectoral impacts without capturing regional or firm-level differences, while the rapid evolution of AI technologies may require frequent updates of the conclusions. Also, addressing AI-related risks could be explored in future research.

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STRUGGLE FOR FREEDOM IN OLAUDAH EQUIANO'S *THE INTERESTING NARRATIVE OF THE LIFE OF OLAUDAH EQUIANO*

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ABSTRACT

This research analyzes the struggle for freedom in Olaudah Equiano's autobiography *The Interesting Narrative of the Life of Olaudah Equiano* (1789) as both a personal testimony and a political instrument. This work traces Equiano's arduous journey from his violent abduction in what is now southeastern Nigeria, through the Middle Passage, assorted Caribbean plantations, and trans-Atlantic trading ventures, to his eventual manumission and literary fame in Britain. It situates the author's individual story within the broader, collective struggle of millions for human dignity, cultural identity, and social justice under the Atlantic slave system. Through a postcolonial lens, the study analyzes how Equiano used literacy, Christian values, and personal storytelling to challenge slavery and influence public opinion in Britain. The research also highlights the role of Equiano's narrative in humanizing the experiences of enslaved Africans and contributing to the abolitionist cause in the 18th century. Grounded in slave narrative studies, narrative theory and psychoanalysis, this research work focuses on qualitative data sources including a close textual reading of Equiano's *The Interesting Narrative of the Life of Olaudah Equiano,* scholarly commentary and interpretations drawn from academic journals, books, and critical essays.This work illuminates Equiano's narrative as a pivotal cultural artifact that has not only portrayed his extraordinary life but also has built up a tangible political momentum toward the abolition of the British slave trade in 1807 and inspired subsequent emancipationist discourse across the Atlantic world.

Keywords: Struggle, freedom, identity, slavery, abolition.

Introduction

The history of slavery cannot be fully understood through statistics or political debates alone. It is also deeply human, filled with individual pain, resilience, and the search for dignity. Among the voices that have survived this traumatic period, that of Olaudah Equiano stands out. Through his autobiography *The Interesting Narrative of the Life of Olaudah Equiano,* published in 1789, we get a rare first-hand account of the transatlantic slave trade from someone who lived through it and fought against it. Equiano's narrative is much more than a personal testimony; it is also a literary and political tool. His writing blends autobiography, moral argument, Christian ethics, and Enlightenment values in a way that speaks powerfully to both his contemporaries and modern readers. He embodies a unique figure: that of a formerly enslaved African who gained his freedom, mastered the English language, embraced Christianity, and used all of these elements to confront the dominant ideologies of his time. His narrative forces us to question not only the horrors of slavery but also the cultural systems that allowed it to persist (Equiano, 1789, p.56). This research project emerged from my desire to understand how Equiano's story continues to resonate today and how literature can serve as a form of resistance. I was particularly interested in how Equiano manages to reclaim his identity and agency in a world that constantly sought to erase them. By analyzing his narrative, I hope to uncover the strategies he used to resist both physical and symbolic oppression. Moreover, Equiano's evolution from a kidnapped child in Africa to a free, literate, and influential abolitionist in Britain raises important questions about identity reconstruction, self-representation, and the psychological impact of slavery. I also seek to understand how religious

faith, access to education, and mastery of language can serve as tools of transformation and survival in hostile environments. My study adopts a postcolonial perspective to examine the different aspects of Equiano's journey: his personal struggle for freedom, his use of narrative as a political weapon, and his role in the broader abolitionist movement. I also consider how his work challenged stereotypes about Africans and offered an alternative voice within European society. This research is structured into three chapters. The first chapter presents the research situation. The second chapter outlines the terms of reference and research methodology adopted and the third chapter analyses and interprets the collected data.

I- Description of the Research situation

1.1. Research area

This research lies at the intersection of literature, history, and human rights. It focuses on how personal narratives, like that of Olaudah Equiano, can bear witness to systems of oppression and contribute to the transformation of public consciousness. *The Interesting Narrative of the Life of Olaudah Equiano* is not only an autobiography. It is a political and historical document that contributed to debates on slavery in 18th-century Britain.

Through this work, we examine how Equiano's personal experiences and rhetorical strategies helped lay the intellectual and moral foundations of the British abolitionist movement. His narrative also allows us to better understand the cultural tensions and identity challenges faced by Africans living in European contexts. The study contributes to African diaspora studies, British colonial literature, and postcolonial theory by investigating how an enslaved man could use writing to reclaim his humanity and influence his society.

1.2. Literature Review

Over the past few decades, numerous scholars have explored the richness and complexity of Equiano's narrative. Paul Edwards (1967) masterfully reintroduces us to the gripping narrative of Olaudah Equiano, his life, and relentless pursuit of freedom. In this riveting account, Equiano, born in Africa and sold into slavery, unravels his odyssey spanning continents and cultures during the 18th century and James Walvin (1986) emphasizes that Equiano offered a credible human voice to the anti-slavery movement.

Vincent Carretta (2005), in *Equiano, the African*, raises the questions about Equiano's place of birth, and proves that his identity was shaped by struggle and resistance, regardless of origin.

Henry Louis Gates Jr., in *The Signifying Monkey* (1988), presents Equiano's work as an early example of African-American literary subversion through self-representation. Gates (1988) situates Equiano within a broader tradition of "signifying," (p.132). where enslaved and marginalized voices speak back to dominant narratives through coded language and symbolic resistance. His approach enriches our understanding of how narrative form becomes a space of power negotiation.

Ashcroft, Griffiths, and Tiffin (2002) read Equiano's narrative as a powerful counter-discourse to colonial stereotypes. Their postcolonial lens reveals how the autobiography destabilizes imperial assumptions about African inferiority and uncivilized behavior. For them, Equiano's mastery of European cultural forms particularly writing in English is not a form of assimilation but an act of strategic appropriation.

Equiano's religious dimension has also attracted significant scholarly attention. His narrative presents a Christianity rooted in moral integrity and justice in sharp contrast with the practices of many Christian slaveholders.

Carey (2005) highlights Equiano's use of sentiment and moral emotion as rhetorical tools aimed at mobilizing readers and legislators. His emotional appeals expressed through tears, prayers, and appeals to shared humanity were essential in moving British audiences who were unfamiliar with the brutal realities of slavery.

In addition, newer research has started to focus on Equiano's economic agency and the way he used trade and maritime labor to negotiate limited freedoms. Simon Gikandi (2011) noticed that *"The perfomative act of writing one's freedom becomes a subversion of the slave trade's dehumanization"* (p.112). He has shown that Equiano's experience also offers a window into the complexities of Black Atlantic commerce and identity.

My research aims to build on these existing studies while focusing more specifically on Equiano's psychological, spiritual, and literary evolution. I believe that a more holistic reading of his narrative can reveal not only his resistance to slavery, but also the internal strategies through which he rebuilt himself and claimed full humanity.

1.3. Main Research Question

How does *The Interesting Narrative of the Life of Olaudah Equiano* portray the struggle for personal freedom and contribute to the abolitionist discourse in 18th-century Britain?

1.4. Specific Research Questions

- How does Equiano describe the psychological and physical effects of slavery on his identity?
- In what ways do literacy and Christianity serve as tools of empowerment in his journey?
- What rhetorical strategies does he use to gain empathy from his audience?
- How did his narrative influence public opinion and political momentum in favor of abolition?

1.5. Main objective of the research

To analyze Olaudah Equiano's personal and literary journey from slavery to freedom, and to assess how his narrative contributed to shaping the abolitionist movement in Britain.

1.6. Specific research objectives

- To examine how Equiano constructs and reclaims his identity through storytelling.
- To study the role of faith, education, and economic initiative in his self-liberation.
- To analyze the persuasive techniques used to engage 18th-century British readers.

1.7. Main hypothesis of the research

Equiano's narrative would not only recount his personal quest for freedom, but would also function as a deliberate political act to humanize the enslaved and influence the abolitionist cause in Britain.

1.8. Specific research hypotheses

- Equiano's self-presentation would challenge dominant colonial stereotypes about Africans.
- His literacy and religious conversion would serve as instruments of personal and social legitimacy.
- Equiano's emotional and moral appeals would be a key to mobilizing support for abolition.

II- Terms of Reference and Research Methodology

2-1 Terms of Reference

2-1-1 Theoretical foundations of research

This study is grounded primarily in postcolonial theory, slave narrative studies, and narrative theory and psychoanalysis, which together provide a rich framework to analyze Equiano's life and work. Postcolonial thinkers like Edward Said, Homi K. Bhabha, and Gayatri Chakravorty Spivak offer crucial

insights into how formerly enslaved Africans like Equiano negotiated their identities in colonial and imperial contexts. Bhabha's concepts of hybridity and mimicry are especially relevant, as Equiano's life represents a continuous balancing act between African roots and British cultural imposition. So, they help to understand how Equiano both adapted to, and resisted the colonial gaze.

Additionally, narrative theory plays a significant role in this research, with inspiration drawn from scholars such as Paul Ricoeur and Hayden White, who explore how storytelling shapes not only personal identity but also collective memory. Equiano's autobiography is more than a chronological record; it is a carefully crafted text designed to persuade readers and assert a particular image of selfhood. This deliberate narrative construction depicts how stories are used as instruments of power and resistance.

Moreover, theories on the rhetoric of abolitionist literature, as developed by scholars like Carey (2005), frame Equiano's literary techniques as strategic acts of advocacy. These approaches suggest that the emotional appeal and testimonial quality of slave narratives were essential in awakening public empathy and support for abolition in Britain. This rhetoric explains how Equiano's narrative functioned not just as personal testimony but as a catalyst for social and political change.

2-1-2 Writings in support of the Terms of Reference

Several key scholarly works reinforce the theoretical framework for this research:

Paul Edwards and James Walvin's *Black Personalities in the Era of the Slave Trade* (1983) critically examine the authenticity of Equiano's narrative and its political significance, helping us navigate debates about its reliability and impact.

Vincent Carretta's *Equiano, the African: Biography of a Self-Made Man* (2005) offers a detailed exploration of Equiano's life, including discussions on how aspects of his identity may have been shaped or constructed in the narrative.

Henry Louis Gates Jr., in *The Signifying Monkey* (1988), provides a broader context on African-American literary traditions, highlighting the importance of autobiographies like Equiano's in shaping cultural expression and resistance.

William Andrews' *To Tell a Free Story: The First Century of Afro-American Autobiography, 1760–1865* (1986) traces the origins and evolution of Black autobiographical writing, underscoring Equiano's foundational role in this literary lineage.

These studies affirm the critical importance of Equiano's narrative not only as a historical document but also as a powerful literary and political text. They justify its use here as a primary lens to explore themes of freedom, identity, and literary activism in the broader context of the 18th-century abolitionist movement.

2-1-3 Important concepts of the chosen model

This research revolves around several central concepts drawn from the theoretical frameworks outlined earlier:

- **Freedom:** More than just a physical condition, freedom here is understood as a complex and ongoing process involving psychological, economic, and spiritual dimensions. It is shaped not only by individual agency but also by the recognition or denial of that freedom by society.
- **Identity Construction:** This concept refers to the way a person's sense of self is continually reshaped through cultural negotiation, memory, and the stories they tell about themselves. Equiano's identity is neither fixed nor simple; it evolves as he navigates between African heritage and British society.

- **Narrative Authority:** At the heart of Equiano's work lies the power to control and share his own story. This authority challenges dominant narratives and reshapes public perception, especially within the politically charged context of the abolition movement.
- **Hybridity:** Borrowed from postcolonial theory, hybridity captures the tension and blending between Equiano's African origins and his life in British culture. This concept helps reveal the complexities and contradictions inherent in his self-presentation.
- **Testimony and Witnessing:** Equiano's narrative serves as both a personal testimony of slavery's horrors and a broader act of witnessing. His voice speaks not only to his own experience but also to the collective suffering and struggle for justice.

These key ideas provide the analytical tools that will guide the close reading and interpretation of Equiano's text in the following chapters, illuminating both its literary form and political significance.

2-2 Methodology

This study adopts a qualitative research approach centered on critical textual analysis of both primary and secondary sources. The goal is to understand how *The Interesting Narrative of the Life of Olaudah Equiano* functioned within the socio-political context of the abolitionist movement, as well as to explore its role in shaping identity and contributing to postcolonial discourse.

2-2-1 Type of information retained

The research focuses on qualitative data sources, including:

- A close textual reading of Equiano's *The Interesting Narrative of the Life of Olaudah Equiano* (1789).
- Scholarly commentary and interpretations drawn from academic journals, books, and critical essays.
- Historical records and data related to the transatlantic slave trade, abolitionism, and 18th-century British society.
- Postcolonial and literary theories applied to unpack the narrative's strategies, themes, and ideological implications.

The analysis prioritizes thematic exploration, rhetorical techniques, and ideological undercurrents present in both primary and secondary texts, seeking to reveal the layered meanings behind Equiano's autobiographical project.

2-2-3 Information gathering tools

Given the academic focus of this study, the main tools for collecting data are digital and archival resources that provide access to a wide range of relevant materials without requiring direct fieldwork. I can cite :

- Digital academic libraries such as JSTOR, Project MUSE, and Google Scholar, which offer a wealth of peer-reviewed articles and critical essays.
- E-books and critical editions of *The Interesting Narrative of the Life of Olaudah Equiano*, allowing for detailed textual study.
- PDF and physical copies of scholarly essays and historical documents sourced from both online repositories like Internet Archive and Hathi Trust, and university libraries.
- Citation management software such as Zotero or Mendeley to efficiently organize and reference sources, which is essential to maintain academic rigor.

Using these tools ensures a comprehensive and systematic approach to gathering a robust corpus of data, while acknowledging the limitations inherent in relying solely on secondary sources and digital archives.

2-2-4 Data analysis methods

The study applies a combination of literary content analysis and Critical Discourse Analysis (CDA) to interpret the data. This layered approach allows for a deep engagement with both the text and its wider social implications. The analysis involves several key steps such as:

- **Thematic coding:** Systematically identifying recurring themes such as freedom, identity, Christianity, violence, and resistance within Equiano's narrative.
- **Close reading:** Paying careful attention to language choices, tone, narrative structure, and rhetorical devices to uncover how meaning is crafted and conveyed.
- **Comparative analysis:** Placing Equiano's narrative in dialogue with other prominent slave narratives and abolitionist literature, such as works by Frederick Douglass and Thomas Clarkson, to highlight similarities, differences, and unique strategies.
- **Contextual interpretation:** Situating the autobiography within the broader historical

and ideological context of 18th-century British colonialism and the transatlantic slave trade to better understand its political and cultural significance.

This multifaceted methodology helps for a nuanced and critical interpretation of Equiano's work, emphasizing its dual nature as both a literary text and a tool of activism. It also reflects an awareness of the complexities involved in reading historical narratives that are both personal testimony and political intervention.

III- Data Analysis and Interpretation

3.1. Olaudah Equiano's Journey to Liberation

In this section, I have analyzed the major steps that marked Equiano's progressive path toward freedom. Olaudah Equiano's life is located within the broader historical and ideological framework of transatlantic slavery. By recounting his personal experiences, Equiano does not only document the brutality of the slave trade but he also illustrates how enslaved individuals found ways to resist and transform their condition.

3.1.1. Historical Background of Slavery

To understand Olaudah Equiano's journey to liberation, it is important to consider the broader context of 18th-century slavery, especially during the peak of the transatlantic slave trade. This system was both an economic engine and a deeply entrenched social structure shaping global relations.

The transatlantic slave trade was part of a triangular system connecting Europe, Africa, and the Americas. European ships exchanged goods like textiles and firearms for enslaved Africans, who were then transported under brutal conditions across the Middle Passage to the Americas. There, they were forced to work on plantations producing crops such as sugar and tobacco, which were then shipped back to Europe, fueling colonial economies.

As Walvin (2001) documents in *Black Ivory*, "*slavery constituted the economic foundation of European colonial empires*" (p.73). British ports like Liverpool and Bristol prospered from this trade, which was justified through racial and religious ideologies that dehumanized Africans and framed slavery as a "civilizing mission."

Born around 1745 in what is now southeastern Nigeria, likely among the Igbo people, Equiano was kidnapped at about eleven and sold into slavery a common fate for many West Africans. His life story reflects the trauma of forced separation, violence, and dehumanization experienced by enslaved

Africans. Yet, Equiano's narrative also reveals resilience and agency. He learned to read and write, converted to Christianity, gained his freedom, and became a prominent abolitionist. His autobiography, *The Interesting Narrative,* challenged prevailing racist views and played a key role in the British abolitionist movement

Equiano's story is inseparable from the brutal history of transatlantic slavery. His life offers insight into both the horrors of the system and the enduring strength of those who resisted it, highlighting the ongoing need to confront historical injustice.

3.1.2. Equiano's Path to Freedom

In *The Interesting Narrative of the Life of Olaudah Equiano* (1789), Equiano recounts his journey from enslavement to freedom, offering a rare personal testimony that critiques slavery and highlights human resilience. After being captured in Africa and sold multiple times, he ended up on British ships, where he gained exposure to new languages and cultures. Unlike many plantation slaves, Equiano learned to read, write, and speak English skills that became essential to his eventual emancipation.

His conversion to Christianity was both a spiritual awakening and a strategic alignment with European values, helping him navigate a society that preached Christianity while practicing slavery. Through faith and education, he gained the trust of his masters and later used Christian rhetoric to appeal to European readers in his abolitionist efforts.

Equiano also developed commercial and navigational skills, which allowed him to trade independently and save money. In 1766, after years of saving, he purchased his freedom for forty pounds a defining moment that marked his transformation from property to a free, self-determined man.

His story challenges prevailing European views of Africans as inferior, showing that enslaved individuals could reason, learn, and assert their dignity. While most enslaved people had little chance for such autonomy, Equiano's success was exceptional and paved the way for his role as a writer, Christian, and abolitionist

Equiano's path to freedom was not just about legal emancipation but a profound personal and intellectual transformation. His life demonstrates how literacy, faith, and economic independence can empower enslaved people to reclaim their agency and become agents of change.

3.1.3. Identity and Personal Transformation

Equiano's journey is also an internal one, marked by a profound transformation in identity. Initially stripped of his cultural roots and renamed "Gustavus Vassa," Equiano gradually reclaims his African identity through writing and activism. He becomes both African and British, slave and citizen, outsider and insider. This complex identity is articulated in his narrative: "*I am neither a saint, a hero, nor a tyrant. I am black and I am free*" (Equiano, 1789, p.210). Through literacy and Christian faith, Equiano reshapes himself into a voice of conscience in British society. His embrace of Christianity, while complex and sometimes controversial, provided him with moral legitimacy in a society that often equated race with savagery. Equiano's transformation also anticipates the modern concept of diasporic identity: an individual living between worlds. As Paul Gilroy suggests in *The Black Atlantic* (1993), Equiano exemplifies "*transcultural agency*" by navigating both African and Western traditions to forge a liberated self.

3.2. Olaudah Equiano and the Abolitionist Movement

3.2.1 Equiano's Narrative as a Political Tool

Olaudah Equiano's *The Interesting Narrative of the Life of Olaudah Equiano* (1789) is not merely an autobiography it is a political document. Published during the height of the abolitionist struggle in Britain, the narrative served to awaken public conscience by humanizing the enslaved African and

exposing the brutality of slavery. Equiano carefully structured his account to appeal to Christian morality, Enlightenment values, and British patriotism. He states: "*O, ye nominal Christians! might not an African ask you, learned you this from your God?*" (p.113). This direct appeal to religious hypocrisy resonated with abolitionist audiences. The narrative became a bestseller, with nine editions published during Equiano's lifetime, and was widely read by both the public and Parliament. As Carey (2005) demonstrates, "*Equiano's narrative was the most influential African text in the campaign for abolition in Britain. It was both a testimony and evidence*" (p.142). The text combined personal suffering, economic rationality, and moral reasoning key strategies for influencing legislation, including the 1807 Abolition of the Slave Trade Act.

3.2.2 Collaboration with Abolitionist Figures

Equiano's political activities went beyond his writing. He was deeply involved with the *Sons of Africa*, a group of freed Africans in Britain who worked with white abolitionists like Granville Sharp and Thomas Clarkson. According to Vincent Carretta, "*Equiano's ability to move between Black and white abolitionist circles made him a bridge between communities and a key organizer within the movement*" (*Equiano, the African*, 2005). He presented petitions to Parliament, gave speeches, and wrote letters to influential figures, including Queen Charlotte. Equiano's unique position as a literate, Christian African gave his advocacy authenticity and power. In 1788, he was appointed to a government expedition to Sierra Leone, aimed at resettling freed Black Britons. Although he later criticized the project's mismanagement, this appointment reflects the trust he had earned in elite circles.

3.2.3 Advocacy and Activism

Equiano remained a tireless campaigner for justice until his death in 1797. He used his platform to denounce not only slavery but also racism, colonial violence, and economic injustice. In his narrative, he criticizes slave owners and traders with a boldness that was rare at the time: "*Tortures, murder, and every other imaginable barbarity…are practiced upon the poor slaves with impunity*" (Equiano, 1789, p.87). He also wrote articles for newspapers, lobbied politicians, and spoke at anti-slavery events across Britain. His activism was both grassroots and institutional, combining popular mobilization with elite engagement. Scholars like Paul Edwards (1967) have noted that "Equiano's life and writings placed him at the heart of one of the most significant human rights struggles of modern history" (*Equiano's Travels*, p.121). In today's discourse, Equiano is celebrated as one of the earliest global human rights activists. His legacy lives on in educational curricula, literature, and memorials, especially as contemporary movements continue to combat systemic racism and neocolonialism that pave the way for freedom.

3.3. Impact and Perspectives on Freedom of Olaudah Equiano's *The Interesting Narrative of the Life of Olaudah Equiano*

3.3.1 Impact on the Abolition of the Slave Trade

Olaudah Equiano's legacy is deeply intertwined with the eventual success of the abolitionist movement in Britain. His narrative and activism significantly contributed to the passage of the 1807 Abolition of the Slave Trade Act. Although Equiano died in 1797- ten years before the law passed his efforts laid crucial groundwork. His autobiography, *The Interesting Narrative of the Life of Olaudah Equiano*, brought the horrors of slavery into the parlors of British middle-class readers. Equiano's story, written in accessible English and infused with moral appeals, made the suffering of enslaved Africans a tangible reality for people who had never seen a plantation or a slave ship. Parliamentarian William Wilberforce, one of the leading figures of the abolitionist movement, referred to the importance of slave narratives in shaping public opinion. Equiano's *The Interesting Narrative of the Life of Olaudah Equiano* has influenced the cultural and political climate that led to legislative change (Walvin, 1998). His experience has become one of the earliest examples of how personal testimony could influence international policy and public morality.

3.3.2 Perspectives on Freedom

Beyond the abolition of the slave trade, Equiano's work continues to resonate in modern discussions about freedom, human dignity, and racial justice. His narrative is now seen as one of the foundational texts in Black Atlantic literature and a precursor to modern human rights discourse. Equiano articulated a vision of freedom that was both personal and collective. He described his liberation not only as a legal status but also as a moral and intellectual awakening. He wrote: "*I was sensible of the invisible hand of God, which guided and protected me when I was an ignorant heathen in Africa*" (Equiano, 1789, p.194). This fusion of spirituality and liberation would go on to influence African diasporic movements and theologies in the centuries that followed. Modern scholars such as Paul Gilroy (*The Black Atlantic*, 1993) and Henry Louis Gates Jr. (*The Signifying Monkey*, 1988) argue that Equiano's narrative set the stage for a Black literary tradition that uses personal storytelling to contest social injustice. In many ways, Equiano's work foreshadowed the narratives of later figures like Frederick Douglass and W.E.B. Du Bois. Equiano is studied for his historical role and for the universal themes of perseverance, justice, and resistance. His life remains a symbol of how the written word can become a tool for freedom.

Conclusion

This research has explored the deeply personal and spiritually rich journey of Olaudah Equiano, tracing his transformation from an enslaved child into a self-liberated man, a committed Christian, and a compelling abolitionist voice. Equiano's conversion to Christianity was far from a passive acceptance of European norms; rather, it was a conscious spiritual awakening that helped him make sense of his suffering, reclaim his humanity, and construct an identity that transcended the imposed label of "slave." In *The Interesting Narrative*, spirituality is not an abstract concept but a lived experience, embodied in Equiano's evolving relationship with God through trials and moments of grace. This faith became both his shield and his weapon, providing the moral and psychological strength necessary to resist dehumanization and asserts his dignity. Through his narrative, Equiano actively challenges and dismantles prevailing ideas of African inferiority, presenting instead a portrait of an African man who is intelligent, rational, and spiritually capable. His strategic use of biblical references, his mastery of English moral rhetoric, and his appeals to Christian values are not acts of mimicry but deliberate efforts to engage, confront, and persuade a British audience on its own terms. In this respect, Equiano's autobiography functions not only as a personal life story but also as a profound political and theological statement. Equiano's exploration of identity is equally striking. He stands simultaneously as witness, survivor, believer, and agent of change. His story teaches to face the brutal realities of slavery and highlights the enduring resilience of the human spirit. In fine, this study has shown that Equiano's legacy transcends the abolitionist cause. Equiano's struggle for freedom invites reflection on the complex intersections between suffering and salvation, historical violence and spiritual endurance. It proves that the struggle for freedom is not only a matter of history but an ongoing spiritual and moral challenge.

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ABOUT THE DIGITAL STRATEGY AND THEIR APPLICATIONS

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ABSTRACT

Business programming is among the necessary skills for professionals in all business sectors, e.g. in accounting and financial services. Mastering knowledge and skills of data management using algorithms gives company's competitive advantages and advancement [1].

This work is devoted to developing an introductory understanding of the IT Fundamentals for digital infrastructure in Business [2]. The programming solutions and related algorithmic thinking to solve common business and decision problems have been provided. In particular, the practical problem of human resources management of companies is investigated. Graph data structures to modeling optimization problems and provide efficient algorithms of solution has been developed. The digital strategies and their applications of human resource management have been implemented. The tools applied in this development based on the algorithm concepts and development; object-oriented programming methodologies; language syntax; graphical interface design and event based programming.

The topic allows to developing digital infrastructure applying of algorithmic analysis and implementing plans to help a company achieve efficient management of human resources

The algorithms with efficient time and space complexity are provided. Corresponding Software implementations are made in C++. The work is multidisciplinary and includes areas of applied mathematics and computer science, business management and Graph Theory Concepts [2].

Keywords: management; algorithm; graph theory.

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A DIFFERENT GAME. HOW ALBANIA'S ARENA KOMBËTARE REDEFINES SUSTAINABLE DEVELOPMENT

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ABSTRACT

Contemporary sports stadiums have evolved beyond their primary role as athletic venues, now serving as multifaceted urban structures that powerfully symbolize a city's aspirations for global prominence and its trajectory of development. This paper explores the evolution from single-use, publicly funded monoliths toward a new model of integrated, privately financed, year-round destinations. This shift is analyzed through the Triple Bottom Line (TBL) framework, which evaluates performance across environmental, economic, and social dimensions. While leading venues in North America and Western Europe increasingly prioritize verifiable environmental performance, this paper argues that the Arena Kombëtare in Tirana, Albania, represents a divergent yet potent paradigm for sustainable stadium development in transitional economies. Shaped by a unique post-socialist history, the Arena prioritizes economic self-sufficiency and national image-building as its primary sustainability metrics. Through a comparative case study analysis, this research demonstrates that the Arena Kombëtare offers a model where financial viability and symbolic capital are the foundational pillars of sustainability. This makes it a compelling, replicable, but cautionary template for other nations navigating similar developmental paths, highlighting that the very definition of sustainability is context-dependent and its success may come at the cost of documented environmental performance and equitable urban development.

Keywords: sustainable architecture, stadium design, urban development, Triple Bottom Line, gentrification, Albania, Public-Private Partnership

The Evolution of the Multi-Purpose, Sustainable Sports Facility

The modern sports stadium has transcended its function as a mere venue for athletic competition to become a complex urban artifact and a potent symbol of a city's global ambition and developmental trajectory (Gratton & Preuss, 2008; Sklair, 2006). In recent decades, a significant paradigm shift has occurred, moving away from the publicly funded, single-use monoliths of the 20th century—many of which became "costly 'white elephants' due to underutilization and high maintenance costs" (Hedayati et al., 2014)—toward a new model of integrated, privately financed, year-round destinations. This evolution is driven by a confluence of economic pressures, environmental consciousness, and shifting social expectations. The central challenge confronting developers, city planners, and communities is how to achieve a truly balanced model that delivers on a trio of objectives: environmental responsibility, economic viability, and positive social impact.

To navigate this complexity, the Triple Bottom Line (TBL) framework, initially proposed by John Elkington (1997), is frequently employed. This framework suggests that genuine sustainability is

realized when an organization's performance is assessed across its social, environmental, and economic impacts (Gregori-Faus et al., 2024). In the context of stadium development, this translates into a tripartite mission: to build and operate facilities that are ecologically sensitive, financially self-sufficient, and serve as catalysts for positive community engagement and urban regeneration. However, the practical application of the TBL framework is far from uniform. The practical application of the TBL framework frequently sees its three pillars weighted and prioritized differently, a phenomenon often influenced by local political agendas, the market's developmental stage, and the unique socio-cultural environment of the project. In developed economies in North America and Western Europe, a mature regulatory environment and strong public pressure have elevated environmental performance, often verified through rigorous third-party certifications, to a prominent position.

In transitional economies, however, the calculus is different. This paper argues that the Arena Kombëtare in Tirana, Albania, represents a divergent yet potent paradigm for sustainable stadium development in such contexts. Shaped by a unique post-socialist history of economic trauma, a national drive for European integration, and a pervasive informal economy, the Arena prioritizes economic self-sufficiency and national image-building as its primary sustainability metrics. While the global discourse on sustainable stadiums increasingly emphasizes integrated environmental design and operational efficiency, the Arena Kombëtare offers a model where financial viability and symbolic capital are the foundational pillars of sustainability. This makes it a compelling, replicable, but cautionary template for other nations navigating similar developmental paths, demonstrating that the very definition of sustainability is context-dependent, with its success potentially coming at the cost of documented environmental performance and equitable urban development.

Theoretical Framework: The Triple Bottom Line in Modern Stadium Design

To critically evaluate the Arena Kombëtare, it is essential to first establish the theoretical benchmarks and best-practice examples that define the contemporary sustainable stadium. The Triple Bottom Line (TBL) provides a robust framework for this analysis, allowing for a structured examination of the environmental, economic, and social dimensions of modern stadium design and operation (Gregori-Faus et al., 2024). This section synthesizes academic and industry literature to define these three pillars, using leading international stadiums as case studies to illustrate the current state-of-the-art.

Environmental Sustainability: From Greenwashing to Certified Performance

Traditional sports facilities possess a considerable environmental impact. As massive structures, they consume vast quantities of nonrenewable energy, water, and raw materials, while generating significant waste and carbon emissions (Hedayati et al., 2014; International Olympic Committee, 2013; McCullough, 2023). In the United States alone, commercial buildings contribute significantly to environmental impact, accounting for up to 40% of raw materials use, 38% of carbon dioxide emissions, and 72% of electricity consumption, with large stadiums being notable contributors to these figures (Casper et al., 2014). This has led to increasing public and institutional pressure on the sports industry to adopt more environmentally responsible practices, moving beyond superficial "greenwashing" to embrace comprehensive, verifiable sustainability strategies (Cui, 2022; Zhu, 2023).

A key driver of this shift has been the rise of green building certification systems, particularly the Leadership in Energy and Environmental Design (LEED) program developed by the U.S. Green Building Council. LEED provides a framework for designing, constructing, and operating high-performance green buildings, with certification levels (Certified, Silver, Gold, Platinum) awarded based on points achieved across various sustainability metrics (Stouhi, 2018; WeBuildValue, 2024). Achieving LEED certification, especially at the Platinum level, has become a globally recognized symbol of environmental leadership in architecture.

The Mercedes-Benz Stadium in Atlanta serves as a leading benchmark, having achieved LEED Platinum certification upon its completion, notably earning the highest LEED score globally for any sports facility (Green Sports Alliance, 2018; Mercedes-Benz Stadium, 2016). This was not an incidental outcome but the result of a deliberate strategy targeting specific, quantifiable environmental goals. In terms of energy efficiency, the stadium was designed to achieve a substantial reduction in energy use compared to typical facilities of its size, with some reports indicating a decrease of over 40% (Climate Action, 2017; Mercedes-Benz Stadium, 2016; YouTube, 2018; AECOM, n.d.). This achievement is realized through features such as an operable roof for natural light, comprehensive LED lighting and video boards, and the installation of 4,000 solar photovoltaic (PV) panels that generate approximately 1.6 million kWh of renewable energy annually—an amount sufficient to power more than nine Atlanta Falcons games (Climate Action, 2017; Mercedes-Benz Stadium, 2016; YouTube, 2018).

Water conservation constituted another fundamental aspect of its design. The stadium achieved a 47% reduction in water use compared to baseline standards, primarily through the implementation of low-flow fixtures and a comprehensive stormwater management system (Green Sports Alliance, 2018; Mercedes-Benz Stadium, n.d.-d; SumanLuitel, 2019; Integrity Energy, n.d.). This system, with a total capacity reported to be over 2 million gallons, includes cisterns for rainwater harvesting, utilized for cooling towers and landscape irrigation, and an underground vault designed to capture stormwater, thereby preventing flooding in the adjacent Westside neighborhood, which is "a historically underserved community" (Green Sports Alliance, 2018; Mercedes-Benz Stadium, n.d.-d; SumanLuitel, 2019; Integrity Energy, n.d.).

Beyond construction, operational sustainability is critical. In addition, Mercedes-Benz Stadium has earned TRUE (Total Resource Use and Efficiency) Platinum certification, signifying its commitment to zero-waste initiatives. This achievement reflects its success in diverting over 90% of all waste from landfills through a comprehensive program encompassing recycling, composting, and material repurposing within its dedicated on-site resource recovery room (Mercedes-Benz Stadium, n.d.-d; Mercedes-Benz Stadium, 2022; Rough Draft Atlanta, 2023; YouTube, 2022; Green Lodging News, n.d.). This holistic approach extends to community engagement, with on-site edible gardens used for educational programs and to supply fresh produce (Mercedes-Benz Stadium, n.d.-d). This integration of design, technology, and operations demonstrates a comprehensive commitment to environmental stewardship. Similarly, other leading venues have adopted internationally recognized standards for ongoing operations. Both the Tottenham Hotspur Stadium in London and SoFi Stadium in Los Angeles have achieved ISO 20121 certification for Sustainable Event Management, a framework that guides organizations in managing the environmental, economic, and social impacts of their events through a process of continuous improvement (SoFi Stadium, 2025; Tottenham Hotspur, n.d.-b).

Economic Viability: The Multi-Purpose Revenue Engine

For decades, the prevailing model for stadium financing in many countries, particularly the United States, involved significant public subsidies. This model has been the subject of extensive criticism from economists, who have consistently found that stadiums generate little to no tangible net economic impact for their host communities. "The promised benefits of job creation and increased local spending often fail to materialize, as spending on sports is typically a substitution for other forms of local entertainment, not new spending" (Bradbury et al., 2023; Coates & Humphreys, 1999). Consequently, publicly funded stadiums have frequently become long-term financial liabilities for taxpayers, failing to justify the massive public investment (Coates & Humphreys, 2003).

In response to this well-documented market failure, the modern paradigm has shifted decisively toward financial self-sufficiency, driven by private financing and a diversified, multi-purpose operational model. The goal is no longer just to host a dozen home games a year but to create a year-round

entertainment destination that generates a continuous and varied stream of revenue. This economic imperative has, in turn, become a primary driver of architectural and technological innovation.

The Tottenham Hotspur Stadium in London exemplifies this new model, distinguished by its groundbreaking innovation: the world's first dividing, retractable natural grass pitch. This engineering feat allows the football pitch to separate into three sections and retract beneath the South Stand, unveiling a synthetic turf field suitable for American football. This technological flexibility, enabling a rapid changeover, was instrumental in securing a 10-year NFL contract for at least two games annually (Ingenia, 2019; Mace, n.d.; Populous, n.d.; Wikipedia, 2024g; Bluebeam, n.d.). This single feature unlocks a major, entirely separate revenue stream that would be impossible in a traditional stadium. The stadium's economic model is further bolstered by an extensive array of premium hospitality offerings, including 8,000 premium seats, private suites, sky lounges, Michelin-star dining options, and conference facilities. These are complemented by general admission attractions like the on-site Beavertown microbrewery and Europe's longest bar, all designed to maximize visitor spending and activate the venue 365 days a year (Arcadis, n.d.; Populous, n.d.).

The epitome of the stadium as a diversified economic engine is realized with SoFi Stadium in Inglewood, California. This venue functions not merely as an isolated facility but as the central anchor of Hollywood Park, an expansive, privately financed, master-planned development spanning 300 acres, effectively creating a "city within a city" (Guerrilla Foundation, 2023; Hollywood Park, n.d.; Wikipedia, 2024f). The development integrates retail, commercial office space, a hotel, residential units, and extensive public parkland around the stadium, creating a destination that draws visitors and generates revenue completely independent of stadium events (Deloitte, n.d.; Enclos Tensile Structures, n.d.; Wikipedia, 2024f). The operational management of such a complex is correspondingly sophisticated, involving a parent company (Hollywood Park), multiple sports franchises (the NFL's Rams and Chargers), and dedicated management teams for every facet of the business, from event operations and programming to global partnerships and guest experience (SoFi Stadium, 2025; The Org, n.d.; Hollywood Park, n.d.). This integrated development model represents the ultimate strategy for de-risking the massive capital investment required for a modern stadium by embedding it within a much larger, diversified real estate and entertainment ecosystem. The financial success of the stadium is thus not solely dependent on ticket sales or broadcast rights, but is intertwined with the commercial success of the entire district.

The evolution from a publicly funded liability to a privately financed, multi-purpose asset demonstrates a fundamental shift in the economic logic of stadium development. This shift suggests an implicit hierarchy within the TBL framework for stadium development, where economic viability serves as the foundational pillar. For a project to proceed, it must first demonstrate a compelling case for financial self-sufficiency and return on investment to attract the necessary private capital. Only upon establishing this economic foundation can the other dimensions of sustainability be effectively addressed. Environmental features, for instance, are most readily adopted when they align with economic incentives, such as long-term operational savings on energy and water, or when they provide significant reputational and marketing benefits (Kellison & Hong, 2015). This economic foundation is enabled by a symbiotic relationship between finance and technology. The financial imperative to be multi-purpose drives investment in complex technological solutions like retractable pitches and highly adaptable digital infrastructure (e.g., configurable A/V systems, lighting, and wayfinding) (Buro Happold, n.d.; Populous, n.d.; Ross Video, n.d.). In turn, these technological capabilities are what make the hyper-flexible, high-revenue, multi-event operational model possible, creating a feedback loop where venues become increasingly sophisticated—and expensive—technological hubs.

Social Impact: Urban Catalyst or Agent of Gentrification?

The social dimension of stadium development is arguably the most complex and contested pillar of the Triple Bottom Line. Advocates, including sports franchise owners and municipal authorities, frequently portray new stadiums as significant drivers of urban revitalization and social unity. This perspective suggests that such landmark developments can foster civic pride, elevate a city's national or international profile, forge a collective identity, and function as central points for community assembly (Chema, 1996; Crompton, 2004; Wulz, 1957; Deloitte, 2024). The architecture itself is often imbued with social meaning, designed to be a landmark that reflects the culture and aspirations of its community (Gratton & Preuss, 2008).

Conversely, a substantial and increasing volume of academic literature and community-level reports offer a contrasting perspective. These analyses frequently illustrate how major stadium developments, especially when situated in urban centers, can become significant drivers of gentrification. The resulting surge in investment and the proliferation of upscale amenities can inflate property values and rental costs, consequently displacing long-standing residents, particularly those from low-income and minority groups, who are then priced out of their communities (Siegfried & Zimbalist, 2000; Stinnett, 2013; Ramirez, 2021; Clark University, n.d.). Local businesses that served the original community may be pushed out in favor of chains and upscale establishments catering to a new, wealthier demographic (Bollano, 2024; Halla, 2025). The result can be the erosion of a neighborhood's unique cultural fabric and the exacerbation of social and economic inequality.

This dichotomy is evident in the case of SoFi Stadium. On one hand, the developers undertook an extensive community engagement process, conducting listening tours for over a year to understand residents' needs and concerns. This led to the incorporation of community-desired features, such as preserving and enhancing a local lake and parkland for multi-generational use, and the implementation of a 30% local hiring requirement for construction jobs (Avison Young, n.d.). These efforts represent a model for how developers can proactively seek community buy-in. On the other hand, the reality for many Inglewood residents has been characterized by significant disruption and a sense of exclusion. They have reported considerable negative consequences, including heightened traffic congestion, increased noise levels, and a scarcity of parking on event days. More significantly, the stadium's development has been directly associated with a sharp escalation in housing costs, with one study indicating that property values within a five-mile radius of the stadium appreciated at nearly twice the rate of those further afield since the project's inception (Ramirez, 2021; LA Times, 2022). Residents express a feeling of being pushed out of their own community, which they see being reshaped to cater to visitors rather than locals (NCRC, 2022; Ramirez, 2021).

The design and function of the stadium itself can reinforce these social dynamics. Despite being conceptualized as public gathering spaces, contemporary stadiums function as meticulously controlled environments. Entry is regulated via ticketing and stringent security measures, and their internal design actively directs spectators toward consumption and organized viewing experiences, rather than fostering spontaneous social interaction (Society and Space, 2020; CAME, n.d.). The stadium can thus function as a "shelter of last resort" in times of crisis, as seen with the Houston Astrodome after Hurricane Katrina, but its everyday purpose is to manage and discipline crowds for commercial purposes (Society and Space, 2020). This raises critical questions about whether these facilities truly serve the broader public or primarily benefit a narrow set of interests, including team owners, developers, and a more affluent class of consumers (Coates & Humphreys, 2003). The social impact of a modern stadium is therefore not a simple outcome but a complex negotiation between the promise of regeneration and the peril of displacement, between community integration and social exclusion.

Table 1 *Comparative Matrix of Modern Sustainable Stadiums*

Feature	Mercedes-Benz Stadium	Tottenham Hotspur Stadium	SoFi Stadium	Johan Cruyff ArenA
Location	Atlanta, USA	London, UK	Inglewood, USA	Amsterdam, Netherlands
Capacity	~72,000	~62,850	~70,240 (expandable)	~55,000
Cost (est.)	$1.5 billion	£1 billion	$5.5 billion	€140 million (original)
Funding Model	Public-Private Partnership	Private	Private	Public-Private Partnership
Key Innovation	LEED Platinum Certification; TRUE Zero Waste; Community Water Mgmt.	World's first dividing, retractable pitch (Grass/NFL)	Anchor of 300-acre mixed-use district; Infinity Screen	"Living Lab" for smart city & stadium innovation
Sustainability Certification	LEED Platinum, TRUE Platinum, ISO 20121	ISO 20121	ISO 20121	N/A (Focus on operational innovation)
Core Purpose	Environmental & Social Benchmark	Revenue Maximization via Multi-Use	Urban Anchor & Real Estate Development	Innovation Hub & Advisory Model

Note. Data compiled from sources (Coates & Humphreys, 1999; Hedayati et al., 2014; Green Sports Alliance, 2018; SoFi Stadium, 2025; Ingenia, 2019; Populous, n.d.; Mace, n.d.; Wikipedia, 2024f; Enclos Tensile Structures, n.d.; Johan Cruyff ArenA Innovation, n.d.; Nyenrode Business Universiteit, 2025; Johan Cruyff ArenA, n.d.-d; Johan Cruyff ArenA, n.d.-c). Costs are approximate at time of construction and may vary based on currency and reporting.

Case Study: The Arena Kombëtare as a Post-Socialist Paradigm

To understand the Arena Kombëtare in Tirana, one cannot simply apply the benchmarks of sustainability developed in the stable, high-income economies of North America and Western Europe. The stadium is a product of Albania's tumultuous and unique modern history, a context that fundamentally shapes its priorities, its financial structure, and its symbolic meaning. Its development model can only be deciphered through the lens of a nation's journey from extreme isolation to ardent European aspiration, a path scarred by economic trauma and defined by a relentless drive for modernization.

Contextual Backdrop: From Isolation to Integration

Albania's 20th-century history is one of profound isolation. Under the iron-fisted, 40-year rule of Stalinist dictator Enver Hoxha, the country was transformed into one of the most secluded and controlled societies in the world, often dubbed the "North Korea of Europe" (Beaudry, 2024; Dervishi & Johnson, 2020; Wallpaper, 2025). The regime's ideology of absolute self-reliance was enshrined in the constitution, which banned all foreign aid, loans, and investment (Britannica, 2024b; International Monetary Fund, 1992; U.S. Library of Congress, 1992). The economy was entirely centrally planned,

private property was abolished, and all means of production were state-owned (Britannica, 2024b; International Monetary Fund, 1992; Wikipedia, 2024e). By the time the communist regime collapsed in 1991, Albania was the poorest and least developed nation in Europe, its infrastructure decrepit and its people cut off from the world (Britannica, 2024a; International Monetary Fund, 1992; International Monetary Fund, 1999).

The fall of communism thrust Albania into a chaotic transition to a market economy. Guided by the International Monetary Fund (IMF) and the World Bank, the country adopted a radical "shock therapy" approach in July 1992 (Marangos, 2004; Proedrou, 2013). This involved the rapid dismantling of state controls and privatization, but it was implemented in a country with no prior experience of market institutions or democratic culture (Insajderi, n.d.; Proedrou, 2013). The process was aggressive and destabilizing, eliminating old economic structures before new ones were fully functional, which created a fertile ground for a burgeoning informal economy that came to represent a significant portion of all economic activity (Gërxhani, 2003; International Monetary Fund, 2024; M. Muço & P. Sanfey, 2002; V. Muço et al., 2014).

This fragile new economic order culminated in a national catastrophe in 1997 with the collapse of massive pyramid schemes. In a country with a rudimentary and distrusted formal banking system, a significant portion of the population—lured by promises of fantastical returns—invested their life savings, and even sold their homes, to pour money into these fraudulent funds (Alikaj, 2022; International Monetary Fund, 1999). At their peak, the schemes' liabilities amounted to nearly half of the country's GDP. Their inevitable collapse in early 1997 triggered a complete societal breakdown. Protests turned into violent riots, the government fell, and the country descended into anarchy and a near-civil war that resulted in the deaths of an estimated 2,000 people (International Monetary Fund, 1999; Unboxify, 2023; Wikipedia, 2024a). This event left a deep and lasting trauma, shattering public trust in both state institutions and the formal financial system, and reinforcing a reliance on informal channels and cash-based transactions (Alikaj, 2022; Azarri & Carletto, 2009).

In the decades since, Albania's overarching political and social objective has been integration into Euro-Atlantic structures, culminating in NATO membership in 2009 and the ongoing pursuit of full membership in the European Union (EU) (D'Orazio, 2025; European Council on Foreign Relations, 2025; Gëdeshi, 2021; Ministry of Foreign Affairs of the Republic of Türkiye, n.d.; Regional policy of Albania, 2023; Structural reforms in Albania, 2024; Wallpaper, 2025). The EU accession process has become the primary external driver for deep structural reforms, particularly targeting the judiciary and combating the country's persistent problems with corruption and weak governance (D'Orazio, 2025; European Council on Foreign Relations, 2025; Newlines Institute for Strategy and Policy, 2025; Structural reforms in Albania, 2024). Within this historical and political context, significant modern infrastructure developments, such as the Arena Kombëtare, transcend their utilitarian function. They serve instead as potent and concrete symbols of Albania's ongoing "Europeanization," its advancement, and its decisive departure from a history of isolation (Andreini, 2023; Simon & Schuster, 2024). The contemporary economic landscape reflects this journey: a dynamic economy buoyed by a booming tourism sector and significant remittances from its large diaspora, yet still grappling with a large informal economy, governance challenges, and a GDP per capita that remains only a fraction of the EU average (ALTAX, 2024; ALTAX, 2025; Gëdeshi, 2021; International Monetary Fund, 2024; International Monetary Fund, 2025c; V. Muço et al., 2014; World Bank, 2024b).

The Architectural Vision: A Monument to National Rebirth

The design of the Arena Kombëtare, led by Italian architect Marco Casamonti of Archea Associati, is deeply infused with the narrative of national renewal. It is explicitly conceived not as a simple sports venue but as a "contemporary monument" intended to project the image of a modern, confident, and

culturally rich Albania (Andreini, 2023; Casamonti, n.d.). The stadium's architecture is a deliberate exercise in national branding. Its peculiar multi-faceted, 8-sided rectangular form was envisioned to symbolize the geographical shape of Albania itself (Wikipedia, 2024b). The façade is clad in thousands of black and red metal panels, arranged in patterns reminiscent of traditional Albanian carpets and textiles, directly referencing the colors and heritage of the national flag (Archea Associati, 2020; Wikipedia, 2024b).

A central theme of the project is the dialogue between history and modernity, a crucial element in Albania's post-communist identity formation. The new stadium was built on the exact site of the former Qemal Stafa Stadium, a historic landmark designed in the 1930s by Italian architect Gherardo Bosio. While the old structure was almost entirely demolished to meet modern UEFA standards and increase capacity, the project meticulously preserved the monumental marble façade of the original VIP entrance (Casamonti, n.d.; Re-thinking The Future, n.d.; Wikipedia, 2024b). This historic element was carefully disassembled, stored, and then reconstructed and integrated into the new building, serving as the access point for the new VIP areas (Archea Associati, 2020; Re-thinking The Future, n.d.). This act of architectural preservation serves a powerful symbolic function, signaling a respect for the nation's pre-communist, European-influenced history while simultaneously embracing a forward-looking, contemporary design. It is a physical manifestation of continuity and innovation, a narrative that resonates deeply within a country seeking to reclaim its European identity (Andreini, 2023; Casamonti, n.d.; Simon & Schuster, 2024).

The stadium's urban presence is designed to be dominant and transformative. Located at the southern end of Tirana's main ceremonial boulevard, its scale and distinctive design establish it as a new city landmark (Casamonti, n.d.; Wikipedia, 2024b). This is further amplified by the integration of a 112-meter, 24-floor tower into one corner of the stadium structure. This tower, which houses a Marriott hotel, makes the stadium visible from across the city and acts as an observation point, cementing its role as a "calling card" for the capital and a symbol of its urban rebirth (Casamonti, n.d.; Wikipedia, 2024b).

The Financial Architecture: A Public-Private Partnership in a High-Risk Environment

The financing model of the Arena Kombëtare is as central to its identity as its architecture. The project was realized through a Public-Private Partnership (PPP) between the Albanian Football Association (FSHF), a public body, and AlbStar Sh.P.K., a major private Albanian construction and engineering company (AlbStar Sh.p.k., n.d.-a; Lisaku, 2016). The core of the agreement was that AlbStar would bear the full cost of construction, estimated to be between €50 million and €85 million, without any direct financial outlay from the Albanian government or the FSHF (Lisaku, 2016; Re-thinking The Future, n.d.; Wikipedia, 2024b). In exchange for this massive private investment, the PPP granted AlbStar ownership and long-term management rights over all the commercial and non-sporting elements integrated into the stadium complex (Lisaku, 2016; Re-thinking The Future, n.d.; Wikipedia, 2024b). This includes the 24-floor hotel tower, 14,000 square meters of business and office space, and all the ground-floor retail areas surrounding the stadium perimeter (Lisaku, 2016; Re-thinking The Future, n.d.). This model was publicly lauded by government officials as a fiscally prudent triumph, a way to deliver a world-class public asset that cost the state "not a single cent" (Lisaku, 2016).

This financial structure inherently dictates the stadium's multi-purpose nature. The project's economic sustainability is entirely dependent on its ability to generate year-round revenue from these commercial assets. The integration of the high-profile Marriott hotel, along with numerous bars, restaurants, shops, conference rooms, and gyms, is designed to transform the stadium from an occasional sports venue into a continuously active urban commercial hub (Andreini, 2023; Casamonti, n.d.; Expedia, n.d.; Hotels.com, n.d.; Re-thinking The Future, n.d.; Travelocity, n.d.). This core revenue model is further supplemented by a naming rights deal with the national airline, Air Albania, which rebranded the venue

as the "Air Albania Stadium," adding another layer of commercial income and reinforcing the theme of national branding (Duka, 2025; Inside World Football, 2025).

The development of the Arena Kombëtare cannot be separated from the historical context that produced it. The Arena project, therefore, serves as a potent socio-political instrument, arguably conceived to symbolically address and overcome the historical traumas of Albania. The nation's history is defined by the profound infrastructure deficit and cultural isolation of the Hoxha regime, followed by the catastrophic failure of public finance and state authority during the 1997 pyramid scheme collapse (Bollano, 1974; International Monetary Fund, 1999; Wikipedia, 2024a). These events created a dual legacy of deep public distrust in state-led financial projects and a powerful yearning for modern, European-style infrastructure. The Arena's development model directly addresses both legacies. Architecturally, its open, contemporary, and commercially integrated design is a physical and symbolic break from the closed, austere aesthetic of the past, representing an outward-facing, "European" monument (Andreini, 2023; Casamonti, n.d.; Simon & Schuster, 2024). Financially, the PPP model, which explicitly avoids direct state expenditure, insulates the public budget from the perceived risk of another large-scale financial debacle, allowing political leaders to showcase fiscal prudence (Lisaku, 2016). This makes the stadium a project of immense political capital, a tangible narrative of a modern, competent, and financially responsible Albania that transcends its function as a mere sports facility.

However, this very model is also a product of Albania's challenging governance environment. The country's large and persistent informal economy, particularly within the construction and real estate sectors, is often linked to illicit financial flows that can distort market prices and create artificial demand (ALTAX, 2024; International Monetary Fund, 2024; V. Muço et al., 2014). Foreign investors consistently cite corruption, a lack of transparency, and weak rule of law as major impediments to doing business (U.S. Department of State, 2024). The PPP arrangement for the Arena, while praised for its lack of public cost, involved the transfer of highly valuable public land and long-term commercial rights to a single private entity, AlbStar, which was the sole bidder in the tender process (Lisaku, 2016). The lack of competition and the opacity regarding the long-term value of the commercial rights granted versus the actual construction cost raise significant governance questions. This type of arrangement, where a major public asset is developed through a non-competitive deal with a private entity, can be seen as a formalization of practices common in an economic environment characterized by high informality and weak institutional oversight. It leverages private capital for a public good, but in a manner that concentrates long-term profits in private hands with limited public transparency or competitive bidding. This suggests that the model's success is deeply intertwined with the specific economic and governance conditions of Albania, making its direct replication in contexts with stronger regulatory frameworks and less tolerance for opaque deals highly problematic.

A Critical Assessment of the Arena Kombëtare's Sustainability Model

Applying the Triple Bottom Line framework to the Arena Kombëtare reveals a clear hierarchy of priorities. The stadium represents a resounding success in the economic and political dimensions of sustainability, aligning perfectly with the primary objectives of its developers and the Albanian state. However, its performance on the environmental and social pillars is far more ambiguous and contested, highlighting the trade-offs inherent in its development model.

Economic and Political Sustainability: A Definitive Success

From an economic standpoint, the Arena Kombëtare is a masterclass in financial self-sufficiency within a developing economy. By integrating a hotel, extensive office space, and ground-floor retail and restaurant facilities, the PPP model ensures a diversified and continuous revenue stream that is not solely reliant on match-day income (Casamonti, n.d.; Re-thinking The Future, n.d.; Wikipedia, 2024b). This multi-purpose design, which transforms the stadium into a year-round commercial destination,

effectively inoculates it against the "white elephant" syndrome that has plagued so many publicly funded, single-use stadiums. The project was designed to be economically sustainable from the outset, a necessity for attracting the required private investment from AlbStar (Archea Associati, 2020; Re-thinking The Future, n.d.). The subsequent naming rights deal with Air Albania further solidifies its financial footing, demonstrating a successful application of modern sports marketing models in a new market (Duka, 2025; Inside World Football, 2025).

Politically, the stadium is an unqualified triumph. It serves as a powerful, tangible symbol of Albania's national rebirth, its modernization, and its determined pivot toward Europe (Casamonti, n.d.; Simon & Schuster, 2024). The project is consistently framed as a "flywheel for the regeneration" of Tirana and a beacon of cultural renewal (Re-thinking The Future, n.d.; Simon & Schuster, 2024; Vrapi, 2022). This narrative was powerfully validated in 2022 when UEFA selected the Arena to host the inaugural final of the Europa Conference League. This event placed Tirana on the international sporting map, showcasing the new facility to a continental audience and confirming its status as a top-tier European venue (Andreini, 2023; Telegrafi, 2024). For the government and the FSHF, the stadium is a testament to a "visionary step" that has transformed the landscape of Albanian football and revitalized the local community, all achieved without public expenditure (Lisaku, 2016; Telegrafi, 2024).

Environmental Performance: A Gap Between Aspiration and Documentation

While the Arena's economic success is clear, its environmental credentials are far less substantiated. A critical assessment reveals a significant gap between general aspirations for sustainability and the provision of specific, verifiable data. Sources related to green building in Albania speak in broad terms about the integration of "energy-efficient systems," "sustainable materials," and "advanced waste management practices" in new developments (Constructive Voices, n.d.). The construction company, AlbStar, publicly states its commitment to reducing environmental impact and improving engineering solutions for sustainability (AlbStar Sh.p.k., n.d.-a; AlbStar Sh.p.k., n.d.-b). The architect, Marco Casamonti, notes the use of glazed glass for the curtain walls to enhance energy savings and acoustic insulation (Casamonti, n.d.).

However, there is a conspicuous absence of any formal environmental certification for the Arena Kombëtare, such as LEED or BREEAM, which are the global standards for verifying green building claims (Stouhi, 2018; WeBuildValue, 2024; U.S. Green Building Council, n.d.). This stands in stark contrast to the data-rich, certified performance of venues like Mercedes-Benz Stadium, where specific metrics on energy reduction, water conservation, and waste diversion are central to the project's identity and public promotion (Green Sports Alliance, 2018; Mercedes-Benz Stadium, 2016; Mercedes-Benz Stadium, n.d.-d). While Albania as a nation is actively pursuing a green energy transition, with a focus on developing solar power to complement its hydropower resources, and is working to align its waste management strategies with EU standards, the Arena's specific contribution to these national goals remains undocumented and unquantified (GFA Consulting Group, 2020; International Monetary Fund, 2025c; Kasemets, 2025; Ministry of Infrastructure and Energy, 2021; UNECE, 2012; UNECE, 2021; United Nations, 2023). The sustainability narrative for the Arena appears to be primarily focused on its economic and social dimensions, with environmental performance treated as an assumed benefit rather than a documented and certified achievement.

Social Integration and Urban Impact: A Contested Legacy

The social impact of the Arena Kombëtare is presented in overwhelmingly positive terms by its proponents. It is framed as a force for social integration, a project that strengthens the bond between the community and national sport, and a source of immense national pride (Casamonti, n.d.; Coliseum, 2025b). The design is intended to create a vibrant urban pole, active 365 days a year, that revitalizes a key part of Tirana and brings new life to the city center (Andreini, 2023; Casamonti, n.d.; Re-thinking

The Future, n.d.; Telegrafi, 2024). The successful hosting of major events and the creation of an "intimidating atmosphere" for opposing teams are seen as having a direct positive impact on the national team's performance and the collective morale of the nation (Telegrafi, 2024).

This positive narrative, however, must be situated within the broader, more critical context of Tirana's recent urban development. The city has been undergoing a rapid and often controversial transformation characterized by a construction boom, the demolition of historic buildings (such as the National Theater), and the displacement of residents to make way for new, high-end projects (Bollano, 2024; Halla, 2025; Politika.io, 2021). This urban transformation has been characterized as a process of aggressive gentrification, in which public spaces are increasingly privatized and the urban landscape is reconfigured to prioritize commercial objectives, frequently at the detriment of the city's established social fabric and historical character (Guerrilla Foundation, 2023; Vrapi, 2022). The Arena Kombëtare, as a major development in a prime central location, is an integral part of this transformation. By its very nature, the project has significantly increased the real estate value of the surrounding neighborhood, an effect explicitly noted as a benefit of the regeneration (Re-thinking The Future, n.d.). While it may not have directly caused residential demolitions in the same way as other projects, its focus on high-end commercial, office, and hospitality functions—including a Marriott hotel and upscale shops and restaurants—caters to a wealthier clientele and inevitably contributes to the gentrification pressures that can alter the character of a neighborhood and push out lower-income residents and businesses (Bollano, 2024; Expedia, n.d.; Hotels.com, n.d.; Travelocity, n.d.; Vrapi, 2022).

Furthermore, there is a notable lack of documented, formal community engagement strategies in the development process, a stark contrast to the extensive (if imperfect) consultation processes described for projects like SoFi Stadium (Avison Young, n.d.). The Arena's social value is largely defined from the top down, as a contribution to national pride and economic vitality, with less apparent focus on the granular, ground-level impacts on the immediate community.

This critical assessment reveals that the concept of "sustainability" is not universal but is weighted differently according to context. In the developed economies of the West, strong institutions and public pressure compel stadium developers to address all three pillars of the TBL, with a particular emphasis on quantifiable environmental performance through certifications like LEED (Green Sports Alliance, 2018; Mercedes-Benz Stadium, n.d.-d; Tottenham Hotspur, n.d.-b). In Albania, the most acute pressures are economic (the need to overcome a legacy of poverty and create jobs) and political (the drive for EU integration and the projection of a modern national image) (Peshkopia, 2014; Structural reforms in Albania, 2024). The Arena Kombëtare's development is a direct reflection of these local pressures. It excels in the areas of greatest domestic concern: economic self-sufficiency and symbolic national value. Its environmental features are mentioned but are not a central part of its public identity, suggesting they are a lower-tier priority compared to the economic and political imperatives (AlbStar Sh.p.k., n.d.-a; Constructive Voices, n.d.). This demonstrates that for a transitional economy like Albania, sustainability is primarily defined as economic and political endurance, with environmental performance being a secondary consideration rather than a core, non-negotiable driver of the project.

Furthermore, the stadium can be understood as an "island of formality" within a wider sea of economic informality. Albania's economy is characterized by a large informal sector, challenges with the rule of law, and weak governance structures, which can deter conventional foreign investment (Gërxhani, 2003; International Monetary Fund, 2024; M. Muço & P. Sanfey, 2002; V. Muço et al., 2014; World Bank, 2024a). The Arena Kombëtare project circumvents these challenges by creating a highly formalized, self-contained economic ecosystem. With its high-profile international partners like Marriott and UEFA, its formal commercial contracts for naming rights, and its modern, regulated retail and office spaces, the Arena operates according to "Western-style" business rules (Andreini, 2023; Duka, 2025; Wikipedia,

2024b). This creates a predictable and profitable environment that is attractive to international brands and capital, effectively insulating the project from the uncertainties of the broader domestic economy. This model showcases a strategy for executing large-scale projects in high-risk environments, but it also underscores the profound challenge of extending this bubble of formality and good governance to the rest of the economy.

Discussion

By juxtaposing the Arena Kombëtare with prominent stadium models from North America and Western Europe, a critical question emerges: Does the Albanian approach offer a viable and desirable template for other nations, especially those undergoing similar economic and political transitions? The synthesis of the case study and the theoretical framework suggests that the Arena is indeed a replicable template, but one whose applicability and desirability are contingent on a specific set of local conditions and whose adoption carries significant, inherent risks.

The analysis presented in this paper substantiates the core argument that the Arena Kombëtare exemplifies a unique model of stadium sustainability, one characterized by its primary emphasis on economic autonomy and national image projection over other TBL dimensions. It demonstrates a clear pathway for a transitional economy to deliver a landmark piece of public infrastructure without direct state expenditure, leveraging private capital in exchange for long-term commercial rights. This model is most likely to be successfully replicated in contexts that share several key characteristics with Albania. First, there must be a strong, centralized political will to pursue a symbolic, modernizing project that can serve as a centerpiece of a national development narrative. Second, there must be a pool of domestic private capital with the capacity and risk appetite to undertake a large, long-term infrastructure investment, and a willingness to accept commercial real estate rights as the primary form of return. Third, the political and public desire for such a project must be strong enough to outweigh potential concerns regarding the transparency of the PPP arrangement, the lack of competitive bidding, or the explicit prioritization of economic objectives over documented environmental and social equity goals.

However, the adoption of the Arena Kombëtare model is fraught with considerable risks that must be carefully weighed by any city or nation considering a similar path. The first and most evident risk is the potential for environmental neglect. When economic return is the undisputed primary driver of a project, and when there is no strong regulatory or public pressure for third-party verification, environmental sustainability can easily be relegated to rhetoric rather than practice. The "build now, certify later (or never)" approach risks locking in decades of suboptimal environmental performance. Without the discipline imposed by frameworks like LEED, there is little incentive for developers to go beyond the minimum required standards, potentially resulting in what can be termed "greenwashing-by-omission."

The second major risk is that of elite capture and the entrenchment of poor governance. Public-Private Partnerships (PPPs) that lack transparency and competitive bidding, exemplified by the Arena's single-bidder contract, carry the risk of consolidating substantial economic power and valuable public resources within a limited number of politically connected entities (Lisaku, 2016). Rather than fostering a more transparent and competitive market economy, such deals can reinforce existing patronage networks and undermine the rule of law. This is a particularly acute danger in transitional economies already struggling with high levels of perceived corruption (U.S. Department of State, 2024). The model can become a mechanism for privatizing public wealth under the guise of public good.

The third significant risk relates to social exclusion and inequitable development. The economic logic of the model, which relies on maximizing revenue from high-end commercial, retail, and hospitality offerings, inherently orientates the development toward a wealthier consumer base (Expedia, n.d.; Hotels.com, n.d.; Travelocity, n.d.). This can accelerate gentrification in centrally located urban areas, leading to the displacement of existing communities and the creation of exclusive, rather than inclusive,

public spaces (Bollano, 2024; Vrapi, 2022). The very success of the stadium as a real estate venture can undermine the social fabric it claims to support. Without robust, legally mandated mechanisms for community benefit agreements, affordable housing provisions, and support for local small businesses, the stadium risks becoming a gilded island in its city, disconnected from the lives of many of its residents.

Conclusion

The global trend in stadium development is unmistakably moving toward a multi-purpose, sustainable model. However, this research demonstrates that "sustainability" is not a monolithic concept. The Arena Kombëtare in Tirana offers a powerful but complex paradigm of stadium development tailored to the unique pressures and historical context of a post-socialist, EU-aspirant nation. It successfully achieves economic self-sufficiency and serves as a potent symbol of national renewal, addressing the most pressing domestic political and economic priorities. In doing so, it provides a compelling alternative to the fully private or heavily subsidized models common elsewhere.

This paper's principal contribution lies in its critical and context-sensitive application of the Triple Bottom Line framework. Through a comparative analysis of the Arena Kombëtare against established Western models, the research uncovers an inherent "hierarchy of sustainability," demonstrating how TBL pillars are prioritized distinctly according to a nation's developmental stage, institutional capabilities, and political imperatives. The Arena Kombëtare emerges not as a flawed version of a Western model, but as a distinct fourth model of its own—the "transitional-symbolic" model—which prioritizes economic resilience and nation-branding as its foundational components.

This model, however, is a double-edged sword. Its replicability in other transitional economies is clear, but so are its inherent risks of environmental tokenism, opaque governance, and socially inequitable outcomes. The path forged by Tirana is a cautionary tale as much as it is a success story. It underscores that for large-scale urban interventions like modern stadiums to deliver truly holistic and lasting benefits, a conscious and deliberate balancing of all three pillars of sustainability is required. Therefore, this paper concludes with a recommendation for international bodies such as UEFA, FIFA, and development banks that support or sanction such projects. Future project approvals and support should be contingent on stronger, more transparent, and verifiable commitments across all three dimensions of sustainability. This includes mandating internationally recognized environmental certifications like LEED, requiring transparent and competitive bidding processes for PPPs, and embedding legally binding community benefit agreements into the project framework from its inception. Only by insisting on this balanced approach can the global sports community ensure that the next generation of stadiums are not just economically viable and symbolically potent, but are also truly sustainable for the environments and communities they are built to serve. Future research should focus on the long-term empirical impacts of these divergent stadium models, tracking metrics on real estate prices, local business survival rates, and verified environmental performance over the full lifecycle of the facilities.

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Appendix

Appendix A: Key Albanian Economic and Social Indicators (2022-2025)

Indicator	2022	2023	2024 (est./proj.)	2025 (proj.)	Source(s)
Real GDP Growth (%)	4.8	3.9	3.3 - 3.9	3.1 - 3.8	
GDP per capita (USD)	6,743	8,300	-	10,530	[International Monetary Fund, 2025c; International Monetary Fund, 2025d]
Inflation Rate (avg, %)	6.7	4.8	2.2 - 2.3	2.4 - 2.8	

Indicator	2022	2023	2024 (est./proj.)	2025 (proj.)	Source(s)
Unemployment Rate (%)	11.0	10.7	8.8 - 9.4	8.8 - 9.0	
Public Debt (% of GDP)	65.5	58.4	54.2 - 56.4	52.8 - 55.5	
Current Account Balance (% GDP)	-6.0	-1.2	-3.4	-3.1 - -3.7	
Foreign Direct Investment (USD bn)	1.45	1.62	1.58	-	
Corruption Perceptions Index (Rank)	101/180	-	80/180	-	[Investment Council, 2025]

Note. Data ranges reflect varying estimates and projections from different reports published by the International Monetary Fund (IMF), the World Bank (WB), the European Bank for Reconstruction and Development (EBRD), and Albania's Institute of Statistics (INSTAT) throughout 2024 and early 2025. The Corruption Perceptions Index is from Transparency International. Blank cells indicate data not consistently available across sources for that specific year.

ARTIRILMIŞ GERÇEKLİĞİN AÇIK HAVA REKLAMCILIĞINA ETKİSİ: DİJİTALLEŞME SÜRECİNDE YENİ BİR DÖNÜŞÜM

THE DIZZYING PACE OF TECHNOLOGICAL ADVANCEMENTS HAS LED TO PROFOUND CHANGES IN ALL ASPECTS OF DAILY LIFE, RESHAPING INDIVIDUAL LIFESTYLES

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ÖZET

Teknolojik gelişmelerin baş döndürücü bir hızla ilerlemesi, günlük yaşamın her alanında köklü değişimlere neden olmakta, bireylerin yaşam biçimlerini yeniden şekillendirmektedir. Akıllı telefonlar, tabletler ve bilgisayarlar, günümüz insanı için vazgeçilmez araçlar hâline gelmiş; dijitalleşme, bireylerin hem tüketim alışkanlıklarını hem de üretim pratiklerini derinden etkilemiştir. Bu dijital dönüşüm, insanlığın teknolojiye olan ilgisini ve bağımlılığını açıkça ortaya koymaktadır.

Bu süreçten etkilenen alanlardan biri de reklamcılıktır. Geleneksel iki boyutlu reklam anlayışı yerini daha etkileşimli ve deneyim temelli uygulamalara bırakırken, özellikle açık hava reklamcılığı önemli bir dönüşüm geçirmiştir. Artırılmış gerçeklik (AR) teknolojisi, reklamcılığa yeni bir boyut kazandırarak kullanıcı deneyimini interaktif hâle getirmekte ve hedef kitleyle daha güçlü bir etkileşim kurulmasını mümkün kılmaktadır.

Bu çalışmada, artırılmış gerçeklik teknolojisinin açık hava reklamcılığı alanındaki rolü detaylı bir biçimde incelenmektedir. Artırılmış gerçeklik teknolojisinin (AR) temel özellikleri ele alınarak bu teknolojinin reklamcılık sektörüne sunduğu katkılar değerlendirilmektedir. Ayrıca, konuya ilişkin güncel akademik literatür taranmış ve artırılmış gerçekliğin (AR) açık hava reklamlarında kullanımına yönelik Türkiye'den ve Dünya'dan örnekler analiz edilmiştir. Bu bağlamda, reklam yapılarındaki dönüşüm ile tüketici etkileşiminin nasıl yeniden şekillendiği üzerinde durulmuştur. Artırılmış gerçeklik (AR) tabanlı reklam uygulamaları, kullanıcıları kampanyanın aktif bir parçası hâline getirerek marka ile doğrudan bir ilişki kurmalarını sağlamakta; böylece geleneksel reklamcılığın ötesine geçen bir iletişim modeli ortaya koymaktadır.

Anahtar Kelimeler: Dijitalleşme, AR teknolojisi, reklamcılık

ABSTRACT

Smartphones, tablets, and computers have become indispensable tools for modern individuals; digitalization has significantly influenced both consumption habits and production practices. This digital transformation clearly reveals humanity's deepening interest in and dependence on technology.

One of the fields most affected by this process is advertising. Traditional two-dimensional advertising approaches have been replaced by more interactive and experience-oriented applications, with outdoor advertising undergoing particularly notable changes. Augmented reality (AR) technology has introduced a new dimension to advertising, enabling a more interactive user experience and facilitating stronger engagement with target audiences.

This study thoroughly examines the role of augmented reality technology in the field of outdoor advertising. The fundamental features of AR technology are discussed, and its contributions to the advertising sector are evaluated. Furthermore, recent academic literature on the subject is reviewed, and examples of AR usage in outdoor advertisements from both Turkey and around the world are analyzed. In this context, the transformation in advertisement structures and the reshaping of consumer interaction are emphasized. AR-based advertising applications engage users as active participants in campaigns, fostering a direct relationship with the brand and establishing a communication model that goes beyond the traditional understanding of advertising.

Key words: Digitalism, AR Tech., Advertising

THE EFFECTIVENESS OF THE DECO–S.E. PROGRAM IN DEVELOPING SOCIO-EMOTIONAL SKILLS IN EARLY EDUCATION: EVIDENCE FROM AN EXPERIMENTAL STUDY

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ABSTRACT

The development of socio-emotional skills in children aged 5-6 is crucial and can be facilitated through a tailored and innovative program. This study aimed to evaluate the efficacy of a novel program titled DeCo – S.E. (Development of Socio-Emotional Skills). The program integrates socio-emotional education strategies, intervention techniques for addressing maladaptive behaviors, and methodologies for interpersonal problem-solving. We focused on how these methods enhance socio-emotional skills in early childhood, promoting healthy emotional and social development. The study involved a sample of 18 educators, alongside 146 children with a mean age of $X \pm SD = 5.87 \pm 2.87$ years, and their parents. Participants were divided into two groups: the experimental group (EG), comprising 74 children and coordinated by 10 educators, who engaged in a structured experimental program over 16 weeks. In contrast, the control group (CG) consisted of 72 children and was supervised by eight educators who implemented standard curricular activities without an emphasis on cultivating socio-emotional skills. To evaluate the emotional competencies of the children, the Emotional Competence Screening questionnaire (tailored versions for both educators, SCE-E, and parents, SCE-P) was administered before and after the intervention. Data collection was facilitated through the Cognitrom PEDa platform, enabling a comprehensive assessment of the children's emotional skill development. Data analysis using SPSS 26 revealed significant differences in scores between EG and CG, indicating substantial differences in emotional competencies across all assessed dimensions in the EG. Specifically, the findings reveal significant comparative indices for Understanding Emotions ($t = 5.568$, $p < 0.01$), Expressing Emotions ($t = 5.614$, $p < 0.01$), and Emotional Self-Regulation ($t = 6.900$, $p < 0.01$), all demonstrating marked improvements compared to the control group. The study highlights the importance of targeted strategies for developing socio-emotional skills in preschoolers. These strategies lead to increased self-confidence, improved communication with peers and adults, greater awareness of others' feelings, better problem-solving abilities, respect for differing opinions, adaptability to routines, and a clearer understanding of social expectations. Overall, fostering these skills has a positive impact on children's interpersonal interactions and classroom dynamics.

Keywords: socio-emotional skills; socio-emotional education strategies, management of undesirable behaviors, early education.

COMPARING THE MOTOR EFFECTIVENESS OF TRADITIONAL PHYSICAL EDUCATION METHODS WITH BLENDED METHODS THAT INTEGRATE ARTIFICIAL INTELLIGENCE (AI) AT THE HIGH SCHOOL LEVEL

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ABSTRACT

The transformations brought about by digitalization in education, along with recent changes, have prompted a significant innovation of the methodology used in physical education lessons. This is particularly relevant in terms of optimizing the active engagement time during which students participate in physical exercise. The study aimed to investigate how integrating AI as a virtual teacher in blended physical education lessons can enhance motor density. The study compared engagement between traditional teaching methods and modern approaches. The study compared traditional teaching methods with modern approaches over 12 lessons in six weeks, involving 62 10th-grade students attending 50-minute physical education (PE) classes twice a week. Students were divided into a control group (CG) of 30, who received traditional lessons, and an experimental group (EG) of 32, who used blended methods that included a virtual teacher alongside in-person PE teachers. The lessons assessed motor density (MD) by analyzing active participation in physical exercises relative to lesson time. We used Polar H10 watches to track total and active time, calculating MD about PE lesson structure. MD measures student engagement in physical exercises, formula MD = active time (AT) / lesson duration (LT). IBM SPSS 30 software was used for inferential statistical analysis of the data, $p < 0.05$. ANOVA was performed to examine the relationship between PE lessons' total time and active time parameters. The effect size was calculated using Cohen's d. Comparative results from two types of PE lessons indicate that hybrid lessons increased active time by an average of 4.30 minutes compared to traditional lessons. The percentage of MD in hybrid lessons was 70.12%, while traditional lessons had a score of 57.78%. This indicates that hybrid lessons were 2.78% more effective than traditional lessons ($p < 0.001$); with a large effect size $d = 0.738$. The results highlight the positive impact of incorporating virtual teachers into the PE methodology. Modernizing pedagogical methods in PE focuses on systematically restructuring instructional frameworks to enhance students' engagement. This optimization of lesson efficacy facilitates increased student participation in active learning and skill development, enhancing physical competencies and educational outcomes.

Keywords: motor density; active time; virtual teacher; in-person teacher; innovation methods.

BEYOND COMPLIANCE: A BEHAVIORAL FRAMEWORK FOR ADVANCING FOOD SAFETY CULTURE IN THE GLOBAL FOOD INDUSTRY

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ABSTRACT

Food safety culture has emerged as a strategic cornerstone in achieving sustainable and proactive food safety across the global food supply chain. It transcends traditional compliance-based models by integrating the shared values, beliefs, and behaviors that influence decision-making and daily practices at all organizational levels. Leading international food safety standards including BRCGS, FSSC 22000, and IFS have recognized food safety culture as a measurable and mandatory dimension within modern food safety management systems.

This paper provides an in-depth behavioral perspective on food safety culture, emphasizing how leadership, transparent communication, ongoing training, and active employee engagement collectively drive cultural maturity. It draws on authoritative publications from FAO and WHO, which underline the necessity of cultivating a resilient food safety culture for long-term industry success. The study further examines behavioral vulnerabilities such as procedural shortcuts under pressure, demotivation, and fear-induced non-reporting that continue to compromise food safety despite robust technical systems.

To address these challenges, the paper evaluates widely used diagnostic tools including employee perception surveys, observational checklists, performance indicators, and cultural maturity frameworks. These instruments provide actionable insights into organizational dynamics and serve as the foundation for continuous cultural improvement.

Additionally, the paper presents real-world industry case studies showcasing successful implementation of culture-enhancing strategies, such as incentive-based reporting systems, cross-functional safety huddles, and leadership-led behavioral modeling. The long-term benefits of investing in food safety culture include improved regulatory compliance, reduced recall incidents, elevated employee accountability, and enhanced consumer trust.

Ultimately, this study advocates for a paradigm shift in food safety management, one that embeds behavioral science into system design and offers a practical roadmap for building resilient, people-centered food safety cultures.

Keywords: Food safety culture, behavioral approach, employee engagement, leadership, cultural maturity, food industry

INTRODUCTION

Food safety, once primarily regarded as a function of technical control systems and hazard analysis protocols, is now increasingly understood as a behavior-driven discipline (Yiannas, 2009; Taylor & Rostron, 2020). In the context of complex, globalized food supply chains, achieving consistent food safety outcomes requires more than procedural compliance—it necessitates the intentional cultivation of a positive food safety culture embedded across all organizational levels (Griffith, 2022; Nyarugwe et al., 2020).

Food safety culture refers to the collective values, beliefs, attitudes, and behaviors that influence food safety decision-making and practices within an organization (GFSI, 2018). This culture affects how

individuals respond to risk, report deviations, and engage with preventive systems on a daily basis (Jespersen et al., 2017). Increasingly, global standards such as BRCGS Issue 9 (2023), FSSC 22000 Version 6 (2023), and IFS Food Version 8 (2023) mandate the formal assessment and continual development of food safety culture as a measurable and auditable component of food safety management systems.

Recent publications from WHO and FAO (2022) highlight that without cultural maturity, even the most advanced food safety infrastructures remain vulnerable to breakdowns driven by human behavior. As such, cultivating a strong food safety culture is no longer optional—it is a strategic imperative for organizations seeking resilience, compliance, and consumer trust in a dynamic global food landscape.

Defining Food Safety Culture

Food safety culture is increasingly recognized as a foundational dimension of food safety management, reflecting the shared values, beliefs, and behavioral expectations that shape how individuals perceive and act upon food safety responsibilities within an organization (GFSI, 2018). It extends beyond written procedures and formal training programs, influencing how food safety is prioritized, communicated, and sustained across all operational levels and departments.

According to the Global Food Safety Initiative (GFSI, 2018), food safety culture is defined as "shared values, beliefs, and norms that affect mindset and behavior toward food safety in, across, and throughout an organization." This culture governs not only how employees respond to risk, but also how they internalize responsibility, report deviations, and model safety practices in routine operations.

Key pillars of a strong food safety culture include visible leadership commitment, employee involvement and empowerment, competence through targeted training, transparent communication and feedback mechanisms, and a proactive approach to risk awareness and reporting (FAO & WHO, 2020; Jespersen et al., 2017). These elements are interdependent and must be cultivated in a systemic, organization-wide manner to achieve true cultural maturity.

Global standards have begun to formalize these expectations. For instance, BRCGS Food Safety Issue 9 explicitly requires documented evaluations of food safety culture across multiple dimensions including communication, training, employee feedback, and performance metrics (BRCGS, 2023). Similarly, FSSC 22000 Version 6 introduces requirements for monitoring cultural development through internal audits, management reviews, and stakeholder engagement (FSSC, 2023).

Recent academic literature emphasizes that a robust food safety culture cannot be implemented overnight; rather, it evolves through intentional leadership behavior, continuous education, and a psychologically safe environment that encourages honest dialogue and learning from failure (Griffith, 2022; Nyarugwe et al., 2020). Without a strong cultural foundation, even the most advanced technical systems may falter due to human error or disengagement.

Thus, defining and institutionalizing food safety culture is not a one-time activity, it is a continuous strategic process requiring long-term leadership commitment, consistent evaluation, and the integration of behavioral science into the very fabric of food safety systems.

Behavioral Influences and Risk Factors

Even in facilities with well-documented procedures and certified management systems, food safety incidents continue to arise often as a result of human behavior rather than system failure. These behavioral lapses reflect deeper cultural and psychological dynamics that are frequently overlooked in traditional risk assessments (Griffith, 2022; Nyarugwe et al., 2020).

Key behavioral risk factors include taking procedural shortcuts due to time pressures or production demands, hesitating to report non-conformities for fear of blame or disciplinary action, lack of intrinsic

motivation or personal accountability, and inadequate or poorly reinforced training programs (Neal et al., 2000; De Boeck et al., 2015). Such factors create silent vulnerabilities within an organization, especially in high-throughput environments where compliance fatigue and routine normalization of risk are prevalent.

Leadership plays a defining role in either mitigating or amplifying these risks. Supervisors and managers who visibly adhere to safety protocols, reinforce expectations, and foster psychological safety send strong behavioral cues to their teams (Yiannas, 2009; Taylor & Rostron, 2020). On the other hand, inconsistent leadership behaviors, mixed messages, or tolerance for minor infractions can erode trust and diminish compliance over time.

The organizational climate shaped by how leaders respond to deviations, reward transparency, and encourage dialogue has a measurable impact on employee behavior (Neal et al., 2000; Jespersen et al., 2017). Studies show that workers are more likely to engage in safe behavior when they perceive leadership to be fair, accountable, and genuinely invested in food safety outcomes (Griffith, 2022).

Addressing behavioral risk factors requires more than corrective actions. It calls for proactive engagement strategies that build emotional ownership, reward desired behaviors, and eliminate punitive response systems that discourage transparency. By shifting from a compliance mindset to a culture of shared responsibility, organizations can reduce behavior-driven risk and enhance long-term food safety resilience.

Assessment Tools for Food Safety Culture

Strengthening food safety culture requires more than intention. It demands reliable, evidence-based assessment tools to diagnose organizational strengths and weaknesses. Without structured evaluation, cultural improvement efforts risk being vague, reactive, or disconnected from real behavioral patterns (Griffith, 2022).

A variety of tools are now available to support food businesses in assessing cultural maturity. Common instruments include employee perception surveys, which gauge staff attitudes and values; behavioral observation checklists, which capture actual practices in day-to-day operations; and key performance indicators (KPIs) that track measurable outcomes such as hygiene compliance rates, near-miss reporting, and training effectiveness (De Boeck et al., 2015; Jespersen et al., 2017). These tools allow organizations to move from anecdotal feedback to structured, data-driven insights.

Beyond individual tools, cultural maturity models such as the BRCGS Culture Excellence framework or the GFSI's five-dimension model provide organizations with a staged roadmap for improvement, allowing them to benchmark their current level and define progressive targets (GFSI, 2018; BRCGS, 2023). Such models typically evaluate domains such as leadership, communication, employee engagement, risk awareness, and learning systems.

Recent studies emphasize the importance of triangulating multiple tools to obtain a holistic view of organizational culture. For example, combining surveys with observational data and leadership interviews can reveal gaps between policy and practice, or between perceived and actual behavior (Wilcock et al., 2013; Jespersen et al., 2017).

Moreover, assessment should not be treated as a one-time event. Continuous culture monitoring through routine audits, feedback loops, and trend analysis enables dynamic decision-making, targeted interventions, and sustainable cultural transformation over time (Nyarugwe et al., 2020). As food safety becomes increasingly people-dependent, the ability to measure and manage cultural indicators is a strategic advantage.

Case Examples from the Food Industry

Real-world examples from the food industry provide compelling evidence that intentional cultural interventions can lead to measurable improvements in food safety outcomes. Organizations that successfully embed food safety culture do so through strategic, sustained actions that engage employees and visibly align leadership behaviors with safety priorities.

For instance, a global beverage corporation reported a 35% reduction in foreign body-related consumer complaints within 12 months after implementing a dual strategy: a peer-to-peer coaching model and a non-punitive reporting incentive system that encouraged early disclosure of deviations (Nyarugwe et al., 2020). This initiative not only improved incident reporting rates but also enhanced trust and ownership among frontline workers.

In another example, a European dairy manufacturer introduced daily food safety huddles, combined with anonymous feedback mechanisms and real-time KPI dashboards, which led to a notable decline in GMP non-conformities and a 22% improvement in internal audit scores over one year (FAO & WHO, 2020). These changes were supported by a leadership program that trained mid-level managers in behavior-based communication techniques.

A frozen food processing facility in North America implemented a behavioral observation program that trained quality staff to conduct weekly "culture walks." Within six months, there was a 40% increase in near-miss reporting and a significant reduction in training gaps, prompting the organization to institutionalize culture metrics in quarterly reviews (Griffith, 2022).

Furthermore, a multinational confectionery company conducted a culture maturity baseline assessment using the BRCGS Culture Excellence tool. Following targeted interventions in leadership visibility and cross-departmental learning, the company advanced from "developing" to "proactive" within a single assessment cycle (BRCGS, 2023).

Collectively, these cases underscore that food safety culture is not built through slogans or one-off training sessions. It emerges through consistent leadership modeling, system-wide engagement, and the deliberate integration of cultural metrics into business operations. The organizations that succeed in cultural transformation view it not as a compliance checkbox, but as a driver of competitive advantage, risk reduction, and brand trust

Long-Term Benefits of Strong Food Safety Culture

Investing in a robust food safety culture yields sustainable and far-reaching benefits that go well beyond regulatory compliance. Organizations with mature food safety cultures consistently demonstrate improved performance across critical business indicators, including operational continuity, consumer confidence, workforce stability, and brand equity (Griffith, 2022; Wilcock et al., 2013).

From a regulatory perspective, companies that foster strong food safety culture exhibit higher audit success rates, fewer non-conformities, and a more proactive engagement with legal and customer requirements. Regulators increasingly view culture as a determinant of system reliability and are moving toward evaluating not only what companies do, but how and why they do it (FAO & WHO, 2022).

Financially, the benefits are equally compelling. Studies indicate that organizations with an embedded food safety culture experience fewer product recall, lower rework costs, and shorter response times during crisis situations (Soon et al., 2012; Jespersen et al., 2017). This resilience results from early detection of risks, open communication, and employee ownership of food safety responsibilities.

Employee engagement and morale also improve in culture-forward organizations. When staff members feel psychologically safe to speak up, report concerns, and contribute to problem-solving, it fosters a

high-trust environment that supports continuous improvement (Taylor & Rostron, 2020). In such environments, food safety is not a top-down obligation. It becomes a shared mission.

In addition, a strong culture acts as a brand differentiator in an increasingly competitive marketplace. Consumers and clients are more likely to trust and remain loyal to companies that demonstrate authenticity, integrity, and commitment to safety at every level of operation (Griffith, 2022).

Ultimately, cultural maturity embeds food safety into the organizational DNA, transforming it from a regulatory requirement into a strategic asset that protects public health, strengthens stakeholder confidence, and drives long-term business sustainability.

CONCLUSION

In an era where global food systems face increasing complexity, scrutiny, and expectation, food safety culture has emerged not merely as a supporting concept but as a strategic imperative. This study reinforces the understanding that food safety outcomes are shaped as much by human behavior and organizational values as they are by formal systems and technical protocols (Griffith, 2022; Jespersen et al., 2017).

Developing a resilient food safety culture requires more than policy. It demands intentional leadership, measurable cultural diagnostics, and a commitment to continuous learning. Organizations must move beyond compliance checklists toward a proactive culture that empowers employees, embraces transparency, and embeds food safety into everyday decision-making.

As demonstrated by both the literature and case examples presented, the integration of behavioral science into food safety strategy enables organizations to build systems that are not only compliant but agile, psychologically safe, and capable of adaptive learning. This cultural foundation strengthens preparedness, reduces risk exposure, and reinforces consumer trust over time.

For policymakers, industry leaders, and quality professionals alike, the message is clear: Investing in food safety culture is not a cost. It is a competitive advantage. The future of food safety belongs to those organizations that understand culture not as a slogan but as a system, not as a side initiative but as a core pillar of performance, integrity, and resilience.

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MICROPLASTICS IN THE ENVIRONMENT: A GROWING THREAT

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ABSTRACT

Microplastics, tiny plastic particles smaller than 5 millimetres, have become an increasingly concerning form of pollution in recent decades. These particles are either produced intentionally for use in products like exfoliants and industrial abrasives or formed as larger plastic items break down over time. As a result, microplastics have spread throughout nearly every part of the environment, including oceans, rivers, soil, and even the air we breathe.

In aquatic environments, microplastics are easily consumed by marine organisms such as fish, plankton, and shellfish. This ingestion can cause physical damage, internal blockages, and chemical exposure, since plastics often carry toxic substances either added during manufacturing or absorbed from the surrounding water. On land, microplastics can disrupt soil structure and harm beneficial microbes, potentially affecting crop health and food production. Their presence in the air, carried by dust or fibers, also raises concerns about respiratory exposure and long-term health risks.

Microplastics are particularly problematic because they don’t break down easily. They can last for decades or longer, and they tend to attract and transport harmful chemicals like heavy metals and persistent organic pollutants.

Dealing with the problem requires action on several levels. Reducing single-use plastics, improving waste management, encouraging alternatives like biodegradable materials, and investing in scientific research are all crucial steps.

In summary, microplastics are an urgent environmental issue with significant implications for ecosystems and human health. Their widespread presence, persistence, and potential to cause harm make them one of the most pressing pollution challenges of our time. Tackling this issue requires awareness, innovation, and a global commitment to long-term solutions.

Keywords: Microplastics, Environmental pollution, Aquatic ecosystems, Bioaccumulation, Global environmental policy.

Physical&Life Sciences/Environment

THE FUTURE OF CRYPTOCURRENCIES IN CLASSICAL FINANCIAL SYSTEMS: REGULATORY RISKS AND MARKET IMPACTS

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ABSTRACT

The increasing speed of cyclical changes in financial markets allows for the emergence of alternatives to traditional financial instruments. In addition to online payment methods, cryptocurrencies have recently been among the most discussed financial topics. However, a different structure in return for money other than the current payment method differs for the current market investor. The high speed of development of cryptocurrencies by taking advantage of the blockchain system structure's easy access and productivity feature due to their structure has helped them gain global popularity, especially during the Kovid period. There are several reasons why cryptocurrencies, seen as an alternative to financial market instruments, are not yet present in today's financial systems. Through a future investment scenario, this study examines the regulatory arrangements necessary for integrating the cryptosystem into the classical financial systems and what kind of impact it may have on the financial markets if accepted. In particular, it will explain what problems central banks face in regulating cryptocurrencies, what steps should be taken in the cryptosystem for it to constitute trust for central banks, how the central management system should look like as an infrastructure, and what the necessary and obstacles for it to be issued as a financial instrument that provides trust, especially for investors. Cryptocurrency regulations differ significantly across jurisdictions, reflecting a diversity of approaches to integrating digital assets into existing financial systems. This paper provides an overview of the legal status, regulatory developments, and key policy considerations surrounding cryptocurrencies on a global scale, with specific insights into the United States, the European Union, and selected other countries.

Keywords: Cryptocurrency, Financial Markets, Bitcoin, International Financial Markets

INTRODUCTION

The financial markets have experienced a remarkable transformation over the past few decades, driven by rapid technological advancements and the emergence of novel financial instruments. Among these innovations, cryptocurrencies have risen to prominence as both an alternative investment vehicle and a potential disruptor of traditional financial systems. Developed on the foundation of blockchain technology, cryptocurrencies such as Bitcoin and Ethereum offer a decentralized, transparent, and secure method of transaction, distinguishing them from conventional monetary systems.

However, this new class of digital assets presents both opportunities and challenges for investors, regulators, and financial institutions. While the global popularity of cryptocurrencies has surged, especially during periods of economic uncertainty like the COVID-19 pandemic, the lack of regulatory clarity and structural integration into traditional financial frameworks remains a significant hurdle.

Issues surrounding market volatility, consumer protection, and the potential misuse of cryptocurrencies for illicit activities have highlighted the urgent need for comprehensive regulatory strategies.

This paper examines the regulatory risks and market implications of cryptocurrencies, focusing on their integration into classical financial systems. It explores the challenges faced by central banks in establishing trust and regulatory frameworks, the disparities in cryptocurrency regulations across jurisdictions, and the potential of cryptocurrencies to transform financial markets. By analyzing global regulatory developments and providing insights into key policy considerations, this study aims to shed light on the path forward for cryptocurrencies as a legitimate and sustainable component of the global financial ecosystem.

1. Regulatory Risks and Market Implications of Cryptocurrencies

The rapid evolution of financial markets has paved the way for the emergence of alternative financial instruments, among which cryptocurrencies have gained considerable attention. The development of cryptocurrencies, facilitated by the blockchain system's accessibility and efficiency, has led to their widespread popularity, particularly during the COVID-19 pandemic. According to Narayanan et al. (2016), blockchain technology provides the foundation for cryptocurrencies, offering a decentralized and tamper-resistant ledger that supports secure and transparent transactions. Tapscott and Tapscott (2016) also highlight the transformative potential of blockchain technology in revolutionizing various industries, including finance. However, the adoption of these digital assets is still a contentious issue in traditional financial systems, primarily due to regulatory and structural challenges. This paper explores the regulatory risks and market implications of cryptocurrencies, focusing on the conditions necessary for their integration into classical financial systems and the resulting impact on financial markets if such integration occurs.

2. The Rise of Cryptocurrencies as Financial Instruments

Cryptocurrencies, like Bitcoin and Ethereum, have become a significant topic of discussion in the financial world. Their decentralized structure, transparency, and promise of enhanced security differentiate them from traditional forms of money. This appeal has allowed them to gain significant traction as an alternative investment option. During the pandemic, these digital currencies witnessed a surge in popularity as individuals sought alternatives to fiat money due to economic uncertainty and an increasingly digital economy. Despite these advancements, cryptocurrencies face several barriers to acceptance in mainstream financial systems. As noted by Catalini and Gans (2016), one of the key barriers to cryptocurrency adoption is the regulatory uncertainty that surrounds their use, which has led to hesitation among institutional investors. Gandal and Halaburda (2016) further point out that the lack of coordination between regulators across different jurisdictions has created additional challenges for the widespread acceptance of cryptocurrencies.

The appeal of cryptocurrencies lies not only in their decentralized nature but also in their potential to offer lower transaction costs, faster international payments, and a high level of security through cryptographic protocols (Nakamoto, 2008). Moreover, the transparency of blockchain technology, where all transactions are recorded in a public ledger, enhances trust and accountability in the system. However, the volatility of cryptocurrencies remains a major concern for investors and regulators. Research by Baur, Hong, and Lee (2018) suggests that the high volatility of cryptocurrencies is largely driven by speculative trading, which makes them unsuitable as a stable store of value. Cheah and Fry (2015) also emphasize that the speculative nature of cryptocurrency investments contributes to their extreme price fluctuations, raising concerns about their viability as a currency.

2.1. Regulatory Challenges

The most significant obstacle to integrating cryptocurrencies into conventional financial systems is the lack of regulatory clarity. Cryptocurrencies operate outside traditional regulatory frameworks, which poses risks to both investors and financial stability. Unlike traditional financial instruments, cryptocurrencies are not backed by central banks or governmental institutions, which makes their value highly volatile and subject to speculative activities. Regulators around the world are grappling with how to manage these risks while allowing innovation to flourish. The challenge lies in establishing regulations that protect consumers, mitigate financial crime risks, and ensure market stability, without stifling technological advancement. According to Auer and Claessens (2018), effective regulation must strike a balance between fostering innovation in financial technology and mitigating the risks associated with unregulated financial activities. Similarly, Zohar (2015) underscores the importance of creating a regulatory framework that promotes transparency while allowing for technological growth.

Cryptocurrencies are also subject to different regulatory approaches across jurisdictions, which adds to the complexity of creating a cohesive regulatory framework. Some countries have embraced cryptocurrencies by implementing progressive regulations, while others have imposed outright bans. This inconsistency has been highlighted by the Financial Action Task Force (FATF), which emphasizes the need for a standardized approach across different jurisdictions to foster global cooperation (Financial Action Task Force, 2021). This inconsistency complicates the ability of cryptocurrencies to operate on a global scale, as investors and businesses must navigate varying legal landscapes. To address this, international regulatory bodies such as the Financial Action Task Force (FATF) have begun to establish guidelines to standardize cryptocurrency regulations across borders, promoting global cooperation.

One notable example of regulatory inconsistency is the difference in approaches between the United States and China. While the U.S. has taken a more measured approach by creating guidelines for cryptocurrency exchanges and imposing Know Your Customer (KYC) and Anti-Money Laundering (AML) requirements, China has opted for outright bans on cryptocurrency trading and mining activities. Such divergent approaches create confusion and barriers for international investors and businesses, hindering the potential for a unified global market for cryptocurrencies. To foster international cooperation, regulatory bodies need to collaborate and develop a cohesive framework that addresses cross-border issues, such as taxation, AML, and consumer protection. As stated by Houben and Snyers (2018), international cooperation is crucial to ensure a level playing field and prevent regulatory arbitrage, where firms exploit differences in regulations across jurisdictions. The International Monetary Fund (IMF, 2020) also stresses the importance of global coordination to address the regulatory challenges posed by digital assets.

2.2. Central Bank Concerns and the Need for Regulatory Frameworks

Central banks play a crucial role in maintaining the stability of financial markets. However, the rise of cryptocurrencies poses several challenges to these institutions, including concerns about their impact on monetary policy, financial crime, and systemic stability. Cryptocurrencies are characterized by their decentralized nature, which makes it difficult for central banks to monitor transactions and implement monetary policy effectively. This lack of control raises concerns about the potential use of cryptocurrencies for illicit activities, such as money laundering and financing terrorism. Foley, Karlsen, and Putniņš (2019) found that a significant portion of cryptocurrency transactions are linked to illicit activities, highlighting the need for effective AML measures. Europol (2020) has also reported an increasing trend in the use of cryptocurrencies for illegal transactions, emphasizing the importance of regulatory oversight to combat financial crime.

To address these issues, central banks must develop a comprehensive regulatory framework that can adapt to the unique characteristics of cryptocurrencies. Such a framework should include measures to

ensure transparency, enforce anti-money laundering (AML) and combating the financing of terrorism (CFT) regulations, and protect consumer interests. Moreover, it is essential to establish mechanisms that foster trust between market participants and regulatory bodies. Trust is a fundamental component of any financial system, and for cryptocurrencies to be accepted as a legitimate financial instrument, they must demonstrate their reliability and stability.

One possible solution is the creation of a central regulatory authority specifically dedicated to overseeing digital currencies and block chain technologies. Zohar (2015) suggests that creating such a central authority would help ensure consistency in regulatory standards and foster greater confidence in the cryptocurrency market. Such an authority could work in collaboration with existing regulatory bodies to develop consistent standards and best practices for the industry. Additionally, self-regulatory organizations (SROs) within the cryptocurrency industry could play a role in establishing ethical guidelines and promoting transparency, thereby increasing confidence among regulators and investors.

Another significant concern for central banks is the potential threat that cryptocurrencies pose to financial stability. Cryptocurrencies, due to their high volatility and speculative nature, can lead to financial bubbles that may have a ripple effect on the broader economy. The speculative boom in Bitcoin during late 2017 and its subsequent crash in early 2018 is a prime example of how unchecked cryptocurrency speculation can lead to significant market disruptions. To mitigate these risks, central banks must work towards establishing macro prudential regulations that prevent excessive risk-taking and ensure that financial institutions are adequately prepared to handle the risks associated with cryptocurrencies.

2.3. Integration of Cryptocurrencies into Traditional Financial Systems

The successful integration of cryptocurrencies into traditional financial systems requires both regulatory innovation and market adaptation. For cryptocurrencies to gain acceptance, they need to meet the standards of stability, transparency, and security expected by both regulators and investors. This process may involve creating a hybrid system where cryptocurrencies operate within a regulated environment while retaining some aspects of their decentralized nature.

One potential approach is the introduction of central bank digital currencies (CBDCs), which combine the benefits of digital currency with the regulatory oversight of central banks. CBDCs could serve as a bridge between cryptocurrencies and traditional financial systems, allowing for the coexistence of digital and fiat currencies while maintaining financial stability. According to Frost and Shin (2020), the introduction of CBDCs would also help central banks maintain control over monetary policy while reaping the benefits of blockchain technology. Additionally, developing infrastructure that supports the interoperability of cryptocurrencies with existing payment systems is crucial for their widespread adoption.

Another solution is to develop public-private partnerships that facilitate the integration of blockchain technology into existing financial infrastructures. Such partnerships could leverage the strengths of both the public sector (regulatory oversight and stability) and the private sector (technological innovation and efficiency) to create a cohesive framework for cryptocurrency adoption. Furthermore, the development of secure custody solutions, insurance products, and risk management tools can help mitigate some of the risks associated with investing in cryptocurrencies, thereby encouraging greater institutional involvement.

Public-private partnerships can also play a crucial role in establishing regulatory sandboxes, which allow for the testing of new financial technologies, including cryptocurrencies, in a controlled environment. Regulatory sandboxes provide an opportunity for both regulators and innovators to understand the potential risks and benefits of cryptocurrencies while ensuring that consumer protection and financial

stability are maintained. By fostering innovation in a safe and regulated manner, regulatory sandboxes can pave the way for the gradual integration of cryptocurrencies into the traditional financial ecosystem.

2.4. Market Implications of Regulatory Changes

The regulation of cryptocurrencies will have significant implications for financial markets. On one hand, regulatory clarity could lead to increased investor confidence, thereby promoting broader adoption of cryptocurrencies as a mainstream financial instrument. On the other hand, overly stringent regulations could stifle innovation and limit the growth potential of the cryptosystem. Striking a balance between fostering innovation and ensuring market stability is essential for the sustainable growth of the cryptocurrency market.

Furthermore, the acceptance of cryptocurrencies in traditional financial systems could lead to changes in the way financial markets operate. For instance, the increased use of digital currencies may reduce the demand for cash and traditional banking services, potentially disrupting established financial institutions. Additionally, the integration of blockchain technology could enhance the efficiency of financial transactions, reduce costs, and improve transparency, ultimately benefiting both consumers and businesses.

The integration of cryptocurrencies also has the potential to democratize access to financial services, particularly for the unbanked population. By leveraging block chain technology, cryptocurrencies can provide secure and cost-effective financial solutions to individuals who do not have access to traditional banking services. Gomber et al. (2018) argue that block chain-based financial solutions can significantly enhance financial inclusion by lowering costs and reducing reliance on intermediaries. Additionally, Narayanan et al. (2016) note that block chain technology's decentralized nature can help reduce barriers to entry for unbanked individuals, thus promoting greater financial inclusion. This financial inclusion could lead to increased economic growth and reduced income inequality in developing regions. The World Bank (2022) has noted that block chain technology offers unique opportunities to increase financial inclusion and empower individuals in developing countries by providing access to secure financial services. However, ensuring that the regulatory frameworks are inclusive and do not inadvertently create barriers to access for marginalized communities is critical to realizing these benefits.

Moreover, the integration of cryptocurrencies into traditional financial markets may lead to the emergence of new financial products and services. For example, the development of crypto-based derivatives, exchange-traded funds (ETFs), and lending platforms could provide investors with new avenues for diversification and risk management. The growth of decentralized finance (DeFi) platforms, which offer financial services such as lending, borrowing, and trading without intermediaries, is an example of how cryptocurrencies can reshape the financial landscape. However, the rapid growth of DeFi also poses regulatory challenges, as these platforms often operate outside existing regulatory frameworks, raising concerns about investor protection and financial stability. As Schär (2021) notes, the decentralized nature of DeFi makes it difficult for regulators to enforce compliance, which poses risks to both investors and the broader financial system. The Financial Stability Board (FSB, 2021) has also highlighted the potential systemic risks associated with the growth of DeFi, urging regulators to develop comprehensive strategies to address these challenges.

2.5. Regional Perspektives

2.5.1. United States

The United States has experienced notable regulatory developments under recent administrations. A pivotal executive order titled "Strengthening American Leadership in Digital Financial Technology" has been enacted to foster the growth of the cryptocurrency industry and explore the establishment of a national digital asset reserve. This order also prohibits the development of a central bank digital currency (CBDC) in the U.S. (Investors Business Daily, 2024).

2.5.2. Tax Reporting Requirements

To enhance tax compliance, new rules requiring cryptocurrency platforms to report user transactions to the Internal Revenue Service (IRS) will take effect in 2026. These measures aim to reduce tax evasion and simplify tax reporting through standardized documentation, such as the 1099 form (Wall Street Journal, 2024).

2.5.3. European Union

The European Union has introduced the Markets in Crypto-Assets Regulation (MiCA), a comprehensive legal framework designed to regulate cryptocurrency issuance and related services. MiCA seeks to ensure consumer protection, market integrity, and transparency within the cryptocurrency industry (Financial Times, 2024).

2.5.3.1. Türkiye

In 2021, the Central Bank of the Republic of Turkey issued a regulation prohibiting the use of cryptocurrencies and other digital assets based on distributed ledger technology for payment purposes. This decision was driven by concerns over potential irreparable damages and transactional risks (Wikipedia, 2021).

2.5.3.2. Key Regulatory Considerations

Consumer Protection

Ensuring the safety of investors and consumers remains a primary objective for regulators worldwide. Measures to safeguard individuals from fraud, market manipulation, and volatility are integral components of emerging regulatory frameworks (Atlantic Council, 2024).

Anti-Money Laundering and Counter-Terrorist Financing

AML and CTF compliance are critical regulatory priorities aimed at curbing the misuse of cryptocurrencies for illicit activities. Governments are increasingly requiring platforms to adhere to stringent verification and reporting standards (Atlantic Council, 2024).

Tax Compliance

Governments are establishing standardized tax reporting protocols to improve compliance and address concerns related to tax evasion. Enhanced transparency is expected to simplify processes for both taxpayers and authorities (Wall Street Journal, 2024).

CONCLUSION

Cryptocurrencies represent a significant shift in the evolution of financial instruments, offering both opportunities and challenges for investors, regulators, and financial institutions. The successful integration of cryptocurrencies into traditional financial systems depends on the development of a robust regulatory framework that addresses the risks associated with their use while promoting innovation. By establishing clear regulations and fostering trust among market participants, cryptocurrencies have the potential to become a viable alternative to traditional financial instruments, with significant implications for the future of financial markets. Yermack (2015) argues that establishing trust and regulatory oversight is crucial for cryptocurrencies to function as a legitimate alternative to traditional currencies.

The development of central bank digital currencies, public-private partnerships, and global regulatory standards will be essential in facilitating the integration of cryptocurrencies into the financial ecosystem. By addressing the regulatory challenges and fostering an environment of trust and innovation, cryptocurrencies can transform the financial landscape, offering new opportunities for investors and promoting financial inclusion. As the regulatory environment continues to evolve, collaboration

between regulators, industry participants, and international bodies will be key to unlocking the full potential of cryptocurrencies as a transformative force in global finance.

In conclusion, cryptocurrencies have the potential to revolutionize the financial system by providing an alternative to traditional banking and financial services. However, for this potential to be realized, it is essential to address the regulatory challenges and establish a framework that ensures the safety and stability of financial markets. A balanced approach that promotes innovation while safeguarding investor interests will be crucial in shaping the future of cryptocurrencies and their role in the global economy. As the cryptocurrency landscape continues to evolve, the need for adaptive, forward-thinking regulatory policies that foster innovation while maintaining financial stability will be more important than ever.

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SYNTHESIS OF A DI-CATIONIC SURFACTANT CONTAINING TWO LONG CARBON CHAINS AND PYRIDIUM CATION, AND ITS EFFECTIVENESS AGAINST METAL CORROSION

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ABSTRACT

In this study, a di-cationic surfactant containing two long carbon chains of 10 and 16 carbons, and pyridinium cation was synthesized. The functional groups in the structure of this compound were confirmed by FT-IR spectroscopy. Corrosion tests were carried out by immersing metal coupons in 1.0 M HCl solution containing different concentrations of this synthesized product (0, 1, 5, 10, 25, 50 and 100 ppm) at 25^{o}C for 24 hours. In these corrosion tests, the inhibition efficiency values against corrosion of mild steel were determined at each inhibitor concentration, taking into account the weight loss in the metal coupons. As a result of the corrosion tests, inhibition efficiency values of 16.22% at 1 ppm, 73.47% at 5 ppm, 86.72% at 10 ppm, 95.58% at 25 ppm, 98.39% at 50 ppm and 98.93% at 100 ppm were obtained. As can be seen from the results, the inhibition efficiency increased as the concentration increased, and the highest inhibition efficiency was observed at an inhibitor concentration of 100 ppm. The adsorption of the surfactant on the metal surface plays an active role in the anti-corrosion effect of the surfactant. To prove this adsorption phenomenon, pure water was dripped onto the metal surface removed from the acidic medium containing 0, 5 and 100 ppm inhibitor, and the contact angles of this water with the surface were measured. After proving that the compound adsorbed on the metal surface by contact angle, Langmuir adsorption isotherm study was performed to determine whether this adsorption was predominantly physical or chemical adsorption. In order to visually demonstrate the resistance of the synthesized di-cationic surfactant against metal corrosion, after the corrosion test, images of the metal surface removed from the acidic medium containing 0, 5 and 100 ppm inhibitor were taken with an optical microscope camera.

Keywords: Synthesis, corrosion inhibition, weight loss, di-cationic surfactant, contact angle

REVIEW OF RESEARCH ON CROATIAN WAR VETERANS AND THEIR FAMILIES: THE ROLE OF THE FAMILY IN THE REINTEGRATION OF CROATIAN VETERANS

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ABSTRACT

This paper provides an overview of existing research on the reintegration of Croatian war veterans from the Homeland War of Independence, with particular emphasis on the role of the family as a crucial yet often overlooked factor in the transition back to civilian life. The primary objective is not to offer a comprehensive analysis, but rather to highlight and raise awareness of the crucial role of the family during the reintegration process of veterans in a post-conflict society. The research employs a qualitative methodology, utilizing national and international academic articles, policy documents, institutional reports, and empirical studies as key sources. At the national level, research primarily focuses on the scope and adequacy of veteran benefits, with only a few notable exceptions addressing the psychological and sociological aspects of reintegration and only marginally acknowledging the role of the family. In contrast, on the international level, particularly within Anglo-Saxon contexts, the significance of this issue has been recognized, highlighting the need to include families in veteran support programs. An analysis of relevant literature and empirical studies reveals that the family can serve as a protective factor and as a "bridge" between traumatic experiences and everyday life, provided that appropriate support is in place. However, in the Republic of Croatia, such integrated, family-inclusive models of support are still lacking. In Croatian academic discourse, the concept of reintegration is most often associated with institutional measures (e.g., employment, entitlements, pensions), with significantly less focus on psychosocial and familial contexts. Therefore, this paper emphasizes the need to develop an interdisciplinary approach that considers the family as an active participant in the reintegration process, rather than merely a passive observer of war-related consequences.

Keywords: veterans, Croatian war veterans, family, reintegration, Homeland War

INTRODUCTION[1]

The Croatian Homeland War for Independence left profound consequences on Croatian society, particularly affecting the lives of those who participated in it—Croatian war veterans. Following the end of the conflict, thousands of men and women faced the challenges of returning to civilian life, which entailed not only physical and psychological adjustment but also reintegration into social, professional, and familial roles. Although veterans' rights have significantly improved over the past decade—

[1] The paper was co-authored with PhD student Barbara Laura Ćalušić Ljubičić during the course of research conducted for the purpose of writing her doctoral dissertation.

primarily focusing on the provision of adequate healthcare and rehabilitation services, as well as various benefits (housing assistance, employment incentives, pensions, etc.) intended to compensate for their wartime involvement (Dobrotić, 2008)—timely institutional support during the critical post-war period of reintegration was largely absent. Due to the limited system of formal psychosocial support, families were left to assume the responsibility for veterans' reintegration into society. This role has been insufficiently recognized, both scientifically and institutionally, making it the central focus of this research.

Numerous studies (Šućurović et al., 2017; Miklošić and Šućurović, 2024; Hilšić and Šincek, 2022) have shown that the psychosocial consequences of war are long-lasting and multidimensional. High rates of post-traumatic stress disorder (PTSD), depression, anxiety, and interpersonal difficulties significantly impact veterans' quality of life. In this context, the family often serves as a crucial source of support but can simultaneously be a source of additional stress and destabilization.

The role of the family in the reintegration process of war veterans is acknowledged in the literature, particularly in Anglo-Saxon contexts (Elnitsky et al., 2017; Fischer et al., 2015; Glynn, 2013), where spouses and children are not only included in therapeutic and resocialization programs but are also systematically studied in relation to their interaction with veterans' recovery processes. In the Republic of Croatia, however, the family is rarely considered an active agent in the reintegration process, despite evidence that it often assumes roles of informal caregiving, psychological support, and mediation between the veteran and broader society.

Therefore, in the context of a limited institutional response in the post-war period, the family emerges as a key social unit that either facilitates or hinders the return to everyday civilian life. Nevertheless, in both scholarly and professional discourse, this role is largely taken for granted and rarely the subject of systematic inquiry. This leaves open the question: how does the family function as a factor in the reintegration of Croatian war veterans, and in what ways do its structure and dynamics shape the course of that process? A review of national and international literature in the following sections will attempt to synthesize the academic community's responses to this question.

REVIEW OF KEY STUDIES IN THE REPUBLIC OF CROATIA

Although no comprehensive studies in the Republic of Croatia have directly and systematically examined the role of the family in the post-war reintegration process of veterans, several works do mention this role explicitly or at least implicitly allude to it.

A systematic overview of the care system for veterans of the Homeland War for Independence is provided by Dobrotić (2008), whose work focuses on the detailed exposition of veterans' rights, as well as those of their family members (e.g., disability and family pensions, housing support, employment, and social entitlements) during the period from 2002 to 2006. The study concludes that, although the formal system recognizes the family as a recipient of various rights, practical implementation remains inadequate due to bureaucratic obstacles. The family is thus recognized as a beneficiary but without evaluation of the actual support received. Dobrotić (2008, p. 80) emphasizes that: "The integrative and compensatory approaches should not be mutually exclusive but rather complementary*"*.

A key insight into the sociological and psychological processes affecting veterans is provided in the book *Psychosocial Adjustment of Croatian War Veterans: Individual and Social Perspectives* by Šućurović, Mikolušić and Knežević (2017). Particularly useful for examining reintegration processes is the chapter titled *Veterans Today and Problems of Integration into Civil Society*, which highlights several major obstacles veterans face in reintegration. The first, according to Šućurović et al. (2017), citing Begić, Sanader and Žunec (2008), is the social transition that occurred while veterans were still on the battlefield. Upon returning, they were confronted with a radically changed socio-political landscape: a shift from socialism to capitalism and a rapid privatization process that undermined the

labor market, resulting in widespread unemployment. Veterans, largely unprepared for this reality, encountered what the authors call the "trauma of peace."

The situation further deteriorated due to political developments in the early 2000s, which included restructuring and downsizing of the armed forces. Many veterans who had been promised stable post-war employment as a form of social security found themselves unemployed within a few years. Another issue identified is the public dispute over the official number of veterans—a consequence of inconsistencies across various registries—which has been used to question the legitimacy and status of veterans. Additional problems include a perceived lack of societal support and sensitivity, exacerbated by negative media portrayals. These factors, researchers argue, can adversely affect interpersonal and family relationships.

The study also contributes to a better understanding of social engagement as a prerequisite for developing reintegration guidelines. Specifically, a sense of usefulness was found to be positively associated with social engagement and thus with contributions to social capital. This insight implicitly extends to family structures, where a similar sense of usefulness may enhance reintegration.

A recent and relevant qualitative study that revived academic interest in this topic is *Living with a Traumatized Partner: Dyadic Approach to Well-being of War-affected Married Couples* by Knežević and Batinić (2023). This study offers an intimate look into spousal dynamics and was conducted on three groups of married couples: veterans with PTSD, veterans without PTSD, and non-veteran control pairs (N = 97 couples). The findings reveal that veterans with PTSD, who exhibit higher levels of anxiety and depression, significantly lower their spouses' subjective well-being (the so-called "partner effect"). This confirms that the quality of life of spouses is significantly influenced by the partner's psycho-emotional state, clearly supporting a dyadic or family-centered approach where the family is not merely a background actor but an active participant. The mental health of one partner directly impacts the other, underscoring the necessity of including families in clinical interventions.

A similar older study by Peraica et al. (2014) directly investigated the impact of veteran PTSD on spouses' quality of life. This research included 164 veterans with PTSD, 281 of their spouses, and control groups—over 750 participants in total. The study concluded that spouses of veterans with PTSD experience significantly lower quality of life in areas such as psychological health, social relationships, and environment compared to spouses of veterans without PTSD. This highlights the direct negative impact of veterans' trauma on families and the importance of incorporating spouses into clinical and rehabilitation programs to improve both their well-being and the overall reintegration process.

A valuable contribution to identifying potential key stakeholders in reintegration programs is provided by Miklošić and Šućurović (2024) in their study *The Sentiments of Croatian Homeland War Veterans Towards Wartime Comrades, Families, and Society in General, 30 Years After the War.* Although the study was conducted on a relatively small sample (N = 17), it yielded useful insights into veterans' sense of connection with various social groups. Veterans reported receiving the most understanding from their families, whom they considered their closest relationships—primarily due to communication and empathy: "The family accepts them as they are and helps and supports them in veterans-related activities." (Milkošić and Šućurović, 2024, p. 441). Furthermore, a strong bond persists among former comrades-in-arms, even 30 years after the war, owing to shared experiences and emotional solidarity: "From veterans, as well as from the family, they report primarily gaining understanding. Especially in instances they call 'dark minutes', when by conversing they help each other bridge difficult moments" (Milkošić and Šućurović, 2024, p. 442). Thus, families—along with comrades—emerge as key sources of lifelong emotional support and are potentially crucial actors in reintegration programs.

The practical experience of the PTSD Club as a sociotherapeutic community and self-help group is documented by Koić et al. (2005) in their study *The Club of Croatian Homeland War Veterans Treated*

for PTSD as a Form of Psychosocial Rehabilitation. This paper outlines the club's positive post-war practices, which include group therapy and self-help initiatives. Notably, the club operated on a family-inclusive model, emphasizing the importance of family involvement in developing psychosocial strategies. The program is based on sociotherapy and self-help, where families played an active role—not just as passive supporters but as active participants in the recovery process. This represents a rare but positive practice in integrating families into structured rehabilitation efforts.

The significance of family for successful integration is further supported by Hilšić and Šincek (2022) in their study *The Importance of Social Participation of Croatian War Veterans in the Quality of Their Lives*. The authors found that social participation (e.g., volunteering, associations, education) significantly improves veterans' quality of life by fostering a sense of belonging and purpose. Although the study does not directly examine families, it underscores the importance of cohesion and perceived usefulness—elements that could be cultivated within family systems. The authors recommend encouraging families to participate in and support veterans' social inclusion, yet a focused analysis of the family's role remains absent, leaving space for future research.

A comparative perspective is provided by Priebe et al. (2010) in the large-scale study *Mental Disorders Following War in the Balkans: A Study in 5 Countries*, which includes Croatia. With approximately 3,300 participants, the study found anxiety and depression prevalence rates between 15% and 42%, with unemployment and not living with a partner identified as key predictors. The correlation between not living with a partner and higher prevalence of mental disorders implies that family support—particularly spousal—plays a protective role in veterans' mental health.

A significant initiative titled *Thematic Network – Veterans* (2020–2023), funded by the European Social Fund and implemented by the Assembly of Associations of Croatian Guard Brigades and 13 partner organizations, conducted six research projects and six structured dialogues aimed at improving the quality of life for veterans and their families. *Research No. 4: Families of Veterans—Demographic and Psychosocial Analysis* identified families as an essential yet under-researched component of veteran care. During six structured dialogues (held in six cities), families were frequently mentioned as informal support systems taking on emotional, caregiving, and logistical roles. The project thus confirmed that families are critical to the reintegration process. Despite frequent psychosocial and informational needs being identified, systemic programs for their inclusion remain insufficient. The main challenge lies in transforming informal family support into an integrated part of public policy and services.

According to the document *Thematic Network – Veterans: Health Care Guidelines for Croatian Veterans* (2023), the family is recognized in specific areas. The *Veterans' Health Guide*, aimed at veterans and their family members, identifies the family as a target group for care planning. The guidelines emphasize the importance of educating and informing families about available programs, particularly in the context of telemedicine and psychosocial support. Notably, over 75% of participants indicated that improved veteran adjustment reduces suicide risk. In this regard, families are positioned as key actors for early intervention and behavioural detection.

However, a prerequisite for developing high-quality sociological programs for veterans is the analysis of demographic and socioeconomic characteristics of their beneficiaries. Current data from the Croatian Bureau of Statistics, processed in cooperation with the Ministry of Croatian Veterans, relies on the outdated 2011 national census, which presents a major limitation. Nevertheless, the data serve as a general starting point. One significant figure is that over 75% of veterans are married, only 15% are unmarried, and 6% are divorced—indicating the importance of spouses in post-war support and identifying unmarried and divorced veterans as potentially vulnerable groups. Additionally, the average household size is 3-4 members, typically including children, elderly parents, or other relatives, pointing to the potential for extended family support networks.

In conclusion, although national research has yet to adopt a systematic approach to studying this topic, the existing body of work implicitly highlights the family's essential role as a source of emotional and psychosocial support. Qualitative studies confirm the link between veterans' mental health and that of their spouses, while practical experience shows that families often take on informal caregiving roles. Despite the insufficient examination of the family's role in the reintegration process, current national studies offer a foundational basis for further research.

REVIEW OF INTERNATIONAL, REGIONAL, AND RECENT STUDIES

In the international context, research on the role of the family has already been integrated into sociological veteran support programs, particularly in the United States, where the reintegration of veterans from Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) in the Middle East remains an ongoing challenge.

A foundational study for the conceptual framework is Elnitsky, C. A., Fisher, M. P. and Blevins, C. L. (2017), which offers a unified definition of reintegration based on a systematic review of the literature and identifies key reintegration domains. According to the authors, reintegration is defined as "a process and outcome of resuming roles in family, community, and workplace which may be influenced at different levels of ecological system" (Elnitsky at al., p. 2). In defining these domains, Elnitsky et al. (2017) conclude that reintegration "is a broad, holistic concept of overall psychosocial functioning that includes psychological and physical health" (Elnitsky et al., p.5) and incorporates a social dimension involving family relationships, friendships, parenting and spousal roles, and marital difficulties. The study (Elnitsky et al., 2017) emphasizes that reintegration is a multidisciplinary issue, requiring more than a psychiatric approach and calling for broader social understanding. Although the focus is on a multidimensional model, the family is identified as a key domain in achieving successful reintegration.

An influential contribution to the field of family-centered care is research made by S. M. Glynn (2013) with title *Family-Centered Care to Promote Successful Community Reintegration After War: It Takes a Nation*, which advocates placing the family at the center of all veteran-related programs. Drawing on numerous studies (Link and Palinkas, 2013; Beardslee et al., 2013; Murphy and Fairbank, 2013; Batten et al., 2009), Glynn stresses the need to expand the care system for U.S. veterans returning from Middle East operations by providing specialized institutional family support within the framework of the U.S. Department of Defense. These studies serve as a direct argument for the institutionalization of family involvement in veterans' hubs, echoing the motto: "To care for him who shall have borne the battle, and for his widow, and his orphan" (Glynn, 2013, p. 413).

Steven L. Sayers (2011) focuses on therapeutic methods aimed at supporting families whose members served in OEF and OIF. He introduces the concept of "family reintegration" to describe the process of navigating the challenges of a veteran's return to the family and becoming a functioning member once again (Sayes, 2011). Sayers (2011) identifies two primary sources of problems: military deployment (i.e., separation and the subsequent reintegration of the service member into the family) and the impact of war-related trauma. He outlines key relational difficulties: the loss of spousal autonomy (partners left at home may experience a sense of diminished autonomy after adapting to independently managing the household), differing expectations regarding emotional and sexual intimacy, spousal resentment (stemming from perceived abandonment), and challenges in adjusting to changes within the family dynamic.

To address these challenges, Sayers (2011) outlines two therapeutic models: *Complicated Family Reintegration (CFR)* and *BATTLEMIND*. The CFR model identifies factors influencing family functioning, such as:

- preexisting levels of couple and family functioning,

- the degree of physical injury and rehabilitation required,
- significant relational events during deployment (e.g., infidelity, financial crises),
- the presence of military-related behaviours after deployment.

The *BATTLEMIND* model uses each letter as a guide for partners[2], offering instructions on how to facilitate veterans' transition (e.g., *Buddies (cohesion) vs. Withdrawal*: bonds formed in combat may lead veterans to withdraw from family and prefer time with war comrades). This work significantly contributes by identifying structured, family-inclusive therapeutic approaches.

In another Fischer et al. (2015) research, authors provide empirical evidence showing that both veterans and their families agree on the necessity of including families in veteran care systems. They propose structured programs focused on increasing awareness of services offered by veteran hubs, PTSD coping strategies, reintegration tools, post-deployment support, and peer-to-peer experience sharing. The researchers strongly affirm that family and joint programming are critical for successful reintegration of veterans with PTSD—models that exclude families consistently prove ineffective. Their findings further reinforce the importance of family involvement in the reintegration process. Consequently, the introduction of family-centered programs in veterans' hubs in Croatia is not only theoretically sound but also reflective of the actual needs of veterans and their families.

In light of recent geopolitical developments, notably the war in Ukraine, relevant study is provided by Pustovoyt et al. (2024) which examines the system of care for veterans of the Russian-Ukrainian conflict. In defining the key principles of medical and psychological rehabilitation, the authors emphasize the "principle of cooperation, partnership, and responsibility", which includes family participation: "The participation of veterans and their families in the rehabilitation process plays an important role in achieving successful outcomes. (…) Undoubtedly, the family is the most significant source of support in achieving successful social adaptation and effective functioning of the patient" (Pustovoyt et al., 2024, p. 59). They suggest several models for implementing this principle: establishing rehabilitation centers within medical-psychological clinics, organizing military psychological and rehabilitation centers within the healthcare system, or developing a network of veteran hubs.

Since 2019, the Republic of Croatia has established a national network of veterans' hubs (e.g., Petrinja, Daruvar, Knin, Šibenik) with the goal of providing health and rehabilitation services to veterans (Ministry of Croatian Veterans, 2025). It can therefore be argued that the logistical and infrastructural prerequisites for applying the "principle of cooperation, partnership, and responsibility"—and, by extension, family-inclusive programs—have already been established.

In summary, international literature, especially from the United States, reveals a consistent research thread that integrates family, reintegration, and veterans into a holistic framework. These studies thus provide a strong conceptual foundation and practical model for research and policy development at the national level in the Republic of Croatia.

CONCLUSION

The reintegration of veterans into civilian life is a complex and multidimensional process, in which the family holds potentially a key role. Nevertheless, in the Croatian context, this dimension remains scientifically underexplored. This review presents existing findings, prevailing approaches, and research gaps from the 1990s to the present, along with a brief overview of international literature for comparative insight.

[2] **B**uddies (cohesion), **A**ccountability, **T**argeted Aggression, **T**actical Awareness, **L**ethally Armed, **E**motional Control, **M**ission Operational Security (OPSEC), **I**ndividual Responsibility, **N**on-Defensive (combat) Driving, **D**iscipline and Ordering

In other post-conflict societies, such as the United States, there exists a long-standing tradition of examining veterans' families in the context of marital relationships and family functioning in the prevention of PTSD. Programs like "family-centered reintegration plans" have been developed, which position the family as a central actor in the recovery process. Numerous studies have underscored the importance of marital counselling, parental support, and family cohesion in facilitating reintegration. Such research, however, remains largely absent in the Republic of Croatia. The Croatian system continues to treat veterans' families as secondary, despite consistent evidence in international literature confirming the family's crucial role.

In Croatian academic discourse, the concept of reintegration is most often associated with institutional measures (e.g., employment, entitlements, pensions), with significantly less focus on psychosocial and family contexts. While qualitative studies do acknowledge the importance of family, there is a notable lack of longitudinal research tracking the reintegration process within the family system. Moreover, almost no domestic research systematically investigates how the family directly contributes to veterans' reintegration such as through support in resocialization, re-engagement with family roles, or the adoption of a civilian identity.

Accordingly, there is a pressing need to develop an interdisciplinary research framework that incorporates psychological, sociological, and family-oriented dimensions of reintegration. Future studies should analyse family dynamics as a determinant of successful or hindered reintegration, include the voices of family members, and design intervention models based on empirical evidence. As the foundational unit of social support and emotional stability, the family should not be regarded as a passive witness to the consequences of war, but rather as an active participant in the reintegration of Croatian veterans. Overlooking its role is to neglect one of the essential mechanisms of recovery and social reintegration.

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CHARACTERIZATION OF NATURAL POZZOLAN AND SANDSTONE AND THEIR PERFORMANCE IN WASTEWATER TREATMENT

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ABSTRACT

In recent years the whole world has been threatened by water shortage. In this context of water stress, alternative solutions for better management of water resources must be developed. In this regard, our research team initiated a study of three domestic wastewater purification scenarios on laboratory scale, to highlight the process most suited to local conditions, namely:

Scenario I: Settling basin followed by a vertical flow filter.

Scenario II: Decantation basin followed by two Moving Bed Biofilm Reactors.

Scenario III: Decantation basin followed by two Moving Bed Biofilm Reactors then a vertical flow filter.

The best reduction was achieved using the wastewater treatment scenario with the combination of the MBBR process and the pozzolan-filled vertical filter [1], [2].

In this regard, the main objective of this study is the chemical characterization of these two materials (pozzolan and sandstone), before and after treatment, using analysis techniques such as X-ray diffraction, TGA/DSC, and infrared spectroscopy. This is done to understand the correlation between the composition and chemical structure of the filtering material and its purifying properties.

Keywords: Sustainable development, MBBR (Moving Bed Biofilm Reactor), vertical filter, chemical composition, morphology, porosity.

COACHING – A METHOD OF MANAGERIAL COMMUNICATION

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ABSTRACT

Communication is a process considered normal and natural in any human context, but when we want to achieve specific results through communication, such as discovering and developing human potential, there is a need to use specialized communication techniques adapted to the desired goal. One such method of communication created and oriented towards a specific goal is coaching. This concept came to public attention less than 50 years ago and is gaining increasing popularity in society. Given that it is considered one of the most effective methods of interpersonal communication used in human development, in identifying solutions and in manifesting a person's autonomy, it has been successfully adopted in organizations and has found its place especially in managerial communication. Nowadays, managers are expected to communicate with their employees in a way that makes them feel motivated, involved, and empowered at work, so they can do their jobs independently and with confidence. As a result, coaching has become the go-to communication method for making this happen. This article presents the defining elements of the coaching method in the context of managerial communication.

Keywords: "communication," "organizational communication," "managerial communication," "coaching," "motivational language"

Introduction

Communication is a word of Latin origin meaning "to make common." Author Ioan Drăgan (2007), in his publication "Communication, Paradigms and Theories," p. 5, defines communication as "a process of transmitting information, ideas, and opinions from one individual to another, from one social group to another." This approach suggests that the communication process is simple and accessible to anyone who wants to embark on such an endeavor. If we were to conduct research in organizations to discover the main dysfunctions, we would likely find that their members place communication difficulties at the root of most of the problems they face.

Certainly, the communication process cannot be avoided, given that all social structures are based on communication processes, which manifest themselves in various forms, and organizational structures are no exception. Thus, the question arises as to how we can communicate in such a way as to facilitate the smooth running of an organization. Even though communication is natural and seems simple, the more social and relational structures diversify, the greater the need to specialize the way we communicate. This article highlights a specialized form of communication that was adopted in organizations at the end of the 20th century and has become increasingly prominent in recent years, namely organizational coaching.

Organizational and managerial communication

An organization can be defined as: "a social system in which and through which people interact (cooperate) to achieve common goals" or "two or more people working together to accomplish a task that could not be performed by one person alone." As a result, an organization represents a mutual link between people and goals and between people and organizational structures. If we look at the organization as a social institution, from the perspective of authors Zorlețean T., Burduș E., Căprărescu Gh. (1998), it reflects a series of culturally accepted needs and values, fulfills certain social purposes, ensuring the coordination of the efforts of different individuals to achieve these objectives, which would be difficult to achieve individually.

In order to achieve its objectives, the organization has created well-defined roles that have this direct responsibility, these being managerial functions. Communication in the form of coaching is currently considered the way to achieve all this in a way that stimulates the potential of employees, as a result of which managers end up adopting specialized modes of communication that until recently were the preserve of specialists from outside the organization. Coaching is increasingly being adopted as a new and more effective way of communicating, especially as the future directions of an organization's operations bring into play concepts such as autonomy, sustainability, responsibility, accountability, and employee involvement in a way that challenges their development and activates their potential.

An essential element in communication is information, which represents any data that adds knowledge to the communication process and leads to the achievement of the parties' interests or the organization's objectives. According to author Cristian Măduța, "all definitions of communication revolve around the concepts of interest and information." However, the same author specifies that communication in which a participant only achieves their personal interests may not be considered effective in the medium or long term if the common goal depends on the mutual involvement of all parties. These coordinates fairly accurately define the communication process that takes place in organizations, even if the common interest is not always sufficiently visible.

Organizational communication is based on the same paradigms as interpersonal communication and fully respects the main functions and axioms of communication. According to Roman Jakobson, quoted by Valentina Marinescu in her book "Introduction to Communication Theory," the structure of interpersonal communication includes the following elements: sender, message, context, channel, code, and receiver. Each of these is assigned a language function:

Emotive function – consists of the sender's self-projection in the message and involves focusing the message on the sender and expressing their emotional state, feelings, moral values, cognitive abilities, and culture.

Conative function – is oriented towards the receiver of the message and refers to inciting them to action or, conversely, to cease an action through orders, instructions, prohibitions, requests, etc.

Poetic function – is related to the message, so the message is oriented towards itself and towards a certain form of structuring and organizing information. This function emphasizes how something is said, how it is spoken, as opposed to scientific language, which emphasizes the content of the message.

Metalinguistic function – corresponds to the code and code indications existing in the message, which may be explicit or implicit. This function aims at the correct and complete understanding of the message and involves checking the understanding of words, their meaning, and the collateral implications of code signs.

The referential function corresponds to the context and refers to the fact that the message refers to an external reality, to something other than the person themselves, through the use of language to express a reality, a personal interpretation, an image, an opinion, or an idea filtered through the sender.

The phatic or contact function – corresponds to the transmission channel and serves to establish contact, the communication relationship, verify its functionality, and cultivate interest in it until the message is fully transmitted.

According to the author, the six functions coexist in any interpersonal communication, differing only in the importance assigned to each. C.N. Parkinson and N Rowe (1978) add to the above functions the element *of trust*, which is considered an essential factor in determining the receiver's interest and making the message credible. The authors highlight that in interactions where trust is high, communication becomes effective, and where trust is low, communication becomes ineffective.

The axioms of communication formulated by Paul Watzlawick and Don Jackson (2014) start from the premise that in order to know what communication is, it is necessary to study situations in which it is not functional. Following such research, several statements were formulated:

"*Communication is inevitable"* – this axiom emphasizes that it is impossible not to communicate. It follows that, in any situation, all human behavior has message value and constitutes communication.

"*Communication takes place on two levels*: *informal and relational*" – this means that it is not only the content of communication that matters, but also the relationship, interaction, and behavior.

"*Communication is a continuous process that cannot be treated in terms of cause and effect or stimulus and* response" – this axiom shows that messages are interdependent in a complex way, so that the line between cause and effect can no longer be distinguished. What is a cause for some may be considered an effect for others.

"*Communication takes either a digital or an* analog *form*" – at the level of the nervous system, information is produced in binary digital form, and at the level of the neurovegetative system, it is produced according to various combinations of substances and their concentrations in the body (analog system).

"*Communication is irrevers*ible" – this axiom states that once communication has occurred and been received, it will have an effect on the recipient.

"*Communication involves power relations and symmetrical or complementary transactions*" – the premise of effective communication lies in the equality of the participants in the communication, and achieving real equality is considered an almost impossible goal; this involves various forms of power relations between the participants.

"*Communication involves processes of adjustment and* accommodation" – this refers to the fact that the meaning of each word is in the mind of each participant in the communication. The diversity and uniqueness of life and linguistic experiences mean that the meaning of the same words differs from individual to individual.

These functions and axioms of interpersonal communication are reflected more explicitly in organizational communication, both in terms of the organization's communication with the outside world and the communication that takes place within the organization. Internal communication within an organization becomes a management tool. It is seen here as an organized structure through which information exchanges take place within the organization (meetings, working groups, surveys, analyses, reports, etc.). From this point of view, we can consider internal communication as a structure that facilitates the transmission and implementation of managerial decisions.

For a long time, managerial communication focused primarily on *the conative function* of communication and was considered effective if the recipient of the message took action as quickly as possible or, on the cont , ceased an action, and was achieved through orders, prohibitions, or, in rare cases, through guidance. Currently, the predominant emphasis on this function has diminished, as the

aim is to reach agreement with the employee so that they become personally involved in solving managerial problems and tasks. The emphasis has shifted to *the metalinguistic function* and the correct and complete understanding of the message conveyed, to checking the understanding of words, their meaning, the collateral implications of the message, and to *the emotive function*, to the expression of affective states, feelings, moral values, organizational culture, and to instilling these in the members of the organization.

Managerial communication thus makes it possible to motivate employees to carry out the tasks assigned at the managerial level (decisions are accepted because employees share and agree with the meaning given to managerial solutions), achieving internal coherence within the organization (involving employees in the problem-solving process and achieving a better understanding of managerial decisions), and creating a certain type of organizational culture.

Based on these managerial communication needs, the theory of motivational language was developed, initially launched by Jeremia Sullivan (1988) and then taken up by J. Maynfield & Maynfield (2012/2018), which assumes that managers adopt different specific types of speech when communicating with employees in order to motivate them with positive psychological and behavioral results. In this sense, three forms of language are identified that can generate this type of result: language that fulfills meaning, empathic language, and language that gives direction.

Meaningful language connects employees and their personal goals with the goals of the organization. To make sense, managers need to communicate a clear picture of the organization's values, mission, vision, and identity to employees. Secondly, they need to link individual employee goals to the overall organizational goal. This can be achieved by knowing and affirming the uniqueness and personal interests of employees, recognizing their contributions to the organization, and guiding them to find their place and identify the levers available within the organization to achieve their personal interests.

Empathetic language refers to supportive language, full of compassion and respect in managers' communication with employees. Managers can use empathetic language when celebrating employees' work successes, supporting employees with personal problems, and providing comfort and reassurance during difficult times at work. Through emotional communication, managers and employees reveal their humanity, empathy, authenticity, and vulnerability to each other. Although it is the language least used by managers, scientists have associated the use of empathetic language with employee satisfaction and engagement (Dutton & Spreitzer, 2014).

Directive language involves articulating what needs to be done to achieve organizational goals, clarifying role ambiguity and tasks, and providing feedback on performance. In addition, directive language includes transparency in communication, which reduces task uncertainty and increases employee work effectiveness (Sun et al., 2016).

By applying motivational language theory in organizations, an emotional culture and a feedback culture can be created within the organization. Schrodt (2002) describes organizational culture as a group learning process involving a cognitive and an affective dimension. *Cognitive culture* (Barsade & O'Neill, 2016) is understood as "shared intellectual values, norms, artifacts, and assumptions" about what to think, say, and do within organizations. *Emotional culture* (Barsade & O'Neill, 2016) is defined as "the sharing of affective values, norms, artefacts and assumptions that govern what emotions people have, which they express at work and which they would be better off suppressing".

Emotional culture exists in organizations, whether or not it is recognized by the members of the organization. Like cognitive culture, emotional culture includes: (a) nonverbal emotional expressions (e.g., tone, facial expression, body language) and cultural artifacts (e.g., physical space, decorations, stories, group rituals, traditions, ceremonies); (b) underlying values (i.e., the collective importance given to certain emotions, such as an understanding of what types of emotions should be expressed or

suppressed); (c) underlying assumptions (i.e., the implicit, self-evident meaning of expressing or suppressing a particular emotion).

The culture of feedback and development in an organization is one in which individuals receive, seek, and use formal and informal feedback to improve their performance at work. This may be linked to effective policies and programs for performance management, continuous learning, and career development. An individual's orientation toward feedback depends in part on the support and climate for learning. The more frequent the feedback and the more closely it tracks the behavior in question, the more likely it is to be accepted (Cederblom, 1982).

Coaching as a method of managerial communication

Coaching is a method borrowed from sports in the early 1980s, which later became known in organizations as an important management practice, eventually becoming a distinct profession. Along with other specific methods of information transfer used in organizations, such as mentoring, counseling, and consulting, coaching involves a one-on-one communication relationship between an experienced employee and another team member, with the aim of developing the latter's professional skills. *The main purpose* of coaching in organizations is to define and achieve professional and organizational goals. This is also the main reason why coaching has found a place within organizations and can successfully meet their needs. Every manager wants to motivate their employees to achieve organizational goals and objectives and encourage them to reach their full potential.

Philipe Rosinski (2019), in his book "Global Coaching," defines coaching as a term used to describe a methodology currently considered effective, that of "facilitating the growth and development of people to become complete human beings—provided they believe in themselves."

The objectives of a coaching process may include the following: overcoming barriers and resistance to change, recognizing and managing stress effectively and proactively, resolving conflicts, creating relationships based on trust, optimising existing skills, developing new skills, effective decision-making, identifying creative solutions, initiating change and adapting to change, discovering personal strengths and limitations, overcoming one's own limitations, etc.

Sir John Withmore believes that Timothy Gallaway, in his book "The Inner Game of Tennis," identified the essence of coaching: "unleashing people's potential to maximize performance." As a result, coaching supports the idea that internal obstacles are stronger than external ones. Thus, through coaching, people discover how to learn from their mistakes and then not repeat them. It is a form of intensive development that helps accelerate change, provides new perspectives, and supports the generation of new attitudes toward the situation being analyzed.

The main means of transformation used in coaching are: *awareness* – the essence of quality coaching lies in strengthening awareness and responsibility; we are only able to control the things we are aware of, being controlled by the things we are not aware of; *taking responsibility* – awareness gives us control over reality; *building confidence in one's own strengths* – confidence can be achieved by taking responsibility for one's own development, one's own choices, and their results.

Management coaching is understood as a tool that can be used in organizations by managers to improve employee performance in the workplace and is considered an effective leadership behavior characterized by one-on-one meetings and development-oriented communication interactions.

Philipe Rosinski (2019), in his book "Intercultural Coaching," emphasizes that in coaching, managers, instead of telling people what to do, act as facilitators and "start from the idea that people have untapped potential," and the coach helps the employee bring this potential to the surface, "just like coaches who help athletes discover champions within themselves." The author believes that organizations today face

increased competition and increasingly frequent changes in market conditions and are therefore forced to achieve more with fewer resources. They need greater creativity and flexibility to respond to unexpected challenges and seize new opportunities, and they can no longer afford to waste their human talent. Organizations are forced to develop and fully utilize their human capacity and become attractive to the most talented people, and the use of coaching in managerial communication is thus becoming one of the responses adopted by organizations to the new market requirements.

The manager-coach accompanies and guides the employee, taking care not to replace them or offer answers or options. Through questions, they help them find solutions on their own, which can lead to new and unique answers that will transform people's perspectives on how they think, feel, and act. As a result, coaching is a dialogue, a deep and special form of communication, supported by communication methods such as active listening, questioning, feedback, and inviting reflection. The coach listens to understand, get to know the other person, and help them get to know themselves better through questions. Feedback and reflective statements bring clarity to understanding, while questions identify motivation and outline a strategy for action.

Communication techniques used in coaching

Ana Karakusevic (2016), in *Coaching Fundamental*, emphasizes that essential to the role of coach is the ability to listen and describe the fundamental elements of communication in coaching:

Active ***listening*** – means being completely connected to the moment, to the other person, to the solution, giving the other person **your full attention and presence**, and is **dynamic,** as it is based on **silence, acceptance, and non-judgment.** This form of listening is based on dialogue and the co-creation of new visions, thoughts, and ideas. Listening in coaching is powerful, dynamic, and difficult. It goes beyond the barriers of "mirroring" and acceptance, going as far as identifying with the other person in order to find the best course of action.

The art of asking questions – in coaching, various types of questions are used, and it is important to ask the right questions. Questions are what make the difference between failure and success.

Feedback – the art of giving feedback includes skills that develop over time and are related to ease and curiosity to explore. We are talking about **ease** in giving feedback, while fully owning the observations, thoughts, feelings, perspectives, and stories that have influenced us. **Exploration** refers to engaging in conversation, seeing how the other person receives the feedback, how it fits with their reality, and what role it could play in creating a new reality for them.

Multiplicity – recognizing and using multiple perspectives means that there are many sides to every story, many ways of looking at, seeing, interpreting, and judging reality. Recognizing this eliminates the need for the coach to reject another point of view and impose their own.

Choices – the fundamental principle of choice refers to the fact that in coaching, the client is the one who takes responsibility for their choices and the coach allows them to be fully in charge of them. The coach's role is more to help the client go through the steps of the decision-making process and become aware of the consequences of their choices.

Trust – is just as important as listening, but comes later because it takes more time to build.

Limits – here we are talking about the fact that it is desirable for the coach to avoid getting drawn into the client's history, to avoid offering advice or solutions, and to take responsibility for the client's situation.

Presence – presence in coaching makes it possible **to accept** the client's reality at any given moment, while also preserving the potential for further development and growth.

Silence – more than just a pause between breaths or ideas, silence in coaching is closely linked to being present, listening, choosing, and trusting.

Skills required of a coach

Terry Levine (2001), in his book Coaching for an Extraordinary Life, highlights the basic skills of a coach:

The ability *to connect with the other person on a deep human level* – the coach recognises the need for human connection, and in the manager-employee relationship helps the employee to open up, person to person, while the manager-coach also opens up to connect.

The ability to listen without judging – as human beings, we tend to label what we hear as good or bad, right or wrong, happy or sad, etc. In coaching communication, the manager-coach will make an effort to believe that no one is right or wrong, to avoid labeling people as good or bad, and to listen to the employee's opinion to find out how they think, to understand what is really going on in their mind. To maintain a deep connection, it is essential for the coach to be able to maintain a neutral and non-judgmental discussion framework. This skill is one of the most difficult for a manager to acquire because, by the nature of their work, they constantly classify information into categories such as right or wrong, in accordance with the rules of the organization.

The ability to reflect the message (message reflection) – when we listen deeply to connect with others, we are able to tell them that we fully understand what they have said, using a skill known as *message reflection*. This allows speakers to know that we have truly heard their message and to correct what we may not have fully understood in their message. When the coach is truly connected, they can pick up more than just words in the speaker's message, as message reflection includes not only the words that are spoken, but also what is not said but is visible in the communication, such as the speaker's inner feelings, emotions, and sentiments. Using such a skill allows the speaker to feel truly listened to and understood, which is the goal of coaching.

The ability to respond from the heart – the usual response pattern is to think about what we are going to say while the speaker is still conveying their message, then to respond strictly to the message and ignore what has not been verbalized but has been expressed non-verbally. In coaching, the response comes only after the message has been reflected upon and its correct understanding has been verified, along with the nonverbal message conveyed. The response in coaching is not about the coach and their opinion, but about letting the speaker know that we have heard them and that they are understood. This skill again poses difficulties for managers, as they are used to listening in order to respond and not to convey that they have understood what the speaker has said and to maintain the communication connection.

Example of a coaching tool – the GROW model

The GROW model is a coaching technique that has been successfully applied in organizations. It is the most popular coaching model that can be used in problem solving, goal setting, and improving performance in the workplace. GROW was created by Graham Alexander, Alan Fine, and Sir John Whitmore in late 1988. GROW is an acronym for Goal; Options, Obstacles, and Will (Way forward) – which are seen as the four elements of a coaching session or an entire process.

Example of how the GROW model works:

Step 1: Setting the goal – involves formulating the behavior you want to change into a SMART goal (Specific, Measurable, Achievable, Realistic, and Time-bound): *What is the topic we are going to address? What do you want to achieve/accomplish? Why is this goal important to you/the team/the*

organization? When/by when do you want to achieve this? What resources do you need? How will you know when you have achieved your goal? How much control do you have over achieving this goal?

Step 2: Examine the current reality, resources, and strategies used: *What is happening now regarding this issue? What have you tried so far, and what were the results? What factors have prevented you from achieving what you wanted so far? How would someone from the outside view things?*

Step 3: Explore options and possibilities, potential obstacles: *What options do you have in this situation? What else could you do? What would happen if... ?What lessons/best practices have you learned in the past that you could apply here? What solutions would X see? How would Y approach the situation? What would happen if there were no Z obstacle? What difficulties do you think you will encounter along the way? How likely are they to occur? What could prevent you from achieving your goal? Do you have a backup plan?*

Step 4: Agree on actions and design a plan to implement them: *What actions and steps will you take to achieve your goal? How will you implement this? Who do you want to involve/inform? When/by when will you do this? When will we meet to monitor progress/see results?*

All these steps are achieved through the questioning and active listening techniques described earlier in the article. It seems like a simple structure, but when you want to follow the communication elements described by author Ana Karakusevic, the process becomes complex and difficult to apply for a manager who has no coaching training. Even when managers in organizations are trained in this specialization, a longer period of training is necessary to communicate easily in the manner required in coaching.

Conclusions

Coaching is a communication method that poses challenges for managers as it transposes the functions of communication into new paradigms. If in ordinary communication we approach *the emotional function* as a projection of the sender in the message, then when the coach becomes the sender, it is the listener who is projected in the message, the sender becoming secondary in the communication process and avoiding self-projection in the communication process. They adopt the role of reflecting, mirroring the communication partner through specific connection, mirroring, and feedback techniques. Thus, interpersonal communication between two people becomes a catalyst for intrapersonal communication, with attention and the message being directed toward a single participant in the communication. In this case, the manager becomes a catalyst in the process by reflecting the verbal and non-verbal message of the employee, which is quite difficult for the manager to master if he fails to give up his hierarchical position and power in relation to the employee and communicate from a position of equality with the employee.

In coaching, *the conative function* of communication is applied, with the manager inspiring the employee to take action. but unlike in normal manager-employee communication, they don't tell them what to do. Instead, they help them figure out the actions, solutions, and deadlines on their own, guide them with questions to make sure they're on the right track, and then let them implement the actions and take ownership of the results. This is similarly difficult for a manager to achieve without conscious training, as the manager feels responsible for the results and feels the urge to direct the employee's actions.

The *poetic* and *metalinguistic* functions become essential in the coaching process, as the coach has to follow a specific communication structure, and guiding and accompanying the employee requires constant attention to the way the message is formulated, the questions asked, and the feedback given, so that the processes of self-reflection and awareness are triggered. The coach carefully monitors the meaning of each word spoken by the employee and applies *"accommodation and adjustment processes."* Last but not least, the connection based on trust that the coach needs to create in the relationship with

the employee requires special attention to *the critical or contact role* and to the constant maintenance of the connection and its quality. This means that, even outside of coaching communication, the manager must nurture a relationship based on trust with the employee.

Despite the challenges posed by learning the specific communication skills of coaching, the benefits it offers bring us closer to a culture of emotion, feedback, and development, which are the current goals of managerial communication. Coaching communication uses motivational language, as described by Jeremia Sullivan (1988), especially *language that conveys meaning*, the very purpose of coaching being to bring meaning to managerial actions and help employees align themselves with the organization on their own initiative. *Empathetic language*, human connection, and active listening are the essence of coaching. In contrast, *language that gives direction* is transposed into coaching in a different way, namely, coaching helps the employee align themselves with the organization and its objectives, allowing them to define their own direction and how to achieve their goals. The manager only intervenes with subtle guidance and feedback to highlight the employee's progress and performance.

This way of working and communicating in organizations is really different from what has been practiced so far and requires adaptation and adjustment of interaction, both on the part of the manager and the employee, in order to benefit from the results that this method makes possible. This practice is increasingly bringing into focus the integration of all these benefits and the development of a coaching culture in organizations.

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COMPARISON OF THE PERFORMANCE OF ANN, SVM, AND RANDOM FOREST ALGORITHMS IN THE CLASSIFICATION OF EMG SIGNALS

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ABSTRACT

Hand loss resulting from occupational accidents and various health problems significantly impairs individuals' ability to perform daily life activities and negatively affects their overall quality of life. In order to reduce the adverse effects of such physical disabilities and to improve the quality of life for these disadvantaged individuals, prosthetic hand systems are being developed. Machine learning models, which have become increasingly prevalent in recent years, play a significant role in making these systems more functional and user-friendly. In prosthetic hand systems, hand movements can be recognized using electromyography (EMG) signals, which are generated by muscle contractions and detected from the skin surface, with the help of various machine learning algorithms. In this study, three widely used machine learning models were employed to classify EMG signals and identify different hand movements. The classification performances of Artificial Neural Network (ANN), Random Forest, and Support Vector Machine (SVM) models were compared based on EMG data. For this purpose, surface electrodes were placed on the Flexor Digitorum Superficialis and Flexor Pollicis Longus muscles of a healthy individual's forearm, and two-channel EMG measurements were conducted. During data collection, four basic hand movements commonly used in daily life - relaxed, fist, thumb closed, and four fingers closed (referring to the four fingers between the index and little finger) - were repeated and recorded. The collected data were filtered and preprocessed using signal processing techniques in the MATLAB environment. Each algorithm was then trained and tested separately, also in MATLAB. As a result, classification accuracy rates were calculated, confusion matrices were analyzed, and the performance of each algorithm in classifying hand movements was evaluated. The experimental results showed that the ANN model achieved the highest classification accuracy among the tested algorithms.

Keywords: Movement Classification, Electromyography (EMG), Prosthetic Hand, Machine Learning, Artificial Neural Network (ANN), Support Vector Machine (SVM), Random Forest,

INTRODUCTION

For individuals experiencing the loss of a hand, daily activities such as maintaining independence, interacting with their surroundings, and performing professional tasks can be extremely challenging due to the limitations imposed by their disability (Biddiss and Chau, 2007). Workplace accidents, congenital anomalies, and various neuromuscular diseases are among the leading causes of hand loss (Belter et al., 2013). Such losses not only impair physical functionality but also have significant adverse effects on an individual's psychosocial well-being (Kyberd and Hill, 2011). Therefore, the development of prosthetic hand systems is of critical importance, offering solutions that enhance both functional capabilities and overall quality of life.

Over time, prosthetic hand technologies have evolved from simple mechanically operated models to advanced bionic systems with multi-joint structures, sensor-based feedback, and highly precise control

capabilities (Atkins et al., 1996; Ortiz-Catalan et al., 2014). Electromyography (EMG) signals obtained from muscle activity play a key role in this development. The surface electromyography (sEMG) method enables the detection of electrical activity generated during muscle contraction through the skin, allowing the identification of the user's intended movements (İşler and İşler, 2019).

However, accurate interpretation of sEMG signals requires attention to certain factors. Variations in electrode placement, electrical noise, muscle fatigue, and individual physiological differences can negatively affect classification performance, potentially leading to erroneous results (Blanc and Dimanico, 2010). Therefore, in signal processing stages, noise reduction, appropriate feature extraction, and the selection of an effective classification algorithm are of great importance (Phinyomark et al., 2012).

In recent years, machine learning algorithms have been widely applied to motion recognition tasks in prosthetic hand systems, as in many other domains. Artificial Neural Networks (ANN) stand out as a powerful option for EMG classification due to their ability to learn and generalize complex patterns (Englehart and Hudgins, 2003; Bishop, 2006). Support Vector Machines (SVM) are recognized for their effectiveness in classifying data within high-dimensional feature spaces, while the Random Forest (RF) algorithm is notable for delivering high accuracy and robust generalization performance through the combination of multiple decision trees (Breiman, 2001; Ho, 1995; İşler and İşler, 2019).

In this study, four basic hand movements commonly used in daily life—open hand, fist, thumb closed, and four fingers closed—were classified using two-channel surface EMG data. The acquired signals were processed in MATLAB (MathWorks, 2023a; 2023b; 2023c; 2023d), including digital filtering and feature extraction, and then separately trained and tested with ANN, SVM, and RF algorithms. The classification performance of each algorithm was analyzed and compared using confusion matrices. In this way, a comprehensive evaluation was conducted to determine the most suitable classification method for prosthetic hand control.

MATERIALS AND METHODS

In this study, motion classification was performed based on EMG signals using Artificial Neural Networks (ANN), Random Forest, and Support Vector Machine (SVM) methods, and the results were compared. Firstly, preprocessing was applied to the two-channel surface electromyography (sEMG) signal data; to reduce noise, the signals were passed through a band-pass Butterworth filter (De Luca, 1997). Time-domain features were then extracted from the processed signals and normalized, thereby creating input data for classification models. In the final stage, the selected machine learning methods were used to train the models, followed by the testing phase. The block diagram of this study is also shown in Figure 1.

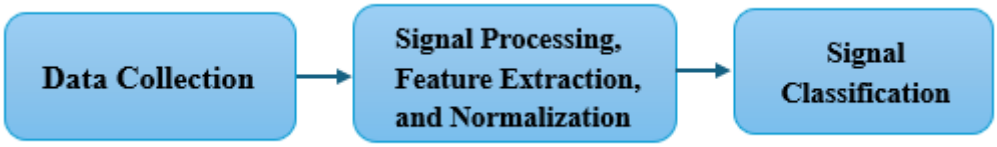


Figure 1: Study Flow Diagram

Data Collection

Surface electromyography (sEMG) signals were collected from the forearm of a healthy adult subject using surface electrodes placed across two channels (Merletti and Parker, 2004). The electrodes were attached to the skin over the Flexor Digitorum Superficialis (FDS) and Flexor Pollicis Longus (FPL)

muscles, which are responsible for finger flexion and thumb movement, respectively. A reference electrode was placed on a bony prominence—specifically, the elbow—to minimize noise.

During the recording session, the subject repeatedly performed four different hand movements commonly used in daily life:

1. Open hand (resting position)
2. Fist
3. Thumb closed
4. Four fingers closed (from index to little finger)

Signal Processing, Feature Extraction, and Normalization

Raw EMG signals were filtered using a Butterworth band-pass filter with a frequency range of 20 to 450 Hz in order to reduce unwanted noise and motion artifacts (De Luca, 1997). The filtered signals were then segmented using a sliding window approach (Phinyomark et al., 2012).

From each segment, time-domain features were extracted as follows (Hudgins et al., 1993):

- Mean Absolute Value (MAV): MAV is calculated by dividing the Integrated Absolute Value (IAV) by the length of the sample. It is particularly useful and commonly used in muscle control systems, as it provides information about the level of muscle contraction.
- Root Mean Square (RMS): The RMS value is calculated by squaring all data points in the EMG sample, summing them, dividing by the number of samples, and finally taking the square root of the result.
- Willison Amplitude (WAMP): WAMP is computed by counting the number of times the absolute difference between two consecutive EMG signal values exceeds a predefined threshold. If the difference exceeds the threshold, the value is counted as 1; otherwise, it is 0.
- Zero Crossing (ZC): ZC counts how many times the signal crosses the zero line. Similar to WAMP, it is sensitive to noise; therefore, a threshold value must be defined to avoid false crossings.

The extracted features were divided into training, validation, and test datasets. Feature scaling was performed using z-score normalization based on the training data (Bishop, 2006). This normalization ensures that the classification models receive balanced and consistent input data.

Signal Classification

Using MATLAB, three machine learning methods were trained and tested sequentially: Artificial Neural Networks (ANN), Support Vector Machines (SVM), and the Random Forest algorithm.

- **Artificial Neural Network (ANN):** A multilayer perceptron (MLP) architecture was used. The network consisted of six hidden layers containing 20, 10, 50, 10, 10, and 10 neurons, respectively. A sigmoid activation function was used in the hidden layers, while a softmax function was employed in the output layer. The model was trained using the backpropagation method with the Levenberg-Marquardt algorithm (trainlm). Training and validation datasets were manually separated, and the model was optimized using these datasets. The training accuracy was calculated, and the trained model was saved as a file (Levenberg, 1944; Marquardt, 1963; MathWorks, 2023c; 2023d).
- **Support Vector Machine (SVM):** For the multiclass classification problem, an SVM classifier with a Radial Basis Function (RBF) kernel was implemented using the "one-vs-all" approach (Hastie et al., 2009). The model was trained on the training dataset using MATLAB's fitcecoc function and tested

on the test dataset (MathWorks, 2023a). The input features were standardized to enhance performance. The test accuracy was calculated, and classification performance was visualized using a confusion matrix.

- **Random Forest:** An ensemble model consisting of 100 decision trees (Bagged Trees) was created. Each tree was trained using the bootstrap sampling method, and classification was performed using the bagging technique (Breiman, 2001; Ho, 1995). The model was trained on the training dataset using the fitcensemble function (MathWorks, 2023b), predictions were made on the test dataset, and the accuracy was calculated. Performance evaluation was visualized using a confusion matrix.

RESULTS

According to the test results, the ANN model achieved the highest performance with an overall accuracy of 89.6%. As shown in Figure 3, ANN achieved high classification accuracy in the four fingers (100%) and thumb (95.2%) classes, while it demonstrated relatively lower performance in the rest (82.6%) and fist (82.4%) classes.

As illustrated in Figures 2 and 4, the SVM and Random Forest algorithms both achieved similar performance levels, with an overall accuracy of 83.1%. However, in both models, the rest class was more frequently confused with other classes.

Upon examining the confusion matrices, it is evident that the multilayer structure of the ANN enabled it to learn the characteristic features of EMG signals more effectively than the other methods. Specifically, the ANN confusion matrix in Figure 3 shows near-perfect classification in the four fingers and thumb classes, while most of the misclassifications occurred between the rest and fist classes.

In contrast, the confusion matrices for the SVM (Figure 4) and Random Forest (Figure 2) models, while showing high accuracy in some classes, indicate a significantly higher misclassification rate for the rest class compared to the ANN model.

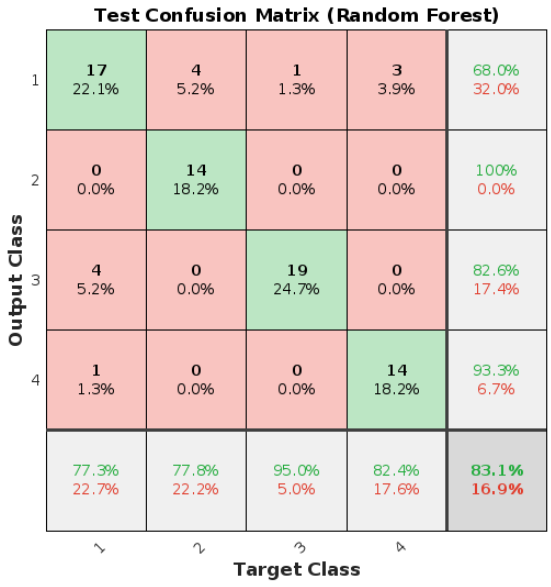


Figure 2: Confusion Matrix of the Random Forest Algorithm

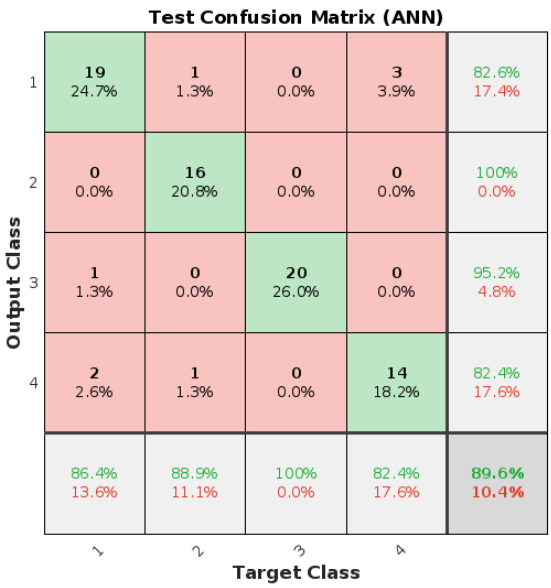


Figure 3: Confusion Matrix of the ANN Algorithm

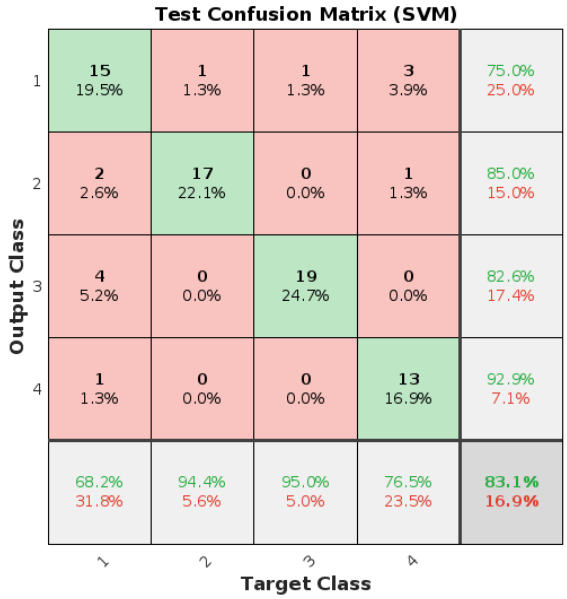


Figure 4: Confusion Matrix of the SVM Algorithm

DISCUSSION

The classification results obtained in this study reveal the distinct strengths and weaknesses of the three methods employed. The superior performance of the ANN method compared to the others can be attributed to its multilayer architecture, which allows for more effective learning of complex and nonlinear decision boundaries. In particular, the subtle variations in EMG signals that are specific to different movements can be better captured by flexible models with a high number of parameters, such as ANN.

The similar performance observed between the SVM and Random Forest algorithms is also noteworthy. This suggests that both methods were able to successfully capture the more distinct class boundaries in the dataset. However, a decrease in accuracy was observed in regions where class features overlap, indicating weaker discriminative power in such cases. While the bootstrap sampling and feature subset selection mechanisms of Random Forest provide robustness to noise, the method was not as effective as ANN in distinguishing between EMG signal patterns with similar activation characteristics.

In the case of SVM, it is well known that the choice of kernel function and the tuning of hyperparameters play a critical role in classification performance.

An examination of the confusion matrices shows a tendency for misclassification particularly between the rest and fist movements. This may be due to the similarity in muscle activation profiles for these movements. Alternatively, external factors such as muscle fatigue during data collection, slight variations in electrode placement, or inter-subject biological variability may also have contributed to this overlap.

CONCLUSION

In this study, the classification of four different hand movements based on surface EMG signals was successfully performed using a limited number of channels and basic time-domain features. Among the compared methods - Artificial Neural Networks (ANN), Support Vector Machines (SVM), and Random Forest - the ANN model demonstrated superior performance over the others.

In the literature, it has been reported that classification accuracy can exceed 90% when the number of channels is increased, time-frequency domain features are incorporated, and deep learning architectures are utilized. However, the high accuracy achieved in this study indicates that the proposed approach offers an effective solution for portable and low-cost biomedical applications.

The main limitations of this study lie in the limited number of subjects from whom data were collected and the fact that the models were trained solely on this dataset. This restricts the generalization capability of the models. Future work could address these limitations by collecting data from a larger and more diverse group of participants, applying data augmentation techniques, extracting additional features, and

evaluating deep learning-based approaches. These steps are expected to enhance both performance and generalizability.

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CODING LITERACY AS LINGUISTIC EMPOWERMENT: A CROSS-DISCIPLINARY FRAMEWORK

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ABSTRACT

In the contemporary globalized world, English literacy and coding are essential competencies to open up global opportunities for youth. Our research investigates the integration of English for Specific Purposes (ESP) in coding education for enabling high school students' linguistic and technical empowerment. On the basis of a mixed-methods research design, quantitative and qualitative data were collected from 50 MetroCode high school students, an Albanian youth program integrating ESP and programming education through workshops and project-based training. Quantitative surveys quantified linguistic confidence and technical skill acquisition, whereas qualitative data through observational studies explored learners' experiences and challenges. Results show that the use of ESP in computer programming environments builds students' technical English lexicon and programming skills, and fosters critical thinking and peer-to-peer problem-solving abilities. The utilization of English as a means for debugging, documentation, and peer-to-peer communication demystified language and technology barriers, particularly for minorities and female students. Inter-disciplinary practice generated increased linguistic self-confidence and more positive attitudes towards global citizenship among students. The research results are in compatibility with United Nations Sustainable Development Goals (SDGs), specifically SDG 4 (Quality Education), SDG 5 (Gender Equality), and SDG 8 (Decent Work and Economic Growth) as the research supports inclusive and equitable education and youth empowerment for the digital economy. The study has practical applications to educators who are ready to develop curricula linking language and technical skills, especially in non-English speaking contexts, to sustainable development and youth empowerment in the 21st century.

Keywords: English for Specific Purposes (ESP), Coding, Youth Empowerment, Language Confidence, Gender Equality, SDGs

1. INTRODUCTION

With the emerging digitization era, literacy has changed even beyond the traditional reading and writing to literacy that involves digital and lingual skills that are needed to make individuals of the world participate and master global economies completely. Out of these, English literacy and computer literacy have proved to be twin structures of the 21st century education (Graddol, 2006). English as lingua franca has been known not only to enable knowledge access, but also has been described as a gateway to professional and technological world (Crystal, 2012).

By including English for Specific Purposes (ESP) in coding training, this creates a strong model to overcome these two requirements. ESP addresses the communication needs of the learners at any given discipline, e.g. computer science and is unlike general English in that it is goal-oriented (Hutchinson & Waters, 1987). The students who undertake ESP in programming are given specific exposure to jargon,

documentation, and syntactic accuracy that is related to reading the coding (Dudley-Evans & St John, 1998).

The ESP and coding combination facilitates learner-centered and project-based instructional style, which further assists improved engagement among students in terms of real-life assignments (Thomas, 2017). This is especially effective in disadvantaged settings, where the conventional curriculum models do not usually equip students with the digital economy (Selwyn, 2019). In high school, programming can be embedded in ESP and the creation of both language and technical confidence can be achieved by the collaboration of peers and the acquisition of experience (Dillenbourg, 1999). By incorporating ESP in the process of programming, these gaps can be alleviated because more inclusive and communicative learning environments can be developed (Spieler & Slany, 2018).

When integrated with ESP, culturally responsive pedagogies support gaining learners with social-linguistic capital, which helps them feel more empowered about their place in technical realms (Brown et al., 2019). This opinion is also emphasized by Freire (2020) who introduces the concept of critical pedagogy, suggesting that giving a learner "relevant tools to handle the concrete contexts in which they live" (Freire, 2020) is the best idea to empower him or her and introduce change.

Globally, the necessity of integrated means in language and digital skills training corresponds to the Sustainable Development Goals (SDGs), namely SDG 4, which aims at inclusive and equitable quality education and SDG 8, which focuses on decent work (UNESCO, 2017). As the digital divide continues to prevail in some parts where English is not the native language, ESP serves as an essential connection between the youth who can use the instrument to close this division (Gubbins et al., 2023).

Moreover, programming and language are both systematic structures implying the existence of logic, sequence and syntax. Therefore, their combination uses cognitive strategies of learners in different areas (Papert, 2020). The ESP frameworks are also associated with the ease of curriculum to accommodate changes in the technology as well as changing needs of the learners (Richards, 2001).

To explore the impact of integrating English for Specific Purposes (ESP) in coding education on high school students' linguistic and technical empowerment, this paper is structured as follows: the next section presents the mixed-methods research design employed to assess the effects of ESP integration within the MetroCode program in Albania, focusing on participant selection, data collection instruments, and research procedures. Following this, results from quantitative surveys measuring linguistic confidence and technical skill acquisition, alongside qualitative observational data reflecting learner experiences and challenges, are detailed. The discussion section interprets these findings by examining how ESP supports the development of technical English lexicon, programming skills, critical thinking, and peer-to-peer problem-solving abilities, with particular emphasis on overcoming language and technology barriers faced by minorities and female students. Finally, the paper concludes with practical implications for educators aiming to develop interdisciplinary curricula linking language and coding skills in non-English speaking contexts, recommendations for future research, and considerations regarding the alignment of these educational practices with United Nations Sustainable Development Goals (SDGs), specifically SDG 4 (Quality Education), SDG 5 (Gender Equality), and SDG 8 (Decent Work and Economic Growth).

2. METHODOLOGY

2.1 Research Design

A quasi-experimental mixed-methods design was undertaken in the study to investigate the effectiveness of integrating English for Specific Purposes (ESP) into the programming learning of high school students towards linguistic and technical empowerment. The study took place in the context of the MetroCode project, a youth education program in Albania that combines the fundamentals of basic

programming, learning Python programming language, a popular coding language, and the Manim tool, a Python-based tool to make mathematical animations, and English language education.

The participants were selected using selection criteria instead of the random selection method used in the study, and these criteria involved proficiency in English, below which the interested students were rejected. The study involved the use of both quantitative data collection (structured surveys and evaluation rubrics) and qualitative data collection (structured classroom observation, student production, focus group interviews). Such a design facilitated a global study of the impact of ESP on the acquisition of vocabulary by students, technical expressivity confidence, coding ability to write in English, and the capability of problem-solving collaboratively.

2.2 Participants

The participants were 50 high school students (15-18 years old) who participated in the research equally divided in terms of gender (25 female and 25 male students). Albanian urban and peri-urban public schools recruited all the participants and all the participants were without formal experience with ESP or programming education.

The selection was based on eligibility, which is proved by a language proficiency placement test, with only the persons scoring A2 to B1 on the CEFR scale being selected. This limit served to make the students have a working knowledge of the English language with the advantage of taking a more focused approach to the language when it came to technical matters. Students were given a chance to voluntarily participate; both students and their legal guardians were provided with a written consent. The special care was taken to guarantee the representation of minority learners and female members, as per SDG 5 (Gender Equality) and SDG 6 (Quality Education).

2.3 Materials

2.3.1 ESP-Integrated Coding Curriculum

This study developed its own curriculum with modules specific to this research that included ESP approaches as well as introductory Python programming and mathematical animation modules using Manim. Curriculum parts were devoted to:

- The English grammatical construction employed in the writing of the code and exposition (e.g. imperatives, modals, conditionals)
- Algorithmic explanation syntactic structure
- Development of vocabulary of such words as variable, loop, debug, render, function, etc.
- Application of derived and compound words applicable in the field of computer science (e.g., compile/compilation/compiled)
- Contextual language activities that entail shared commenting of codes and description of logic in words

2.3.2 Tools and Educational Resources

There was a range of tools and materials that students had to work on to ensure development with both technical and linguistic skills:

- Python IDE Visual Studio Code (VS Code), Jupyter Notebook to write and execute codes
- Manim, a free and open-source Python library that is used to generate visualizations of mathematical and logical concepts
- Code-along notebooks in English, where language is trained with the help of coding tasks
- Technical reports marked by instructors, in which three instructors in the subject area (ESP educator,

programming instructor, and two-language mentor) directly and formative corrected written documentation and allowed project language to be corrected

2.4 Procedure

2.4.1 Phase 1 – ESP Coding Instruction

Within a period of 6 weeks, the students engaged in 2 workshops of 90 minutes per week. The sessions were planned such that instruction on programming was integrated with language development based on ESP. Activities covered in learning were:

- The implementation of code structures into verbal and written English
- Python functions and loop writing of English comments
- Describing program logic in front of an audience using orderly ESP terms
- Participating in debugging activities that require the use of English as their language of communication
- Being able to get nothing but continuous corrections applied by the instructors on their work with annotations, and being corrected not only on technical side but also on language perceptions

2.4.2 Phase 2 – Mini Project and Communication Tasks

During the last two weeks, they formed small project teams and were challenged with establishing a functional mini-project in Python/Manim. This stage necessitated them to:

- Write a technical report in English that describes the aim, architecture and rationale of their code
- Present an oral report, and provide an account of their solutions, in domain-specific English, to the group
- Have their written work reviewed by the three instructors and be corrected and noted about the documentation in regards to the vocabulary precision, clarity of syntactics and cohesiveness of structures

The integration of technical output with language production allowed for a dynamic and interdisciplinary learning process.

2.5 *Data Collection*

Various data collection tools were also used to evaluate the effectiveness of the intervention which is based on the use of ESP:

- **Pre- and post-intervention surveys** which will focus on assessing the self-perceptions of students when it comes to using vocabulary, having self-confidence when it comes to English speaking as well as doing and receiving documentation and communication in tech-related situations.
- **Rubric-based evaluation of students' technical reports**, assessing:
  - Appropriateness and accuracy of ESP vocabulary
  - Grammatical and syntactic correctness
  - Logical flow and clarity of explanations
  - Integration of code and language elements

- **Focus group interviews** conducted with selected students at the end of the program, which explored learners' experiences, linguistic development, collaboration dynamics, and perceptions of the role of English as a global technical language.

2.6 Data Analysis

Data analysis employed a descriptive and interpretative approach to synthesize findings from multiple sources:

- The analysis of the received responses to the surveys was done to reveal how many students paid more attention to self-reported use of vocabulary and proficiency in English, prior to the intervention and after the intervention.
- Technical reports have been evaluated on the basis of the criteria applied by rubric to determine the gained accuracy of ESP vocabulary, grammatical accuracy, threat, and association of programming knowledge to the language.
- The thematic analysis of the qualitative data obtained in focus group interviews was used to define patterns and revelations on how linguistic development, collaborative learning, and English-Specific Purpose attitudes in programming are perceived.
- Gender-disaggregated analysis was carried out to discuss the participation-confidence-collaborative roles differences to make the research relevant to Sustainable Development Goal 5 (Gender Equality).

This multi-faceted analytical framework allowed for a comprehensive understanding of the intervention's impact on both linguistic and technical competencies within the youth programming education context.

2.7 Ethical Considerations

This research adhered to the ethical standards for research involving human participants. Informed consent was obtained from all participants and their legal guardians prior to their involvement in the study. Anonymity and confidentiality of the responses were strictly maintained. The study was conducted in compliance with institutional ethical guidelines and was approved by the ethics committees at both MetroCode and University Metropolitan Tirana.

3. RESULTS

The following section conveys the results of the quasi-experimental mixed-methods research on the effectiveness of introducing English for Specific Purposes (ESP) into programming education in relation to 50 high school students who became the participants of the MetroCode project in Albania. Data were collected through pre- and post-intervention surveys, rubric-based evaluations of technical reports, structured classroom observations, oral presentations, and focus group interviews. Gender-disaggregated analysis was also conducted to explore differential effects.

3.1 Pre- and Post-Intervention Survey Results

A 10-item survey was created to check the self-perceived response of students on the use of English to perform programming activities and it was assessed before and after intervention through a survey. Items of the survey dealt with the use of vocabulary, oral, written communication and cooperation and the capability to explicate programming logic in the English language. Outcomes showed high and steady boost in all aspects.

In Table 1, average scores of the items in pre and after interventions are shown, accompanied by the percentage increase of positive changes. The data varied between 40.0% and 66.7%, which is a significant increase in linguistic and technical wealth *(University Metropolitan Tirana, 2025)*.

Graph 1 graphically represents these gains and shows high increases in students on the level of the ability to describe the concept of programming, collaboration by using the English language, and comments in coding by utilizing the right terminology *(University Metropolitan Tirana, 2025).*

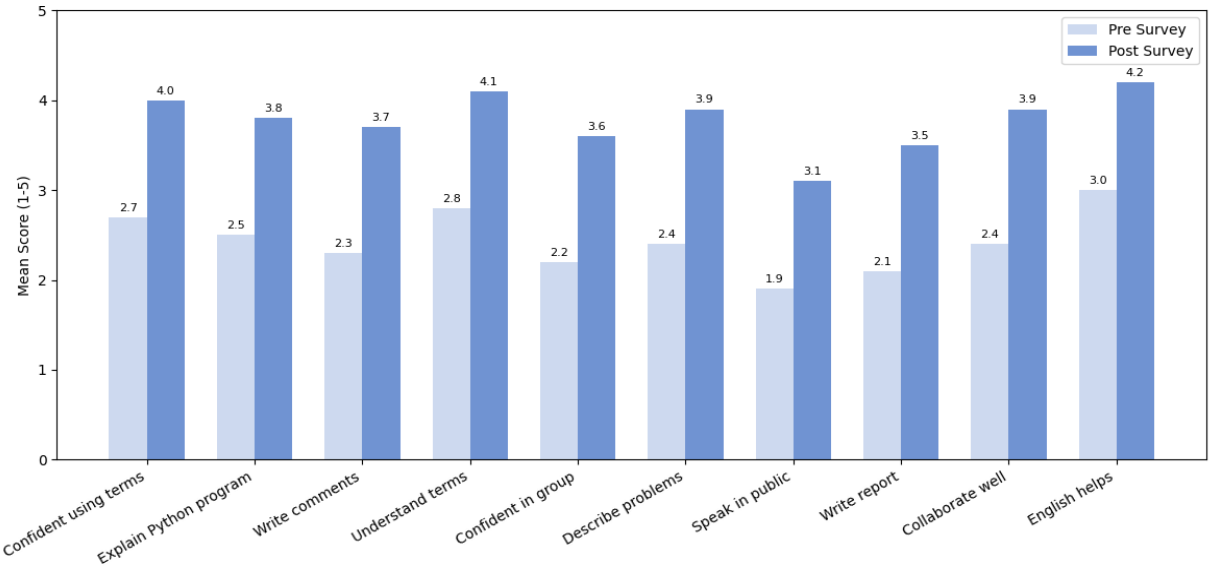


Table 1. Pre- and Post-Intervention Mean Scores (N = 50) *(University Metropolitan Tirana, 2025)*

Nr	Survey Item	Pre-Survey Mean	Post Survey Mean	Improvement Points	Improvement %
1	I feel confident using basic programming terms in English	2.7	4.0	1.3	48.1%
2	I can explain how a simple Python program works using English sentences	2.5	3.8	1.3	52.0%
3	I am comfortable writing English comments in my code to describe what it does	2.3	3.7	1.4	60.9%
4	I understand the meaning of programming-related words when they appear in English texts	2.8	4.1	1.3	46.4%
5	I feel confident working in a group where English is the main language of communication	2.2	3.6	1.4	63.6%
6	I can describe a programming problem and its solution using appropriate technical vocabulary	2.4	3.9	1.5	62.5%

7	I feel confident speaking in front of others when explaining programming logic in English	1.9	3.1	1.2	63.2%
8	I can write a short technical report in English about a coding project	2.1	3.5	1.4	66.7%
9	I am able to collaborate effectively with peers when coding and discussing in English	2.4	3.9	1.5	62.5%
10	I believe English helps me better understand and apply programming concepts	3.0	4.2	1.2	40.0%

Figure 1. Comparative Visualization of Pre- and Post-Intervention Survey Results *(University Metropolitan Tirana, 2025)*

These findings strongly support the effectiveness of ESP integration in enhancing students' perceived communicative competence in programming contexts.

3.2 Evaluation of Technical Reports Using Rubric

The students' technical reports, developed upon completion of the intervention, were evaluated through a rubric-based assessment aligned with the learning objectives described in the methodology. The evaluation was conducted independently by three qualified evaluators, and each criterion was scored on a 5-point scale. As shown in Table 2, the results reveal a consistent pattern of strong performance across all four dimensions of technical communication *(University Metropolitan Tirana, 2025)*.

Table 2. Rubric-Based Evaluation of Student Technical Reports *(N = 50; Scale: 1–5) (University Metropolitan Tirana, 2025)*

Assessment Dimension	Mean Score	Interpretation
Use of ESP Vocabulary	4.10	High
Grammatical and Syntactic Accuracy	4.00	High
Coherence and Logical Flow	4.20	Very High
Integration of Code and Explanatory Language	4.00	High

The highest mean score was observed in *Coherence and Logical Flow* (M = 4.20), indicating students' effective organization of ideas and clarity in presenting complex content. Similarly, the elevated scores in vocabulary use and syntactic accuracy suggest that the ESP-integrated curriculum facilitated the acquisition of precise language and the ability to express technical concepts appropriately. These findings underscore the intervention's success in strengthening students' written communication in programming contexts, particularly in terms of language accuracy, coherence, and code explanation.

3.3 Classroom Observations and Oral Presentations

Structured classroom observations during the six-week intervention period documented a consistent increase in student engagement and ESP vocabulary use, especially during collaborative debugging sessions.

Table 3. Student Engagement and Presentation Outcomes *(University Metropolitan Tirana, 2025)*

Indicator	Week 1	Week 6
Participation Rate (%)	68%	92%

Oral Presentation Success (%)	N/A	100%
Clear and Coherent Explanations (%)	N/A	86%

All students successfully completed mini-project presentations using domain-specific English terminology. Instructors noted that the combined emphasis on language and technical skills significantly contributed to students' confidence and communication effectiveness.

3.4 Qualitative Findings from Focus Group Interviews

To explore students' perceptions and experiences regarding the ESP-integrated programming curriculum, semi-structured focus group interviews were conducted with selected participants. Thematic analysis identified four key themes:

3.4.1 Linguistic Empowerment and Technical Expression

Students reported enhanced ability to clearly articulate programming concepts, debugging steps, and code logic in English, attributing this growth to the specialized ESP curriculum.
Illustrative Quote:
"Before, I found it hard to explain my code in English, but now I feel I can do it clearly and confidently." — Female participant, age 17.

3.4.2 Increased Confidence in Communication

Many students expressed increased self-confidence when using English for technical explanations, both in individual writing and oral presentations.
Illustrative Quote:
"I used to hesitate when speaking about programming in English, but now I am more relaxed and sure of my words." — Male participant, age 16.

3.4.3 Enhanced Collaborative Learning through English

The use of English as the medium for communication encouraged effective peer collaboration and mutual support during coding and debugging tasks.
Illustrative Quote:
"Working in groups with English as our language helped us learn from each other and solve problems faster." — Female participant, age 15.

3.4.4 Perceived Professional Relevance and Motivation

Students recognized the importance of ESP for future STEM education and careers, which increased their motivation to improve both their English and programming skills.
Illustrative Quote:
"Knowing that English is essential for my future career made me take the lessons seriously and try harder." — Male participant, age 18.

3.5 Gender-Based Role Distribution in Collaborative Coding Tasks

This paper focused on investigating the ways in which students at high school who took part in the MetroCode program shared roles in the process of collaborating in the last phase of Mini-Project, which takes two weeks. At this stage, students were put into small groups to create their Python and Manim projects, compose technical reports written in English, and perform oral presentations using the vocabulary of the domain taught in the course of the ESP-integrated course of study.

Based on systematic instructor observations, structured post-session reports, and focus group interviews, four primary roles were identified within team activities:

- **Group Leader:** Responsible for organizing workflow, coordinating team members, and managing task distribution.
- **Code Writer:** Focused on writing, debugging, and refining Python and Manim code.
- **Language Coordinator:** Tasked with drafting, reviewing, and improving English technical documentation, comments, and verbal explanations.
- **Presenter:** Delivered oral presentations, explaining project goals, logic, and outcomes to peers and instructors using the ESP-driven technical language.

Each student was assigned a dominant role reflecting their primary contribution during the collaborative process, determined by instructor notes and student self-assessments.

As shown in **Figure 2**, clear gender-based patterns emerged in role allocation. Among female students, the role of ***Language Coordinator*** was most prevalent (36%), followed by ***Presenter*** (28%), ***Code Writer*** (24%), and ***Group Leader*** (12%). Male students predominantly assumed the roles of ***Code Writer*** (36%) and ***Group Leader*** (28%), with fewer males acting as ***Presenter*** (20%) or ***Language Coordinator*** (16%) *(University Metropolitan Tirana, 2025)*. These distributions correlated with the two focuses of the ESP-integrated curriculum that are linguistics and technical abilities development. The female student results indicated a tendency toward communication-based activities, technical writing and oral presentation, indicating that the representation of the curriculum being taught by the targeted ESP instruction increased levels of confidence and competence in the English technical expression. On the contrary, male students were more often involved in coding and team coordination positions, which may be perceived as an inclination or a higher level of comfort toward programming and team management tasks.

Such a gendered role differentiation is an indicator of the success of the integrated ESP approach as it leveraged the equity through allowing the students to contribute in the place where they could use their inherent strengths both in language and programming areas that are constantly changing. In addition, the findings agree with the program ethos of Sustainable Development Goal 5 (Gender Equality) in that it has created a welcoming atmosphere in which diversified contributions are accepted, and their efforts are appreciated in the realm of STEM teaching and learning.

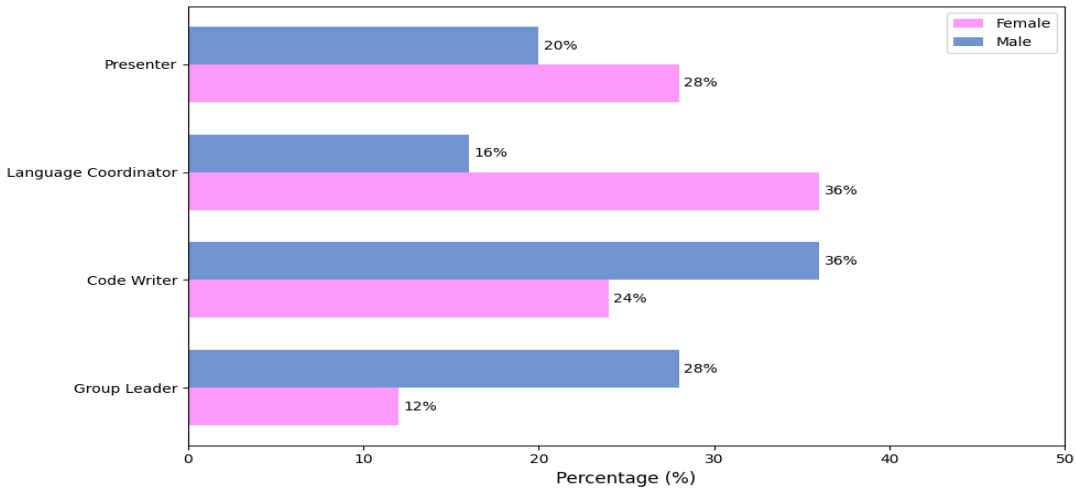


Figure 2. *Gender-Based Role Distribution in Collaborative Coding Tasks (University Metropolitan Tirana, 2025)*

4. DISCUSSION

Implementing English for Specific Purposes (ESP) into the MetroCode programming initiative demonstrates that the interdisciplinary teaching and learning may become a powerful tool of transformational change at the secondary education level. Instead of framing English separately, ESP imparts a form-focused sense of the language as a practical and empowering force of enabling an individual to perform technical tasks, e.g., debugging code, document and communicate about code, engage in collaboration around code. This is in direct agreement with evidence that in situations where language learning is contextualized within real world tasks, domain specific vocabulary and syntactic competence can thrive in settings of authentic programming (Robins et al., 2003).

This would reflect the principles of situated learning, which is to learn knowledge by participating actively in social and practical situations (Johns, 2001). The voluntary acclamation of the English in collaborative problem solving, as opposed to rote learning, aligns with the idea of experiential learning postulated by Dewey (1930), in light of which the application of educational principles in the actual life is held to be significant (Dewey, 1930). Such theoretical underpinnings support the studied advancements in both technical literacy and linguistic fluency choice primarily in those learners who had little or no exposure to either area.

Peer-to-peer collaboration became one of the pedagogical advantages as it enhanced not only the coding ability but communicative competence as well. Joint code evaluation and debugging sessions on the peer level provided mutual learning opportunities between the students as they not only used the chance to help each other to build logic but also to master language (Guzdial & Ericson, 2017). Such interactions fostered a sense of community and collective responsibility that are the main components of a successful interdisciplinary learning environment (Holzer et al., 2018).

Gender inclusivity emerged as a significant benefit of the ESP-integrated model. Gender inclusivity turned out to be one of the main advantages of the ESP-integrated model. Female students tended to be attracted to the language tasks which involved documentation of something, a presentation of a code logic or they took the lead in discussions and such places they also exhibited a greater sense of self efficacy and confidence (Margolis & Fisher, 2002). These tendencies corroborate the findings of the previous studies on the importance of context-sensitive pedagogy as a method of encouraging girls to educate in STEM fields (Rasmussen et al., 2023). The initiative also transformed the identity of the learners especially the marginalized or linguistically inferior groups, since they were no longer expected to use English as a means of memorizing, but saw their role as creators and collaborators in English (Rosser, 1995; Rushkoff, 2010).

The fact that the students could use the systems like GitHub and work with documentation and APIs and communicate in English emphasizes the efficiency of the program to develop the software skills and the skills to communicate by means of the digital communication. Such results equip the student to be more deeply involved in the global digital economies, in which the tools and fluency is a requirement (Jenkins & Ito, 2015; Corbett & Hill, 2015). In addition, the move towards active creation instead of passive learning implies a pedagogy that also follows the principles of participatory culture, which implies that students are a co-author of knowledge (Kafai, 2016).

On the level of curriculum, ESP is not only a scaffold of the language in question, but also an enabler of the inter-disciplinary collaboration. The teachers of languages can collaborate with teachers of stem to co-write the challenges that can be linguistically and technically demanding (Strevens, 1988; Swales, 1990). This will lessen cognitive load and will maximize inclusiveness especially in the situation where the students are confronted with two-fold problems in technology and language.

The wider societal impact of such an approach should not be understated. By aligning with Sustainable Development Goals such as SDG 4 (Quality Education), SDG 5 (Gender Equality), and SDG 8 (Decent

Work and Economic Growth), the MetroCode model demonstrates how educational innovation can contribute to social equity and economic opportunity (Sachs, 2015). Nevertheless, implementation challenges persist. The program's success hinges on teacher preparedness, institutional support, and sustained resources—all of which vary across educational contexts. The relatively small sample size and short timeframe also limit the generalizability of the results.

If scaled thoughtfully, the MetroCode model offers a promising blueprint for integrating language and coding education to foster linguistic empowerment, technical fluency, and digital inclusion.

5. CONCLUSION

This study provides compelling evidence that integrating English for Specific Purposes (ESP) into high school programming education substantially enhances students' linguistic and technical competencies. The MetroCode initiative demonstrated that ESP-driven curricula not only improve domain-specific vocabulary, syntactic accuracy, and communication confidence but also foster collaborative problem-solving and gender-inclusive participation. These gains empower students, especially minorities and female learners, to overcome traditional barriers in STEM education and engage meaningfully in digital innovation.

The results align closely with international educational and development priorities, notably the United Nations Sustainable Development Goals related to quality education, gender equality, and decent work. By treating English as a practical tool for debugging, documentation, and peer communication, the program supported students' linguistic self-confidence and global outlook, preparing them for future academic and professional challenges in an increasingly interconnected world.

Future research should explore longitudinal impacts of ESP integration on students' academic trajectories and career outcomes, as well as investigate its scalability across diverse educational contexts and age groups. Additionally, there is a critical need to develop and evaluate teacher training models that equip educators with interdisciplinary skills to implement ESP-infused programming curricula effectively.

Overall, this study highlights the transformative potential of bridging language and technical education, offering a replicable model to advance digital inclusion, equitable learning opportunities, and youth empowerment worldwide.

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DIGITAL TRANSFORMATION IN ACCOMMODATION STRUCTURES: STRATEGIES FOR INCREASING COMPETITIVENESS

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ABSTRACT

The rapid advancement of technology has brought profound changes to the hotel sector, with digital marketing ushering in a new era of challenges and opportunities. This transformation has redefined the ways hotels engage with customers, promote their services, and remain competitive in the market. Digital technology enables real-time communication with customers through social platforms and apps, providing opportunities for instant service. Hotels can now offer personalized deals using analytics data, increasing customer satisfaction and bookings.
Hotel visibility has improved thanks to SEO, social media marketing, and paid advertising, allowing them to reach wider audiences. Monitoring online reviews helps hotels manage their reputation and respond effectively to criticism. Automated reservation systems enhance operational efficiency, enabling hotels to focus more on customer service.
With the rise of platforms like Airbnb, hotels have been forced to adapt their strategies to keep up with competition by offering unique experiences and superior service. Thus, digital marketing has transformed the hospitality sector into a more engaged and connected environment for customers. The digital marketing methods used by accommodation facilities vary, but their main goal remains increasing visibility and attracting customers.

1. Introduction

The hospitality industry is one of the most dynamic and innovative sectors, which has undergone a fundamental transformation as a result of rapid technological development and the widespread use of the internet. In this new reality, modern customers no longer settle for quality service alone; they demand personalized experiences, instant information, and continuous interaction with the brand. This shift in consumer expectations has made digital marketing an essential element of every hotel's strategy, regardless of size or market positioning.
The use of digital tools—such as social media, search engine optimization (SEO), paid advertising, online booking systems, and customer relationship management (CRM) platforms—has given hotels new opportunities to build closer relationships with consumers, increase visibility, and differentiate their offerings in an increasingly competitive market. Furthermore, data analysis and personalized offers have become key factors in enhancing customer satisfaction and loyalty to the brand.
This paper aims to analyze in detail the role and impact of digital marketing on hotel business performance, evaluating how technology has changed the ways of communication with customers, promotional strategies, and guest experience management. In this context, the study will examine the challenges and opportunities brought by this transformation, as well as the importance of continuous adaptation to new trends to ensure success and sustainability in the global hospitality market.

2. Purpose

This paper aims to:

• Analyze the impact of digital marketing on the performance of hotel businesses, assessing how digital technologies have changed communication, promotion, and customer relationship management.
• Examine the effects of implementing digital strategies on customer experience, including personalization, interaction, and brand loyalty.
• Identify the challenges and opportunities hotels face in adopting digital marketing in an increasingly competitive market.
• Highlight the importance of adapting to new digital trends to maintain competitive advantage and increase long-term business sustainability.

3. Methodology

The study was conducted using the literature review method, based on scientific articles, industry reports, and case studies. Over 20 sources were analyzed to identify key trends, challenges, and benefits of implementing digital marketing in the hospitality sector. Additionally, comparisons were made between different approaches used by traditional hotels and those oriented toward innovation.

4. Analysis of Digital Marketing in Hospitality

The rapid development of technology and the internet has fundamentally transformed the hospitality sector, making digital marketing an essential element for business success. Modern customers demand instant access to information, easy booking processes, and personalized experiences. In this context, digital strategies have become key tools for attracting, engaging, and retaining customers.

Key Platforms and Channels:
• Social media (Facebook, Instagram, TikTok) for interaction, storytelling, and visual marketing.
• SEO to increase organic visibility.
• Google Ads and paid advertising for precise audience targeting.
• OTA platforms (Booking.com, Expedia, Airbnb) for wider reach but higher commission dependency.
• Email marketing and CRM systems for relationship building and personalized offers.

Advantages of Digital Marketing:

• Global reach and audience targeting.
• Lower cost compared to traditional marketing.
• Accurate performance measurement through analytics.
• Real-time strategy adjustment.
• Increased engagement and personalization.

Challenges:

• High online competition and increasing ad costs.
• Reputation management – negative reviews impact bookings.
• OTA dependency and loss of direct bookings.
• Need for continuous investment in tech and skilled staff.
• Data security and privacy compliance.

Trends:
• Content marketing (blogs, video storytelling).

• Influencer marketing.
• AI integration (chatbots, personalized recommendations).
• Mobile bookings and smart device optimization.

5. SWOT Analysis of Digital Marketing in Hospitality

Strengths - Global reach - Lower cost than traditional marketing - Accurate performance measurement - Personalized offers	Weaknesses - Dependence on OTAs (high commissions) - Continuous investment requirement - Complex online reputation management - Need for specialized staff
Opportunities - Use of new technologies (AI, VR) - Growth of online and mobile bookings - Partnerships with influencers - Expansion to international markets	Threats - Strong competition and alternative platforms (Airbnb) - Rapid social algorithm changes - Data security risks - Dependence on online reviews

6. Results and Discussion

Recent studies on the impact of digital marketing in the hospitality industry show significant results both in terms of financial performance and improvement of customer experience.

Increase in Direct Bookings:
Hotels investing in SEO, targeted ads, and social media campaigns have seen a 25-40% increase in direct bookings, reducing third-party commissions and increasing profitability.

Improved Customer Experience:
CRM and data analytics allow for personalized offers, tailored recommendations, and direct engagement, enhancing satisfaction and loyalty.

Social Media Engagement:
Interactive posts, videos, and influencer partnerships strengthen brand loyalty, foster emotional connections, and encourage repeat bookings.

7. Conclusions and Recommendations

Digital marketing is a critical factor for modern hotels' success. To maximize results:

• Invest in SEO and website optimization.
• Use social media for both advertising and relationship-building.
• Implement analytics tools for performance monitoring.
• Utilize AI for personalized offers.
• Actively manage online reputation and integrate positive reviews.

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DIGITALIZATION AND SUSTAINABLE STORE OPERATIONS: A NEW ERA IN THE RETAIL SECTOR

DİJİTALLEŞME VE SÜRDÜRÜLEBILIR MAĞAZA OPERASYONLARI: PERAKENDE SEKTÖRÜNDE YENI DÖNEM

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ABSTRACT

This study aims to examine the influence of digitalization on sustainable store operations within the retail sector, emphasizing its strategic significance beyond mere technological advancement. The integration of digital technologies into business processes not only enhances customer experience but also plays a pivotal role in achieving environmental, economic, and operational sustainability objectives.

Key digital tools including artificial intelligence, data analytics, customer relationship management (CRM) systems, and automation technologies are increasingly employed to optimize diverse functions such as inventory control, energy efficiency, waste reduction, and consumer engagement. The study explores how these technologies contribute to the design and execution of sustainable business models that are both economically viable and socially responsible.

Through a conceptual and analytical approach, the research delineates the bidirectional relationship between digitalization and sustainability. It investigates how the adoption of digital strategies facilitates corporate efforts to meet regulatory standards, reduce carbon footprints, and strengthen stakeholder trust, while concurrently delivering competitive advantage in an increasingly dynamic retail environment.

The findings suggest that digitalization must be recognized not solely as an operational upgrade, but as a strategic imperative in the sustainable transformation of retail enterprises. The study emphasizes that achieving long-term sustainability requires a holistic integration of digital tools into core business strategies, encompassing technological investment, organizational adaptation, and a culture of innovation.

Ultimately, the research contributes to the growing body of literature at the intersection of retail digitalization and sustainability. It offers practical insights for industry stakeholders seeking to navigate the complexities of sustainable retailing, underscoring the critical need for data-driven, customer-centric, and ethically grounded approaches in building resilient and future-ready store operations.

Keywords: Digitalization, Sustainability, Retail Industry, Store Operations, Data Analytics

ÖZET

Bu çalışma, dijitalleşmenin perakende sektöründe sürdürülebilir mağaza operasyonları üzerindeki etkisini incelemeyi ve dijitalleşmenin salt teknolojik ilerlemenin ötesinde stratejik önemini vurgulamayı amaçlamaktadır. Dijital teknolojilerin iş süreçlerine entegrasyonu yalnızca müşteri deneyimini iyileştirmekle kalmaz, aynı zamanda çevresel, ekonomik ve operasyonel sürdürülebilirlik hedeflerine ulaşmada da önemli bir rol oynar.

Yapay zekâ, veri analitiği, müşteri ilişkileri yönetimi (CRM) sistemleri ve otomasyon teknolojileri gibi temel dijital araçlar, envanter kontrolü, enerji verimliliği, atık azaltma ve tüketici katılımı gibi çeşitli işlevleri optimize etmek için giderek daha fazla kullanılmaktadır. Çalışma, bu teknolojilerin hem ekonomik açıdan uygulanabilir hem de sosyal açıdan sorumlu sürdürülebilir iş modellerinin tasarımına ve yürütülmesine nasıl katkıda bulunduğunu araştırmaktadır.

Araştırma, kavramsal ve analitik bir yaklaşımla, dijitalleşme ve sürdürülebilirlik arasındaki çift yönlü ilişkiyi ortaya koymaktadır. Dijital stratejilerin benimsenmesinin, şirketlerin düzenleyici standartları karşılama, karbon ayak izlerini azaltma ve paydaş güvenini güçlendirme çabalarını nasıl kolaylaştırdığını ve aynı zamanda giderek daha dinamik hale gelen bir perakende ortamında rekabet avantajı sağladığını incelemektedir.

Bulgular, dijitalleşmenin yalnızca operasyonel bir iyileştirme olarak değil, aynı zamanda perakende işletmelerinin sürdürülebilir dönüşümünde stratejik bir zorunluluk olarak kabul edilmesi gerektiğini göstermektedir. Çalışma, uzun vadeli sürdürülebilirliğin sağlanması için dijital araçların temel iş stratejilerine bütünsel bir şekilde entegre edilmesinin, teknolojik yatırım, kurumsal adaptasyon ve inovasyon kültürünü kapsayacak şekilde gerekli olduğunu vurgulamaktadır.

Sonuç olarak, araştırma, perakende dijitalleşmesi ve sürdürülebilirlik kesişimindeki giderek artan literatüre katkıda bulunmaktadır. Sürdürülebilir perakendeciliğin karmaşıklıklarını aşmak isteyen sektör paydaşlarına pratik bilgiler sunarak, dayanıklı ve geleceğe hazır mağaza operasyonları oluşturmada veri odaklı, müşteri odaklı ve etik temelli yaklaşımlara duyulan kritik ihtiyacın altını çizmektedir.

Anahtar Kelimeler: Dijitalleşme, Sürdürülebilirlik, Perakende Sektörü, Mağaza Operasyonları, Veri Analitiği

GİRİŞ

Dijitalleşme, özellikle perakende sektöründe iş yapış biçimlerini kökten değiştiren önemli bir fenomen olarak öne çıkmaktadır. Geleneksel yöntemlerin dijital teknolojilerle entegrasyonu, işletmelere verimlilik, müşteri deneyimi ve sürdürülebilirlik açısından yeni fırsatlar sunmaktadır. Perakendeciler, dijitalleşme sayesinde operasyonel süreçlerini optimize ederken, tüketici taleplerine hızlı yanıt verebilmektedir. Örneğin, Türkiye'de e-ticaret hacmi 2024'te %61,7 artarak 3 trilyon TL'yi aşmış ve perakende e-ticaret hacmi 1,6 trilyon TL'ye ulaşmıştır (Ticaret Bakanlığı, 2025).

Sürdürülebilirlik de perakende sektöründe giderek daha kritik hale gelmektedir. Tüketicilerin çevresel duyarlılıkları ve alışveriş alışkanlıklarındaki değişimler, işletmeleri ekolojik etkileri azaltacak yenilikçi yöntemler geliştirmeye yönlendirmektedir. Dijital teknolojiler, enerji verimliliği sağlayan sistemler, atık yönetimi yazılımları ve mobil uygulamalar aracılığıyla sürdürülebilirlik hedeflerinin gerçekleştirilmesini desteklemektedir (Marangoz, 2025).

Bu bağlamda, dijitalleşme yalnızca müşteri memnuniyetini artırmakla kalmayıp, çevresel sürdürülebilirlik ve rekabet avantajı elde etmede de kritik bir rol oynamaktadır. Dijital teknolojiler ve sürdürülebilir operasyonların entegrasyonu, perakende sektörünün temel dinamiklerini yeniden şekillendirmekte ve işletmelerin gelecekteki başarı potansiyelini artırmaktadır.

Dijitalleşmenin Tanımı

Dijitalleşme, bireylerin, işletmelerin ve toplumların bilgi akışını ve iletişim biçimlerini yeniden tanımlayan temel bir dönüşümdür. Teknolojinin entegrasyonunun ötesinde, organizasyonel yapılar, iş süreçleri ve hizmet sunum yöntemlerinde köklü değişiklikler gerektirir. Veri toplama ve analiz mekanizmaları, daha hızlı ve etkili karar almayı mümkün kılarken, süreç otomasyonu, müşteri deneyimini geliştirme ve kaynak kullanımını optimize etme fırsatları sunar. Bu sayede işletmeler,

rekabet avantajı elde eder ve pazar dinamiklerini şekillendirebilir. Dijitalleşme, yalnızca bir teknoloji değil, stratejik bir yaklaşım olarak benimsenmelidir (Üzmez & Büyükbeşe, 2021).

Dijitalleşme ve Perakende Sektörü

Dijitalleşme, perakende sektöründe rekabet gücünü artıran ve sürdürülebilirliği destekleyen temel bir dönüşüm olarak öne çıkmaktadır. Veri analitiği, yapay zekâ, IoT ve omnichannel stratejilerinin entegrasyonu, işletmelere müşteri taleplerine hızlı yanıt verme, operasyonel verimliliği artırma ve kişiselleştirilmiş alışveriş deneyimleri sunma imkânı sağlamaktadır (TÜSİAD, 2023). Mobil uygulamalar, tıkla-al ve mobil ödeme sistemleri gibi dijital hizmetler, tüketici bağlılığını artırmakta ve mağaza içi deneyimleri zenginleştirmektedir.

Araştırmalar, dijital pazarlama araçlarının, CRM sistemleri ve sosyal medya etkileşimiyle desteklendiğinde, marka sadakati ve müşteri memnuniyeti üzerinde olumlu etkiler yarattığını göstermektedir. Bu bağlamda, işletmelerin dijital dönüşüm stratejilerini sürekli güncelleyerek esnek ve yenilikçi yaklaşımlar benimsemeleri, rekabet avantajı elde etmeleri açısından kritik öneme sahiptir (Mert, 2024).

Dijital araçların entegrasyonu, perakende sektöründe rekabet avantajı elde etmek ve müşteri memnuniyetini artırmak için kritik bir unsurdur. Veri analitiği, CRM sistemleri, sosyal medya etkileşimleri ve e-ticaret platformları, işletmelere müşterilerin davranışlarını anlamak, satış tahminlerini geliştirmek ve hedef odaklı pazarlama stratejileri oluşturmak için kapsamlı fırsatlar sunmaktadır. CRM sistemleri, müşteri geri bildirimlerini toplama, segmentlere ayırma ve kişiselleştirilmiş hizmetler sağlama konusunda işletmelere avantaj sağlar; sosyal medya platformları ise marka-tüketici etkileşimini güçlendirerek müşteri bağlılığını artırır (Sarnıç & Özutku, 2025).

E-ticaret çözümleri, fiziksel mağaza sınırlarını aşarak daha geniş bir müşteri kitlesine ulaşmayı ve kullanıcı deneyimini zenginleştirmeyi mümkün kılar. Gelişmiş ödeme sistemleri, kullanıcı dostu arayüzler ve etkili lojistik yönetimi, alışveriş memnuniyetini artırırken, işletmelere yeni gelir kaynakları ve sürdürülebilir iş modelleri oluşturma imkanı sunar. Böylece dijital araçların stratejik kullanımı, perakende sektöründe rekabet avantajı ve sürdürülebilir büyüme için vazgeçilmez bir unsur haline gelmektedir.

Dijital araçların entegrasyonu, perakende sektöründe rekabet avantajı sağlamak ve müşteri memnuniyetini artırmak için kritik bir unsurdur. Veri analitiği, CRM sistemleri, sosyal medya etkileşimleri ve e-ticaret platformları, işletmelere müşteri davranışlarını analiz etme, envanter yönetimini iyileştirme ve hedef odaklı pazarlama stratejileri oluşturma imkânı sunmaktadır. CRM sistemleri, müşteri geri bildirimlerini toplama, segmentlere ayırma ve kişiselleştirilmiş hizmetler sağlama konularında işletmelere avantaj verirken, sosyal medya platformları markalar ile tüketiciler arasındaki etkileşimi güçlendirmektedir. E-ticaret çözümleri, fiziksel mağaza sınırlarını aşarak daha geniş bir müşteri tabanına ulaşmayı ve kullanıcı deneyimini zenginleştirmeyi mümkün kılar. Kullanıcı dostu arayüzler, gelişmiş ödeme sistemleri ve etkili lojistik yönetimi, müşteri memnuniyetini artırırken, işletmelere yeni gelir kaynakları ve sürdürülebilir iş modelleri oluşturma fırsatı sağlar. Dijital araçların stratejik kullanımı, perakende sektöründe sürdürülebilir büyüme ve rekabet avantajı elde etmek için vazgeçilmez bir unsurdur (Sarnıç & Özutku, 2025).

Sürdürülebilirlik Kavramı ve Perakende Sektörü

Sürdürülebilirlik, çevresel etkilerin azaltılmasının ötesinde, sosyal ve ekonomik boyutları da kapsayan çok yönlü bir kavramdır. Perakende sektöründe sürdürülebilirlik; enerji verimliliği, atık yönetimi, dijital sistemlerin entegrasyonu ve çevre dostu ürün ve ambalaj kullanımı gibi stratejik alanları içerir (AYD, 2024). Bu yaklaşım, hem doğal kaynakların korunmasına katkı sağlar hem de müşteri ilişkilerini

güçlendirerek marka sadakatini artırır. Dijitalleşme ile harmanlandığında, sürdürülebilirlik stratejileri, operasyonel verimliliği artırmak ve rekabet avantajı sağlamak için kritik bir araç hâline gelmektedir.

Sürdürülebilirlik, yalnızca mevcut kaynakların etkin kullanımını değil, gelecek nesillerin de bu kaynaklardan faydalanabilmesini garanti altına alacak stratejilerin geliştirilmesini öngörür. Bu bağlamda, işletmeler çevre dostu uygulamaları benimseyerek, ekonomik başarı ile sosyal ve çevresel sorumluluğu bir arada gerçekleştirebilirler. Küresel ölçekte sürdürülebilirlik, Birleşmiş Milletler'in Sürdürülebilir Kalkınma Hedefleri ile somutlaşmakta ve işletmelere uzun vadeli planlama, marka itibarı ve rekabet avantajı sağlama imkânı tanımaktadır. Perakende sektöründe sürdürülebilirlik, hem çevresel hem toplumsal katkılar sağlayarak, geleceğe yönelik yenilikçi ve sorumlu iş modelleri geliştirilmesine olanak tanır (Üzmez & Büyükbeşe, 2021; Mert, 2024).

Sürdürülebilirlik, günümüz perakende sektöründe çevresel, sosyal ve ekonomik boyutları bir arada ele alan stratejik bir gereklilik olarak öne çıkmaktadır. İşletmeler, enerji verimliliği, atık yönetimi, yenilenebilir enerji kullanımı, geri dönüşüm süreçleri ve sosyal adalet odaklı tedarik zinciri uygulamaları gibi önlemlerle hem çevresel etkilerini azaltmakta hem de maliyetlerini optimize etmektedir. Değişen tüketici talepleri doğrultusunda, çevre dostu ve sosyal sorumluluk sahibi ürünler sunmak, müşteri sadakatini artırmakta ve rekabet avantajı sağlamaktadır. Dijital dönüşümle entegre edilen sürdürülebilirlik stratejileri, operasyonel verimliliği yükseltirken, tüketici memnuniyetini ve pazar payını artırma noktasında kritik bir rol oynamaktadır. Bu bağlamda, sürdürülebilirlik, perakende sektöründe yalnızca etik bir sorumluluk değil, aynı zamanda ekonomik başarı ve uzun vadeli rekabet gücünü destekleyen temel bir unsur olarak değerlendirilmektedir (Üzmez & Büyükbeşe, 2021; AYD, 2024; Mert, 2024).

Dijitalleşme ve Sürdürülebilirlik İlişkisi

Dijitalleşme, perakende sektöründe sürdürülebilirlik hedeflerine ulaşmak için kritik bir araç olarak öne çıkmaktadır. IoT, mobil uygulamalar ve veri madenciliği gibi dijital çözümler, kaynak kullanımını optimize etmek, envanter yönetimini daha doğru yapmak ve enerji tüketimini azaltmak için etkin şekilde kullanılmaktadır. E-ticaret ve dijital pazarlama stratejileri, taşıma ihtiyacını ve fiziksel mağaza bağımlılığını azaltarak karbon ayak izini küçültmekte, aynı zamanda tüketici bağlılığı ve marka bilinirliğini artırmaktadır. Veri analitiği, müşteri etkileşimlerini ve geri bildirimleri analiz ederek ürün geliştirme ve sürdürülebilir stratejilerin oluşturulmasında önemli bir rol oynamaktadır. Bu sayede işletmeler hem ekonomik hem de çevresel açıdan güçlü temeller üzerine faaliyet göstermekte ve rekabet avantajı elde etmektedir. Dijital araçların etkin kullanımı, sürdürülebilir büyüme ve çevresel sorumluluk açısından vazgeçilmez bir unsur olarak değerlendirilmektedir (Gooinn, 2024; AYDIN, 2023).

Dijital Araçların Sürdürülebilirlik Üzerindeki Etkisi

Perakende sektöründe dijital araçlar, sürdürülebilir uygulamaların benimsenmesinde kritik bir rol oynamaktadır. Gelişmiş envanter yönetimi, veri analitiği ve akıllı sensörler, enerji ve atık yönetiminden tedarik zinciri optimizasyonuna kadar süreçlerin daha verimli ve çevre dostu yürütülmesini sağlamaktadır. Dijital pazarlama ve platformlar, tüketici davranışlarını anlamayı ve çevre dostu ürünleri önermeyi kolaylaştırırken, toplumsal sorumluluk projelerinin duyurulmasını da mümkün kılmaktadır. Veri yönetimi sistemleri, operasyonel verimliliği artırmakla kalmayıp, sürdürülebilirlik stratejilerinin oluşturulması ve uygulanmasında da temel bir araç olarak öne çıkmaktadır. Büyük veri analitiği ve yapay zekâ ile desteklenen veri sistemleri, gereksiz üretim ve stok oluşumunu önlerken, çevresel etkileri minimize ederek maliyet tasarrufu ve rekabet avantajı sağlamaktadır (Efe, 2024).

Perakende Sektöründe Dijitalleşme Stratejileri

Perakende sektöründe dijitalleşme, online satış kanalları, e-ticaret platformları, müşteri deneyimi ve yapay zeka temelli otomasyon uygulamaları ile rekabetçi bir dönüşüm sağlamaktadır. E-ticaretin

yükselişi, tüketicilerin alışveriş alışkanlıklarını değiştirerek işletmelere global pazarlara açılma ve geniş müşteri kitlesine ulaşma fırsatı sunarken, veri analitiği ve kişiselleştirilmiş dijital pazarlama stratejileri, müşteri memnuniyeti ve bağlılığını artırmaktadır. Omnichannel yaklaşımlar sayesinde fiziksel ve dijital alışveriş deneyimleri kesintisiz hale gelirken, makine öğrenimi ve yapay zekâ destekli sistemler stok yönetimi, talep tahmini ve müşteri hizmetlerini optimize etmektedir. Chatbotlar ve sanal asistanlar, 7/24 hizmet sunarak kullanıcı etkileşimini güçlendirirken, mobil ticaret ve dijital ödeme sistemleri güvenli ve erişilebilir alışveriş deneyimi sağlamaktadır. Tüm bu dijitalleşme stratejileri, işletmelerin operasyonel verimliliklerini artırmak, maliyetleri düşürmek ve sürdürülebilir büyüme ile rekabet avantajı elde etmelerini mümkün kılmaktadır (Efe, 2024).

Sürdürülebilir Mağaza Operasyonları

Perakende sektöründe sürdürülebilirlik, çevresel sorumluluk, ekonomik verimlilik ve sosyal adaletin bütünleştiği bir yaklaşım olarak öne çıkmaktadır. Enerji verimliliği, LED aydınlatma, akıllı iklimlendirme sistemleri ve enerji yönetim yazılımları ile sağlanırken, çalışan eğitimleri ve yenilenebilir enerji kaynaklarının entegrasyonu maliyetleri düşürmekte ve çevresel etkileri minimize etmektedir. Atık yönetimi, atıkların kaynağında ayrıştırılması, geri dönüşüm ve biyolojik olarak parçalanabilir ambalajların kullanımıyla hem çevresel hem de ekonomik kazanımlar sunmakta, tüketici ve toplumsal duyarlılığı artırmaktadır. Sürdürülebilir tedarik zinciri uygulamaları ise, yerel üreticilerin desteklenmesi, adil ticaret ve verimli malzeme kullanımı gibi stratejilerle çevresel ve sosyal sorumluluğu pekiştirirken, dijitalleşme sayesinde veri analitiği ve yapay zekâ kullanımı ile operasyonel optimizasyon sağlamaktadır. Tüm bu stratejiler, perakende işletmelerinin hem rekabet avantajı elde etmesine hem de sürdürülebilir ve sorumlu bir iş modeli oluşturarak uzun vadeli başarıya ulaşmasına olanak tanımaktadır (Alaca, 2025).

Dijitalleşmenin Getirdiği Yenilikler

Perakende sektöründe dijital dönüşüm, akıllı mağaza uygulamaları ve mobil teknolojiler aracılığıyla müşteri deneyimini iyileştirme, operasyonel verimliliği artırma ve sürdürülebilir mağaza operasyonlarını destekleme yönünde köklü değişiklikler yaratmaktadır. Akıllı raflar, sensörlü envanter takibi, yapay zekâ destekli analizler ve IoT tabanlı sistemler, stok yönetimi ve ürün yerleşiminde esneklik sağlarken, müşteri memnuniyetini ve sadakatini artırmaktadır. Mobil uygulamalar ise özelleştirilmiş içerik, sadakat programları, anlık bildirimler ve sosyal medya entegrasyonu ile kullanıcı etkileşimini güçlendirmekte, veri toplama süreçlerini kolaylaştırmakta ve stratejik karar alma süreçlerine katkıda bulunmaktadır. Bu dijital yenilikler, enerji ve kaynak kullanımının optimize edilmesine olanak tanıyarak sürdürülebilirlik hedeflerine de hizmet etmektedir (TÜSİAD, 2023; Öztürk, 2025).

Dijitalleşme ve Sürdürülebilirlik Uygulamaları

Perakende sektöründe dijitalleşme, sürdürülebilirlik hedefleri ile bütünleştiğinde hem operasyonel verimlilik hem de müşteri deneyimi açısından önemli kazanımlar sağlamaktadır. Akıllı veri yönetim sistemleri ve IoT tabanlı uygulamalar, tedarik zincirlerini optimize ederek israfı azaltmakta ve kaynak kullanımını minimize etmektedir. Örneğin, Ikea enerji verimli aydınlatma ve dijital ekranlar ile çevresel etkilerini düşürürken tüketici bilincini artırmakta, Amazon ise ambalaj atıklarını azaltan "Frustration-Free Packaging" uygulaması ile çevre dostu stratejiler geliştirmektedir. Mobil uygulamalar ve dijital platformlar, tüketici etkileşimini güçlendirerek sürdürülebilir ürünlerin pazarlamasına katkı sağlamaktadır. Tesla örneğinde görüldüğü gibi, dijital platformlar aracılığıyla kullanıcılar çevresel etkiler hakkında bilgilendirilmektedir. Küresel ölçekte, İskandinav ülkeleri enerji verimliliği yüksek mağaza tasarımları ve şeffaf dijital hizmetler sunarken, Kuzey Amerika'daki perakendeciler veri analitiği ile envanter ve talep yönetimini optimize ederek atıkları azaltmaktadır. Asya-Pasifik bölgesinde ise yeşil lojistik uygulamaları ve dağıtım optimizasyonları dijitalleşme ile çevresel sürdürülebilirliği

desteklemektedir. Dijitalleşme ve sürdürülebilirlik, perakende sektöründe birbirini tamamlayan, ekonomik, çevresel ve sosyal faydalar sağlayan stratejik araçlar olarak öne çıkmaktadır (Otsay, 2025; Alaca, 2025; Aydın, 2023).

Dijitalleşme ve Sürdürülebilirlikte Karşılaşılan Zorluklar

Perakende sektöründe dijitalleşme ve sürdürülebilirlik uygulamaları önemli fırsatlar sunarken, çeşitli engeller ve zorluklarla da karşılaşılmaktadır. Dijital dönüşüm sürecinde en yaygın zorluklar arasında iş süreçlerinin yeniden tasarlanması ve çalışanların dijital becerilerinin geliştirilmesi yer almaktadır. Küçük ve orta ölçekli işletmeler, sınırlı bütçe ve teknolojik altyapı eksiklikleri nedeniyle dijitalleşmeyi etkin bir şekilde yönetmekte güçlük çekmekte, değişime direnç ve vizyon eksikliği de süreci yavaşlatmaktadır. Ayrıca, müşteri verilerinin güvenliği, siber tehditler ve veri ihlalleri, dijitalleşmenin risk unsurları olarak öne çıkmaktadır (Öztürk, 2025).

Sürdürülebilirlik bağlamında ise yüksek yatırım maliyetleri, uzun geri dönüş süreleri ve tedarik zinciri yönetiminde maliyet-etkinlik dengesinin sağlanamaması önemli engeller olarak görülmektedir. Tüketici davranışları, özellikle düşük maliyet ve kolay erişim önceliklerinin sürdürülebilir ürünlerin benimsenmesini sınırlaması açısından kritik bir faktördür. Ayrıca, kurumsal kültürdeki direnç ve geleneksel iş yaklaşımlarına bağlılık, sürdürülebilirlik hedeflerinin hayata geçirilmesini zorlaştırmaktadır. Bu engellerin aşılabilmesi için kapsamlı eğitim programları, yenilikçi stratejiler, maliyet etkin teknolojilerin entegrasyonu ve tüketici farkındalığının artırılması gerekmektedir (Karakurt, 2022).

Dijitalleşme ve Sürdürülebilirlikte Gelecek Perspektifleri

Perakende sektöründe dijitalleşme ve sürdürülebilirlik, geleceğin rekabetçi ortamında kritik iki unsur olarak öne çıkmaktadır. Dijital dönüşüm, büyük veri analitiği, yapay zeka, nesnelerin interneti (IoT) ve blok zinciri gibi ileri teknolojilerin etkin kullanımıyla müşteri deneyimlerini kişiselleştirmekte ve operasyonel verimliliği artırmaktadır. Özellikle veri analizi, tüketici davranışlarını öngörerek hedef odaklı pazarlama ve kişiselleştirilmiş hizmet sunma imkânı sağlamaktadır. Sanal ve artırılmış gerçeklik uygulamaları ile çok kanallı stratejiler, fiziksel ve dijital mecralar arasında sorunsuz bir entegrasyon sunarak müşteri bağlılığını güçlendirmektedir (Öztürk, 2025).

Sürdürülebilirlik perspektifinde, perakendeciler çevresel ve sosyal sorumluluklarını ön plana çıkararak hem marka değerlerini artırmakta hem de maliyet etkin çözümler geliştirmektedir. Çevre dostu malzemelerin kullanımı, geri dönüşüm programları ve döngüsel ekonomi uygulamaları, işletmelerin tüketici beklentilerine uyum sağlamasında belirleyici rol oynamaktadır. Ayrıca, sürdürülebilir tedarik zinciri yönetimi, yerel üretim, organik ürün kullanımı ve adil ticaret uygulamaları ile çevresel ve toplumsal etkileri minimize etmeye yardımcı olmaktadır (Aydın, 2023; Menteşe & Menteşe, 2023).

Dijitalleşme ve sürdürülebilirlik arasındaki entegrasyon, işletmelere yalnızca rekabet avantajı sağlamakla kalmayıp, kaynakların daha verimli kullanılmasına ve toplumsal farkındalığın artırılmasına da katkı sağlamaktadır. Bu bağlamda, perakende sektörünün geleceği, müşteri odaklı, yenilikçi ve çevresel sorumluluk bilincine sahip işletmeler tarafından şekillenecektir.

SONUÇ

Dijital dönüşüm, perakende sektöründe teknolojik yeniliklerin entegrasyonu aracılığıyla köklü değişimlere yol açarken, aynı zamanda sürdürülebilirlik hedeflerini gerçekleştirme konusunda da kritik bir rol üstlenmektedir. İşletmeler, dijital araçlar sayesinde müşteri davranışlarını derinlemesine analiz edebilmekte, kişiselleştirilmiş hizmetler sunabilmekte ve operasyonel süreçlerini daha etkin yönetebilmektedir. Büyük veri, yapay zeka, nesnelerin interneti (IoT) ve blok zinciri gibi ileri teknolojiler, bu dönüşümün temel motorlarını oluşturmakta ve perakendecilerin stratejik kararlarını daha bilinçli bir şekilde almalarına imkân sağlamaktadır.

Sürdürülebilirlik bağlamında, perakende işletmeleri yalnızca çevresel etkilerini azaltmayı değil, aynı zamanda ekonomik verimliliği ve sosyal sorumlulukları da göz önünde bulundurmayı hedeflemektedir. Çevre dostu malzeme kullanımı, geri dönüşüm programları, döngüsel ekonomi ilkeleri ve sürdürülebilir tedarik zinciri yönetimi, hem marka imajını güçlendirmekte hem de maliyetleri optimize etme fırsatı sunmaktadır. Bununla birlikte, dijitalleşme ve sürdürülebilirlik süreçlerinin entegrasyonu, çalışanların dijital becerilerinin artırılması, değişim yönetimi ve stratejik planlama gibi insan kaynakları boyutlarını da gerektirmektedir. Eğitim eksiklikleri, teknolojik altyapı yetersizlikleri ve organizasyonel direnç, bu sürecin önündeki başlıca engeller olarak ortaya çıkmaktadır.

Gelecek perspektifleri, dijitalleşme ve sürdürülebilirlik arasındaki sinerjinin giderek güçleneceğini göstermektedir. Çevrimiçi alışveriş platformları ve çok kanallı (omnichannel) stratejiler, müşteri deneyimini dönüştürürken, sanal ve artırılmış gerçeklik uygulamalarıyla alışveriş süreçleri daha interaktif hâle gelmektedir. Bu sayede, perakendeciler hem müşteri bağlılığını artırmakta hem de yeni nesil tüketicilere ulaşmaktadır. Aynı zamanda, dijital araçlar sayesinde çevresel etkiler ölçülebilmekte ve sürdürülebilir kararlar daha etkin bir şekilde alınabilmektedir.

Sonuç olarak, dijitalleşme ve sürdürülebilirlik, modern perakende sektöründe yalnızca rekabet avantajı sağlamakla kalmayıp, aynı zamanda toplumsal ve çevresel değer yaratmayı da mümkün kılmaktadır. İşletmeler, bu iki kavramı stratejik bir perspektifle entegre ederek, müşteri memnuniyetini artırabilir, operasyonel verimliliği yükseltebilir ve uzun vadeli başarılarını güvence altına alabilirler. Bu süreç, dijital ve sürdürülebilir odaklı yaklaşımların geleceğin perakende ekosisteminde kaçınılmaz olduğunu ve işletmelere hem ekonomik hem de sosyal fayda sağladığını ortaya koymaktadır.

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GENÇ BİREYLERDE ÖLÜM ANKSİYETESİ VE DEPRESYON ARASINDAKİ İLİŞKİ: DERLEME ÇALIŞMASI

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ABSTRACT

This study aims to evaluate the relationship between death anxiety and depression in young individuals within the framework of mainstream psychological theories. In the human life cycle, death is as natural as birth, growing up, aging, and dying. However, this existential reality is perceived and experienced differently depending on one's developmental stage. Becoming aware of death and confronting it on a cognitive level can trigger intense feelings of anxiety. In psychological literature, this reaction is defined as *death anxiety* and is found to be closely associated with depression, particularly in young individuals.

At the core of death anxiety lies an existential questioning of life's meaning. Faced with the uncontrollability of life, individuals may experience heightened anxiety, which can lead to a search for security through religious or philosophical beliefs, or denial and avoidance behaviors. Continuous exposure to death, loss, and trauma-related content on social media, mass losses during the COVID-19 pandemic, war, and economic instability further contributes to death awareness, thereby increasing anxiety levels.

An increase in death awareness may act as a catalyst for the emergence of depressive symptoms. Within the frameworks of psychodynamic and existential theories, death is conceptualized as a powerful phenomenon that gives life meaning while simultaneously triggering anxiety and defense mechanisms. In the literature, individuals' attitudes toward death have been categorized as denial, anger, bargaining, depression, and acceptance. When the search for meaning falls short, individuals' defenses against death-related thoughts become insufficient, increasing the risk of depression.

This study is a descriptive review based on an analysis of 13 national and international studies published in the last decade. The findings reveal that addressing death anxiety and depression together is critical for effective therapy and treatment processes. In this context, meaning-centered therapeutic approaches, such as Cognitive Behavioral Therapy (CBT), Existential Therapy, and Logotherapy, are beneficial. Additionally, preventive, psychoeducation-based programs that support young individuals' ability to confront death are suggested to be effective in increasing life satisfaction and psychological resilience.

Keywords: Death Anxiety, Anxiety, Depression, Young adulthood, Psychotherapy

ÖZET

Bu çalışma, genç bireylerde ölüm kaygısı ve depresyon arasındaki ilişkiyi ana akım psikolojik teoriler çerçevesinde değerlendirmeyi amaçlamaktadır. İnsan yaşam döngüsünde ölüm, doğum, büyüme, yaşlanma ve ölmek kadar doğaldır. Ancak bu varoluşsal gerçeklik, kişinin gelişim aşamasına bağlı olarak farklı algılanır ve deneyimlenir. Ölümün farkına varmak ve bilişsel düzeyde onunla yüzleşmek, yoğun kaygı duygularını tetikleyebilir. Psikoloji literatüründe bu tepki ölüm kaygısı olarak tanımlanmakta ve özellikle genç bireylerde depresyonla yakından ilişkili olduğu görülmektedir.

Ölüm kaygısının temelinde, yaşamın anlamına dair varoluşsal bir sorgulama yatar. Yaşamın kontrol edilemezliğiyle karşı karşıya kalan bireyler, artan kaygı yaşayabilir ve bu da dini veya felsefi inançlar aracılığıyla güvenlik arayışına veya inkâr ve kaçınma davranışlarına yol açabilir. Sosyal medyada ölüm, kayıp ve travma ile ilgili içeriklere sürekli maruz kalmak, COVID-19 salgını sırasında yaşanan kitlesel kayıplar, savaş ve ekonomik istikrarsızlık da ölüm farkındalığına katkıda bulunarak kaygı düzeylerini artırmaktadır.

Ölüm farkındalığındaki artış, depresif belirtilerin ortaya çıkmasında bir katalizör görevi görebilir. Psikodinamik ve varoluşçu kuramlar çerçevesinde ölüm, hayata anlam katan ve aynı zamanda kaygı ve savunma mekanizmalarını tetikleyen güçlü bir olgu olarak kavramsallaştırılmaktadır. Literatürde, bireylerin ölüme yönelik tutumları inkâr, öfke, pazarlık, depresyon ve kabullenme olarak kategorize edilmiştir. Anlam arayışı yetersiz kaldığında, bireylerin ölümle ilgili düşüncelere karşı savunmaları yetersiz kalmakta ve depresyon riski artmaktadır.

Bu çalışma, son on yılda yayınlanmış 13 ulusal ve uluslararası çalışmanın analizine dayanan betimsel bir derlemedir. Bulgular, ölüm kaygısı ve depresyonun birlikte ele alınmasının etkili terapi ve tedavi süreçleri için kritik öneme sahip olduğunu ortaya koymaktadır. Bu bağlamda, Bilişsel Davranışçı Terapi (BDT), Varoluşçu Terapi ve Logoterapi gibi anlam merkezli terapötik yaklaşımlar faydalıdır. Ayrıca, genç bireylerin ölümle yüzleşme becerilerini destekleyen önleyici, psikoeğitim temelli programların yaşam doyumu ve psikolojik dayanıklılığı artırmada etkili olduğu öne sürülmektedir.

Anahtar Kelimeler: Ölüm Kaygısı, Kaygı, Depresyon, Genç Yetişkinlik, Psikoterapi

GİRİŞ

Gençlik dönemi çoğu zaman canlılık, üretkenlik ve geleceğe yönelik hedeflerle özdeşleştirilse de, ölümle ilgili kaygılar bu yaş grubunda da göz ardı edilemeyecek düzeyde yaşanabilmektedir. Genç bireylerin ölüm anksiyetesini nasıl deneyimlediği, bu dönemin gelişimsel özellikleri, kimlik oluşumu ve belirsizliklere duyarlılık gibi pek çok faktörle ilişkilidir. Gelişimsel ve psikolojik belirleyicilerin yanı sıra, savaşlar, çevre ve iklim krizi, ekonomik zorluklar, pandemi, gibi çevresel etkilerin de gençlerin varoluşlarıyla ilgili bir sorgulamaya girmelerine neden olabileceği düşünülmektedir. Ölüm anksiyetesinin, alan yazındaki çalışmalara bakıldığında çok boyutlu bir kavram olduğu görülmektedir (Doğanay 20). Alan yazında kaygının farklı biçimleri ile depresyonun ilişkiselliği gösteren çok sayıda araştırmaya rastlanmaktadır (Kafes, 2021). Pandemi dönemi ve sonrası yapılan bazı çalışmalar, gençlerin ölümle ilgili düşüncelerinin arttığını ve bunun özellikle sağlık, gelecek planları ve belirsizlikle ilişkili olduğunu ortaya koymuştur. Dijital çağda sürekli olarak felaket haberlerine, savaşlara ve çevresel krizlere maruz kalan gençler, ölüme dair imgelerle daha sık karşılaşmakta ve bu durum anksiyete düzeylerini etkileyebilmektedir (Eisma & ark., 2021).

Çocukluk, bakım gereksinimi yüksek ve fiziksel olarak gelişimini tamamlamamış bireyleri kapsarken; yaşlılık, fiziksel gücün azaldığı ve üretime katkının düştüğü dönemi temsil eder. Çocukluk ve yaşlılık evreleri arasında yer alan yetişkinlik/gençlik dönemi ise, toplumsal enerjinin en yoğun üretildiği evre olarak tanımlanır (İnanır, 2005, s. 38-39). Yörükoğlu'na (2002, s. 375) göre gençlik, 12 ile 21 yaş aralığını kapsayan, bireyin ruhsal ve bedensel olarak hızlı bir değişim ve gelişim yaşadığı bir dönemdir. Ayrıca Batı literatüründe gençliğin "adolescence" yani büyüme dönemi olarak tanımlanması, gençliğin biyolojik yönünün önemini ortaya koyar.

Anksiyete, bireyin varlığını sürdürebilmesi ve olası bir tehdit karşısında gerekli önlemleri alarak harekete geçmesini sağlayan temel duygulardan biridir (Ohman, 2008). DSM-5'e göre anksiyete bozuklukları; ayrılık anksiyetesi, yaygın anksiyete bozukluğu, özgül fobi, seçici konuşmazlık, agorafobi, sosyal anksiyete bozukluğu, panik bozukluğu, bir madde veya ilacın neden olduğu anksiyete

bozukluğu, başka bir sağlık sorununa bağlı anksiyete bozukluğu, diğer tanımlanmış anksiyete bozukluğu ve tanımlanmamış anksiyete bozukluğu olarak sınıflandırılmaktadır (Pıçakçıefe, 2010). Davranışçı kurama göre, anksiyete, açlık ve cinsellik gibi biyolojik dürtülerin yanı sıra, bireyi motive eden ikincil bir dürtü olarak işlev görmektedir (Erdine, 2003). Bilişsel kurama göre, anksiyete doğrudan yaşanan olaylardan değil, bireylerin bu olaylara yönelik beklenti ve yorumlarından kaynaklanmaktadır (Beck & ark., 1988). Psikanalitik kurama göre, idden gelen haz dürtüleri, dış dünyanın gerçekleri ve süperegonun ahlaki değerleriyle çatıştığında ego tarafından engellenir. Eğer bu dürtü tamamen bastırılırsa bilinçdışına itilir; ancak yetersiz bir bastırma söz konusu olduğunda, birey bu dürtüyü tehdit olarak algılar ve anksiyete ortaya çıkar. Freud (1936), anksiyeteyi üç temel başlık altında açıklamıştır: Gerçeklik Anksiyetesi**,** Moral Anksiyete ve Nörotik Anksiyete. Varoluşçular, anksiyetenin insanın varoluşsal gerçekliğiyle doğrudan ilişkili olduğunu savunurlar. Birey, yok olabileceği, yaşamını kaybedebileceği veya hiçliğe sürüklenebileceği gerçeğiyle yüzleştiğinde, bunu varoluşsal bir tehdit olarak algılar ve anksiyete deneyimler (Öner, 2012). Biyolojik kurama göre, noradrenalin ve serotonin gibi kimyasalların düzeylerindeki değişimlerin anksiyete ile ilişkili olduğunu vurgulamaktadır. Yapılan araştırmalar anksiyetenin gelişiminde güçlü bir genetik bileşenin bulunduğunu göstermektedir (Aktaş, 2009). Ölüm kaygısı, doğumla birlikte var olan ve yaşam boyunca süren, tüm korkuların temelinde yer alır ve kişiliğin gelişiminde bir önemli rol oynar. Ölüm düşüncesinin aşırı, patolojik ve günlük işlevselliği bozacak derecede yoğun yaşanması, bireyin psikolojisini olumsuz etkileyip kaygı seviyesini artırabilir (Ayten, 2009).

Zygmunt Bauman (2000), tarih boyunca insanların ölüm ve onun kaçınılmazlığı karşısında büyük bir rahatsızlık duyduğuna vurgu yapmıştır. Ölüm anksiyetesi, limbik sistemle bağlantılı temel beyin mekanizmaları tarafından yönlendirilmektedir. Amigdala ve hipokampus gibi yapılar, ölümle ilişkili tehdit algılarının şekillenmesinde ve anksiyetenin ortaya çıkmasında önemli rol oynadığı düşünülmektedir. (Lehto & Stein, 2009). Jacques Choron (1964), ölüm anksiyetesini üç temel başlık altında ele almıştır: 1.Ölümden sonra ne olacağına dair korku: Ölüm sonrasının olası sonuçları hakkında duyulan kaygı. 2.Ölme sürecine dair korku: Ölüm anının acı verici olabileceği ve bedensel işlevlerin sona erme sürecine duyulan korku. 3.Yok olma korkusu: Varoluşun sona ermesi, benliğin tamamen ortadan kalkacağı düşüncesi. Klinik psikoloji perspektifinden bakıldığında, genç bireylerin ölüm anksiyetesini ifade etme biçimleri doğrudan "ölüm" sözcüğüyle olmayabilir. Bunun yerine uyku bozuklukları, yoğun gelecek kaygısı, anlamsızlık duyguları ya da panik atak benzeri belirtilerle ortaya çıkabilir. Terapi sürecinde bu kaygıların altında yatan varoluşsal sorgulamalar ve belirsizlikle başa çıkma güçlüğü ile çalışmak önemlidir (Doğanay, 2023).

Depresyon, depresif ruh hali, ilgi ve zevk kaybı, suçluluk hissi veya düşük öz değer, uyku ve iştah düzensizlikleri, enerji eksikliği ve odaklanma güçlüğü ile kendini gösteren yaygın bir psikolojik rahatsızlık olarak tanımlanır (Kumar & ark., 2012). Dünya Sağlık Örgütü'ne göre, depresyon küresel ölçekte engelliliğe en fazla katkı sağlayan ruhsal bozukluklardan biri olarak kabul edilmekte ve son yıllarda görülme sıklığının arttığı belirtilmektedir (WHO, 2023). Depresyonun ortaya çıkmasında genetik, biyolojik ve psikososyal faktörlerin iç içe geçmesi söz konusu olabilmektedir (Elif, 2003). Bireyin cinsiyeti, stresli yaşam koşulları, hayal kırıklıkları, aile içi işlev bozuklukları, yetersiz ebeveyn ilgisi, bağımlı veya obsesif kişilik özellikleri, erken yaşta yaşanan olumsuz deneyimler, güvensiz bağlanma stili, kronik fiziksel veya psikiyatrik hastalıklar, sosyal destek eksikliği gibi faktörler depresyona zemin hazırlayabilir ya da hastalığın bir sonucu olarak ortaya çıkabilir (Kimter, 2014). Depresyonun oluşumunda nörotransmitterlerin, özellikle dopamin, nöroadrenalin ve serotonin eksikliğinin depresyona yol açabileceği belirtilmiştir. Psikososyal etkenler, özellikle erken dönemlerde yaşanan travmatik olaylar, ilerleyen dönemlerde depresyonun ortaya çıkmasında etkili olduğu yönünde çalışmalar vardır. Ancak, her travmatik olayın mutlaka depresyona yol açacağına dair kesin bir kural bulunmamaktadır (Güleç, 2009).

Dünya Sağlık Örgütü'ne (WHO, 2023) göre, 15–29 yaş arasındaki bireylerde depresyon, ciddi işlev kaybına yol açan başlıca ruhsal sorunlardan biri olarak kabul edilmektedir. Alan yazındaki çalışmalara göre gençlerde depresyonun başlıca nedenleri 1. Biyolojik ve Nörolojik Faktörler Gençlik dönemi, beynin özellikle prefrontal korteks gibi duygusal düzenleme alanlarının gelişmeye devam ettiği bir dönemdir (Casey, Jones & Hare, 2008). Nörotransmitter sistemlerindeki (özellikle serotonin ve dopamin) dengesizlikler, depresyon gelişimini etkileyebilir. Ayrıca genetik yatkınlığın da önemli bir risk faktörü olduğu vurgulanmaktadır (Levinson, 1977). 2. Aile İlişkileri ve Erken Yaşantılar Aile içi çatışma, duygusal ihmâl, ebeveyn kaybı ya da istismara uğramış olmak gibi erken dönem yaşantılar, gençlerde depresif belirtiler gelişme riskini artırır. Türkiye'de yapılan bazı çalışmalar, özellikle ebeveyn tutumlarının (otoriter veya ilgisiz) gençlerin depresyon düzeyleriyle ilişkili olduğunu göstermektedir (Yıldız & Uluç, 2012).3. Akademik Baskı ve Gelecek Kaygısı Türkiye gibi sınav odaklı eğitim sistemlerinde gençler akademik başarı baskısını yoğun şekilde hissetmektedir. Bu baskı, yalnızca ders başarısını değil, aynı zamanda bireyin özsaygı ve yeterlilik algısını da olumsuz etkileyerek depresif duygu durumlara zemin hazırlayabilir (Özmen & ark., 2008). 4. Sosyal Medya ve Dijital Etkiler Son yıllarda yapılan araştırmalar, sosyal medya kullanımının gençlerin ruh sağlığı üzerinde önemli etkiler yarattığını ortaya koymuştur. Özellikle karşılaştırma, onay ihtiyacı ve dışlanmışlık hissi, depresyonla ilişkili risk faktörlerindendir (Twenge & ark., 2018). 5. Toplumsal ve Kültürel Baskılar Cinsiyet rolleri, ekonomik eşitsizlikler, geleceğe dair belirsizlikler ve sosyo-politik gerginlikler gibi makro düzeydeki faktörler de gençlerin duygu durumunu etkileyebilir.

Literatürde, ölüm kaygısı üzerine yapılan çalışmalarda depresyonun önemli bir değişken olduğu belirtilmektedir. Pek çok araştırmada, depresyon ile ölüm kaygısı arasındaki ilişki incelenmiştir. (Neimeyer ve ark. 2004, Abdel-Khalek 1997). Kimlik arayışı, hayatın anlamını sorgulama ve gelecek kaygısı gibi gelişimsel süreçlerin baskın olduğu bu evrede, ölümün anlamı genç birey açısından sarsıcı olabilmektedir (Tomer & Eliason, 2000). Iverach & arkadaşları (2014) tarafından yapılan kapsamlı bir meta-analiz çalışması, ölüm korkusunun depresyon başta olmak üzere birçok ruhsal bozuklukla pozitif yönde ilişkili olduğunu ortaya koymuştur. Özellikle ergenlik ve genç erişkinlik döneminde, ölümle ilgili kaygıların anlamlandırılamadığı durumlarda, bu duygular bireyin yaşamla bağını zayıflatabilir ve depresif semptomlara neden olabilir.

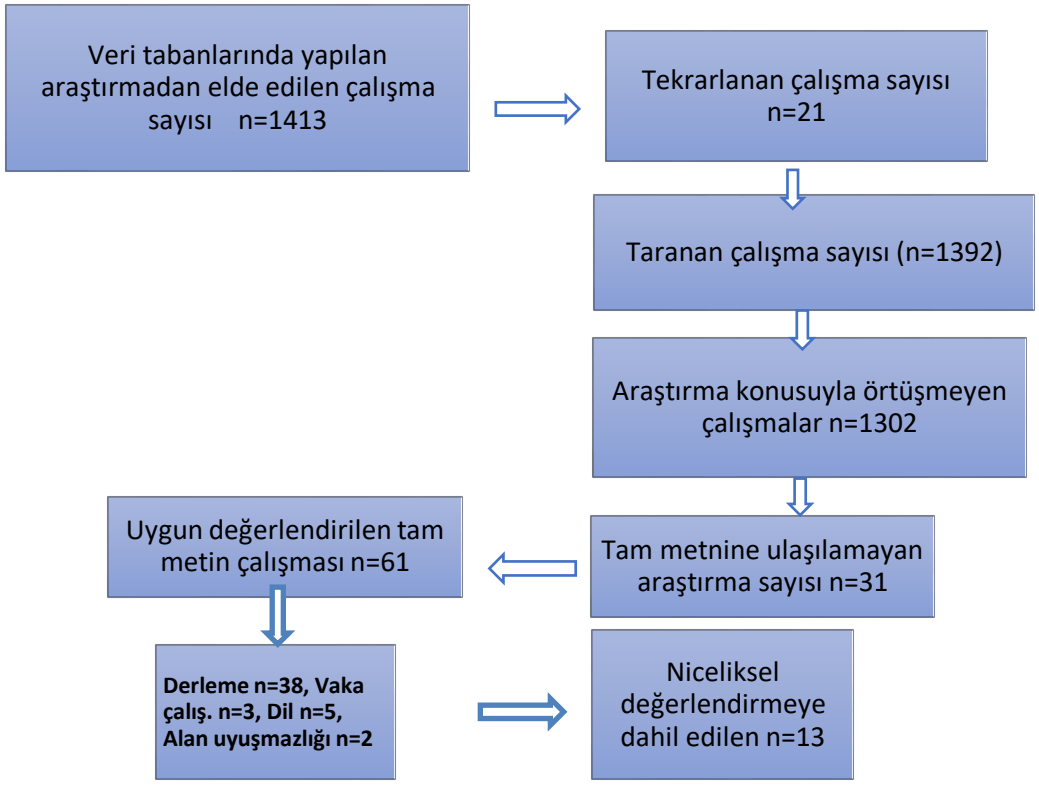
YÖNTEM

Çalışmanın hazırlanmasında, PubMed, Wiley Online Library, Science Direct, Dergi Park veri tabanlarında arama yapılmıştır. Bu bağlamda, "Ölüm Kaygısı", "Depresyon", "Genç Yetişkinlik", "Psikoterapi" anahtar kelimeleri kullanılarak 2015-2025 tarih aralığında ulusal ve uluslararası veri tabanları dahil etme ve dışlama kriterlerine göre araştırılmıştır.

Dahil etme kriterleri	**Dışlama Kriterleri**
• Yaş kriterlerine uyması. • Nicel çalışma olması. • Tam metne ulaşılması. • Alan uyuşması. • 2015-2025 tarih aralığına uyması. • Dil uyuşması.	• Yaş kriterlerine uymaması. • Nitel çalışmalar, vaka çalışmaları, derleme çalışmaları, kongre bildiri ve özetleri, kitap bölümü, poster sunumu olması. • Alan uyuşmazlığı. • 2015-2025 tarih aralığına uymaması. • Dil uyuşmazlığı.

Şekil 1. Dahil Etme – Dışlama Kriterleri Tablosu.

Toplam 1413 çalışma elde edilmiştir. Anahtar kelimeler taranarak bulunan çalışmalar içinden, PRISMA karar kriterleri doğrultusunda kanıta dayalı 13 tanesi, bu çalışmaya dahil edilmiştir.



Şekil 2. Veri Tabanından Eleme Akış Diyagramı.

BULGULAR

Tablo 1. 2010- 2015 yılları arasında gençlerle, depresyon, ölüm kaygısı ve diğer değişkenlerle yapılan çalışma bulguları.

Çalışma	Örneklem sayısı & Cinsiyet	Çalışma amacı	Çalışma deseni	Ölüm kaygısı	Ölçüm araçları	Sonuç
Karadeniz & ark. (2023)	322	Bu araştırma, Covid-19 pandemisinde hemşirelik öğrencilerinin Covid-19 korkusu, ölüm anksiyetesi ve psikolojik sağlamlık arasındaki ilişkiyi	Kesitsel	Meslek seçimi, Covid-19	Covid-19 Korkusu Ölçeği, Ölüm Kaygısı Ölçeği Kısa Psikolojik Sağlamlık Ölçeği	Ölüm Kaygısı Ölçeği ile Covid-19 Korkusu Ölçeği puanları arasında orta düzeyde pozitif korelasyon, Kısa Sağlamlık Ölçeği ile Covid-19 Korkusu Ölçeği toplam puanları arasında ise zayıf ve negatif korelasyon saptanmıştır.

		belirlemek amacıyla yapılmıştır.				
Eryılmaz & ark. (2023)	261	Üniversite öğrencilerinde kişilik özellikleri ile depresyon, stres ve anksiyete arasındaki ilişkileri incelemek amaçlanmaktadır	Kesitsel	Kişilik	Depresyon Ölçeği Anksiyete Ölçeği Stres Ölçeği Beş Faktör Kişilik Ölçeği	Öğrencilerinin depresyon, anksiyete ve stres düzeyleriyle nevrotizm düzeyleri arasında pozitif korelasyon bulunmuştur.
Jenkins & ark. (2023)	75 45 kadın 30 erkek	Farklı etnik kökenli gençlerde, yaş, cinsiyet, sosyokültürel yapı kriterlerine göre depresyon ve anksiyete düzeylerinin değerlendirilmesi.	Kesitsel	Etnik köken	Hasta Sağlık Anketi (PHQ 9) Yaygın Anksiyete Bozukluk Ölçeği (GAD 10)	Öğrencilerin okul ve toplumda yoğunlaşan ayrımcılık ve ırkçılık algılarına ilişkin kaygılarının yüksek olduğu bulunmuştur.
Gündoğan, & Arpacı (2022)	372 240 kadın 132 erkek	Covid-19 Korkusu, depresyon ve ölüm kaygısı arasındaki ilişkileri incelemeyi amaçlamıştır.	Kesitsel	Covid-19	Kovid 19 Korkusu Ölçeği DSM V Depresyon Ölçeği Abdel & Khalek Ölüm Anksiyetesi Ölçeği	Covid-19 korkusunun, ölüm anksiyetesi ve depresyonla yakın ilişkili olduğu bulunmuştur.
Riad & ark. (2022)	591 401 kadın 190 erkek	Rus-Ukrayna savaşını (RUW-22) takiben Çek Cumhuriyeti'ndeki üniversite öğrencileri arasında anksiyete ve depresif semptomları değerlendirmeyi amaçlamıştır.	Kesitsel	Savaş	Yaygın Anksiyete Bozukluğu Ölçeği(YAB-7) Hasta Sağlık Anketi 9 (PHQ-9).	RUW-22 haberleriyle, anksiyete ve depresyon arasında pozitif yüksek ilişkisellik bulunmuştur.
Eck & Bredbenner (2021)	1792	Anoreksiya Nervoza, Blumia, tıkınırcasına yeme bozukluklarının	Kesitsel	Yeme bozuklukları	Yaygın Anksiyete Bozukluğu Ölçeği(YAB-7) Yeme Bozukluğu	Yeme bozuklukları anksiyete ve depresyon arasında

		depresyon ve anksiyeteyle ilişkiselliğinin incelenmesi.			Muayene Anketi (EDE-Q) MD Değerlendiren Hasta Sağlık Ank. (PHQ-2)	pozitif ilişkisellik bulunmuştur.
Köksal & Topkaya (2021)	1372 974 kadın 398 erkek	Üniversite öğrencilerinin yaşadığı sorunlar ve bu sorunların depresyon, anksiyete ve stres ile ilişkisinin incelenmesi amaçlanmıştır.	Kesitsel	Sosyo-demografik özellikler	Depresyon Anksiyete Stres Ölçeği-42	Araştırma bulguları, sınav kaygısı, uyku sorunları, depresyon, yalnızlık, cinsel sorunlar, alkol ve madde kullanımının depresyon, anksiyete ve stres için yordayıcı olduğunu göstermiştir.
Çakar (2020)	239 103 kadın 136 erkek	Gençlerde yalnızlık ve yaşam anlamı değişkenlerinin ölüm kaygısını yordayıcılığının belirlenmesini hedeflemiştir.	Kesitsel	Yalnızlık	Abdel-Khalek Ölüm Kaygısı Ölçeği, Yaşamın Anlamı Ölçeği, UCLA Yalnızlık Ölçeği	Yalnızlık ve yaşam anlamının, ölüm kaygısı ile yalnızlık arasında pozitif ve anlamlı bir ilişki, ölüm kaygısı ile yaşam anlamı arasında negatif bir ilişki bulunmuştur.
Özcan & Ekşi (2020)	326 kadın 199 erkek 127	Üniversite öğrencileriyle yapılan çalışmada, hayatın anlamı ile öz-aşkınlık arasındaki ilişkide ölüm anksiyetesinin aracılık rolü araştırılmıştır.	Kesitsel	Öz aşkınlık	Yaşamın Anlamı Ölçeği, Ölüm Anksiyetesi Ölçeği Öz-aşkınlık Ölçeği	Öz-aşkınlık, yaşamın anlamı ve ölüm anksiyetesi arasında çoklu düzeyde anlamlı bir ilişki, ayrıca ölüm anksiyetesinin, yaşamın anlamı ile öz-aşkınlık ilişkisine aracılık rolü yaptığı bulunmuştur.
Menzies & ark. (2019)	200	Ölüm kaygısı ile psikopatoloji arasındaki ilişkiyi değerlendirmek.	Kesitsel	Psikopatoloji	Abdel & Khalek Ölüm Anksiyetesi Ölçeği SCL-90	Ölüm kaygısı ile 12 bozukluğun semptom şiddeti arasında da güçlü pozitif korelasyon bulunmuştur.
Tahabet & Abdall	216 87 erkek	Filistinli üniversite öğrencileri	Kesitsel	Savaş	Abdel & Khalek Ölüm Anksiyetesi Ölçeği	Ölüm obsesyonu puanları Gazzeli kız öğrencilerde daha

a (2018)	129 kadın	arasında ölüm kaygısı ve ölüm takıntısı arasındaki ilişkinin incelenmesi hedeflenmiştir.			Ölüm obsesyonu ölçeği	yüksek, bulunmuştur. Ölüm kaygısı ile ölüm takıntısı arasında pozitif bir ilişki elde edilmiştir.
Nienaber & Goedereis (2015)	241 lisans 149 lisansüstü 92	Lisans ve lisansüstü öğrencilerde eğitim düzeyi ile kendi ile başkaları için ölüm kaygısı düzeylerinin ölçülmesi hedeflenmiştir.	Kesitsel	Eğitim	Çok boyutlu ölüm kaygısı ölçeği Gözden geçirilmiş ölüm kaygısı ölçeği	Çalışmada lisans öğrencilerinin, lisans üstü öğrencilerine göre ölüm kaygısı daha yüksek bulunmuştur.
Chung, Cha, Cho (2015)	671	Güney Koreli üniversite öğrencilerinde öz saygı, Ölüm kaygısı ve Manevi iyi oluş arasındaki ilişkinin incelenmesi hedeflenmiştir.	Kesitsel	Manevi iyi oluş	Rosenberg öz saygı ölçeği Manevi iyi oluş ölçeği Abdel & Khalek Ölüm Anksiyetesi Ölçeği	Araştırmada öz saygıyla ölüm kaygısı arasında negatif, Öz saygıyla manevi iyi oluş arasında pozitif yönlü korelasyon bulunmuştur.

2010- 2015 yılları arasında yapılan 13 çalışma (n= 6671), genç bireylerde depresyon ve ölüm kaygısını çeşitli değişkenlerle ilişkilendirmiştir. Kesitsel çalışmalarda, ölüm kaygısının yordayıcıları arasında Covid-19 pandemisi, savaşlar, kişilik özellikleri, yeme bozuklukları, eğitim, psikopatolojiler, yalnızlık, etnik köken, sosyo-demografik özellikler, manevi iyi oluş ve öz-aşkınlık gibi çoklu faktörlerin rol oynadığı gözlemlenmektedir.

TARTIŞMA

Karadeniz ve arkadaşlarının (2023), yaptıkları çalışmada, hemşirelik öğrencilerinin Covid- 19 korkusu, ölüm kaygısı ile psikolojik sağlamlık değişkenlerine bakıldığında Ölüm Kaygısı Ölçeği ile Covid-19 Korkusu Ölçeği puanları arasında orta düzeyde pozitif korelasyon elde edilmiştir. .Gündoğan ve Arpacı da (2022) Covid-19 korkusu ile ölüm kaygısı ve depresyon değişkenleri arasında pozitif yönlü ilişkisellik bulgularına ulaşılmıştır. Tang ve arkadaşları (2017), ölüm kaygısının yordayıcılarını belirlemek amacıyla kanserli 219 katılımcıyı dahil ettikleri bir araştırma yapmışlardır. Bu çalışmanın sonucunda, artmış ölüm kaygısının en güçlü iki yordayıcısından birinin, yaşamdaki amaç duygusunun azalması olduğu ifade edilmiştir. Ölüm kaygısı, doğal ve normal bir deneyimdir ve yaşam boyunca küçük derecede ölüm kaygısına sahip olmak, bireyleri olumlu faaliyetlere yönlendirebilir. Ancak, anormal derecede yüksek ölüm kaygısı uyumsuzluğa yol açabilir. Bu tür bir kaygı, stresli koşulları yoğunlaştırır ve yaşamla ilgili bir boşluk hissi ile hayal kırıklığına neden olabilir (Sargent-Cox, 2014). Araştırmalar, ölüm kaygısının yaygın bir fenomen olduğunu göstermektedir. Agras ve diğerleri (1969), yaptığı bir çalışmada, insanların %16'sında ölüm kaygısı ve %3'ünde komorbid anksiyete olduğunu, ayrıca ölüm kaygısının kadınlarda erkeklere göre daha güçlü olduğunu bulmuşlardır. Tahabet & Abdalla

(2018), araştırmalarında Gazze'li kız öğrencilerin, erkeklere oranla 'Ölüm Obsesyon Ölçeği'nden aldıkları puanların daha yüksek olduğunu belirtmişlerdir. Öte yandan Köse ve diğerleri (2017), sağlık hizmetleri meslek yüksekokulu öğrencilerinin ölüm kaygısı düzeyini incelemişlerdir. Çalışmada, erkek öğrencilerin ölüm kaygısı düzeyinin kız öğrencilerden daha yüksek olduğu bildirilmiştir. Nienaber ve Goedereis (2015) lisans ile yüksek lisans öğrencilerinin ölüm kaygısı düzeylerini karşılaştırmışlardır. Araştırmada lisansüstü öğrencilerin ölüm kaygısı düzeyleri lisans öğrencilerine göre daha düşük çıkmıştır. Diğer bir çalışmada eğitim seviyesi düşük olan tüketicilerin, eğitim seviyesi yüksek olanlara kıyasla dışsal ölüm kaygısı, ölümün kabulü ve ölüme ilişkin düşünceler boyutlarında daha kaygılı olduğu anlaşılmıştır. Ölümün kaçınılmazlığı boyutunda ise eğitim seviyesinin bir farklılık yaratmadığı saptanmıştır (Kadıoğlu & İnce, 2021). Uysal ve arkadaşlarının (2016) üniversite öğrencileriyle gerçekleştirdiği çalışmada, ölüm anksiyetesi düzeyi yüksek bireylerin depresyon puanlarının da anlamlı düzeyde arttığı görülmüştür. Ayrıca sınav baskısı, ekonomik belirsizlik, gelecek kaygısı ve toplumsal cinsiyet normlarının da gençlerde ölüm düşüncesi ve depresyonu etkilediği belirtilmektedir (Küçük & Çınar, 2020). Chung ve arkadaşları (2015), öz saygıyla, ölüm kaygısı arasında negatif, öz saygıyla manevi iyi oluş arasında ise pozitif ilişki olduğuna dair bulgulara ulaşmışlardır. Özcan ve Aşkın (2020) ölüm kaygısı, öz-aşkınlık ve yaşamın anlamına ilişkin bir çalışma yapmışlardır. Çalışma bulguları ölüm anksiyetesinin, yaşamın anlamı ile öz-aşkınlık ilişkisine aracılık rolü yaptığını ortaya koymuştur. Depaola ve arkadaşları (2003), ölüm kaygısının cinsiyet, yaş ve dindarlıkla ilişkisi üzerine yaptıkları bir çalışmada, kadınların, yaşlıların ve daha az dindar olanların daha yüksek ölüm kaygısına sahip olduğunu ortaya koymuşlardır. Bu gruplar ayrıca, yaşam kısalığı, ölüme bağlı tam izolasyon, var olmama korkusu ve ölümden sonra bedenin parçalanması gibi ölümün farklı boyutları hakkında daha yüksek kaygı göstermektedirler.

SONUÇ

Bu çalışmada genç bireylerde ölüm anksiyetesi ve depresyon arasındaki ilişkiler çok boyutlu olarak ele alınmıştır. Ölüm anksiyetesi, bireyin kendi ölümlülüğüne dair farkındalığıyla ortaya çıkan bir kaygı biçimi olup, özellikle gelişimsel geçiş dönemlerinde (örneğin ergenlikten yetişkinliğe geçiş) daha yoğun hissedilebilmektedir (Tomer & Eliason, 2000). Gençlik döneminde varoluşsal farkındalığın artması, kişinin yaşam anlamına, amaçlarına ve geleceğine dair belirsizliklerle karşılaşmasına neden olabilir. Bu süreç, depresif duygulanımın gelişmesine zemin hazırlayabilir (Yalom, 1980; Neimeyer, 1994).Yapılan çalışmalar, ölüm anksiyetesinin depresyonla pozitif yönde ilişkili olduğunu ortaya koymaktadır. Iverach, Menzies ve Menzies (2014), farklı yaş gruplarında yaptıkları meta-analiz çalışmasında, ölüm korkusunun depresif belirtiler başta olmak üzere birçok psikopatolojik belirti ile güçlü düzeyde bağlantılı olduğunu göstermiştir. Bu ilişki, özellikle erken yetişkinlik döneminde, bireyin yaşamla kurduğu bağın zayıflamasıyla daha da belirgin hale gelmektedir. Türkiye örnekleminde yapılan araştırmalar da benzer sonuçlar vermektedir. Uysal, Satıcı ve Akın'ın (2016) üniversite öğrencileriyle yaptığı çalışmada, ölüm kaygısı ile depresyon arasında anlamlı ve pozitif bir ilişki bulunmuştur. Ayrıca Küçük ve Çınar (2020), Türkiye'de genç bireylerin yaşadığı ekonomik zorluklar, aile baskısı, sınav stresi ve işsizlik kaygısı gibi sosyal faktörlerin depresyonu artırdığını, bu faktörlerin aynı zamanda ölüm düşüncelerini de tetikleyebileceğini belirtmişlerdir.

Ölüm anksiyetesi ile depresyon arasındaki ilişkide, "anlam arayışı" kavramı da kilit rol oynamaktadır. Frankl (1984), bireyin yaşamında anlam bulamamasının "varoluşsal boşluk" hissine yol açabileceğini ve bunun da depresif belirtileri güçlendirebileceğini ifade etmiştir. Bu görüş, Yalom'un (2018) varoluşsal terapide ortaya koyduğu temel kaygılarla da örtüşmektedir. Özellikle "ölüm", "özgürlük", "yalnızlık" ve "anlamsızlık" gibi temel varoluşsal temaların gençlerde oluşturduğu baskı, psikopatoloji riskini artırmaktadır. Klinik açıdan bakıldığında, bu iki yapının birlikte değerlendirilmesi büyük önem taşır. Sadece depresyon semptomlarını hedef alan tedaviler, ölüm anksiyetesi gibi varoluşsal temelli kök sorunları göz ardı edebilir. Bilişsel Davranışçı Terapi (BDT), bireyin ölümle ilgili olumsuz bilişsel

çarpıtmalarını tanımlayıp yeniden yapılandırmasına yardımcı olabilirken; varoluşçu terapi bireyin yaşam anlamını sorgulamasını ve ölüm farkındalığını içselleştirmesini destekleyebilir (Vos & ark., 2015). Bu bağlamda, genç bireylerin yalnızca psikolojik belirtilerine değil, aynı zamanda onların varoluşsal sorgulamalarına da kulak verilmesi gerekmektedir. Klinik müdahalelerde anlam odaklı terapötik yaklaşımların logoterapi, varoluşçu terapi ve BDT gibi yapılandırılmış yöntemlerle bütünleştirilmesi, daha kapsamlı ve etkili sonuçlar doğurabilir. Ayrıca üniversiteler, gençlik merkezleri ve okullarda uygulanabilecek önleyici psikoeğitim programları, ölüm kaygısı ve depresyonun etkilerini azaltmada önemli rol oynayabilir.

Sonuç olarak, genç bireylerde ölüm anksiyetesi ve depresyon, yalnızca bireysel düzeyde değil, toplumsal ruh sağlığı açısından da önem arz eden konulardır. Bu iki olgunun birbirini besleyen yapısı göz önünde bulundurularak, bütüncül ve kültürel olarak duyarlı müdahale modellerinin geliştirilmesi gereklidir.

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THE IMPACT OF EARTHQUAKE ON GASTRONOMIC CULTURAL HERITAGE: A QUALITATIVE STUDY[3]

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ABSTRACT

This study focuses on the effects of the earthquake on intangible cultural heritage. The effects of the two major earthquakes that occurred in Türkiye on February 6, 2023 and resulted in the destruction of 11 provinces on gastronomic cultural heritage were analyzed in depth. The universe of the research consisted of food and beverage business owners operating in Hatay. Hatay is one of the important gastronomy destinations of Türkiye. It was also accepted to the UNESCO Creative Cities Network in the field of gastronomy in 2017. The qualitative research process was performed in the study. First of all, 20 people were interviewed. After the thematization and coding processes, it was seen that new information acquisition continued. Thus, the interview process was continued. After 26 interviews, it was determined that the repetition rate increased. For data saturation, 2 more people were interviewed and a total of 28 people were reached. After deciphering the data, coding was done through MAXQDA 2020. A total of 7 themes and 49 codes were obtained. The themes were named as "the effects of the earthquake on gastronomy (1)", "changing food habits and material crisis (2)", "religious and cultural interaction (3)", "the potential for gastronomy tourism (4)", "the protection of gastronomic heritage (5)" and "reconstruction and the future of gastronomy (6)". The results showed that negativities such as migration of masters, difficulties in supplying materials and economic contraction seriously threaten this unique culinary culture. Business owners and professionals who continue their work see the post-earthquake period as an opportunity for reconstruction and solution of structural problems that existed before the earthquake.

Keywords: Gastronomic Heritage, Intangible Cultural Heritage, Earthquake, Tourism

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EMOTIONS ACROSS THE ESSAY REVISITED

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ABSTRACT

In 2019, we published our paper "Emotions across the Essay: What Second-language Writers Feel across Four Weeks' Writing a Research Essay" where we investigated how the emotions of undergraduate freshmen changed as they were writing their essays. For the four weeks that coincided with the essay-writing process, we asked the students to reflect on their experience by responding to the following prompt: What was this class like for you this week, and why? Six years later, we are intrigued to explore how the advent of AI has changed said emotions and whether that question is still relevant when professors have become skeptical students are even writing their own essays. We explore three areas where AI affordances have changed the teaching of English for Academic Purposes (EAP). First, we consider impacts on students' positive and negative academic achievement, epistemic, social and topic emotions. Second, we consider areas of necessary changes in teachers' role in regulating student emotions in class. Finally, we reflect on areas of potentially new emotional impacts created by qualitative changes to the character of academic writing stemming from the use of AI.

Keywords: emotions, essay writing, AI

ENVIRONMENTAL INVESTMENTS AND INVESTOR BEHAVIOR: A DID ANALYSIS OF BIST SUSTAINABILITY INDEX FIRMS

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ABSTRACT

This study aims to examine the relationship between environmental investment activities undertaken by companies listed in the Borsa Istanbul Sustainability Index (BIST Sustainability Index) and investor decision-making behavior. In recent years, the growing global awareness of climate change, along with the increasing implementation of environmental regulations and sustainability policies, has encouraged companies to align their strategies with environmental sustainability goals. Investments in environmental projects are no longer viewed solely as a compliance requirement or a corporate social responsibility effort, but rather as strategic actions that can influence firm value and investor confidence. Within this framework, the amount of environmental investment by companies can play a dual role: first, by contributing to the reduction of the company's ecological footprint, and second, by signaling to investors that the company is committed to long-term sustainable practices. However, due to limitations in environmental data reporting, the study focuses on selected years in which reliable data were publicly disclosed. The data were collected from open-access sources and analyzed using a multi-period Difference-in-Differences (DID) model to identify causal relationships between environmental investment levels and investor reactions. The findings indicate a steady increase over time in the number of companies in Turkey that both engage in environmental investments and disclose these efforts publicly. Simultaneously, the number of limited assurance reports, which are designed to enhance the credibility of environmental disclosures, has also increased. These developments suggest a growing trend toward transparency and accountability in corporate sustainability reporting. The results demonstrate that transparent and credible environmental disclosures have a significant impact on investor decisions and help to highlight the financial as well as the environmental implications of corporate sustainability investments.

Keywords: Environmental investment, sustainability index, responsible investment

THE AESTHETICS OF SHARING: IDENTITY, MEMORY, AND PUBLICNESS IN ESRA ERSEN'S *ASHURE* PERFORMANCE

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ABSTRACT

This study examines the 1998 performance " Ashure " by Esra Ersen, one of Turkey's leading figures in contemporary art, which she performed in Weimar, Germany as a guest artist at ACC Gallery. The performance is analyzed within the framework of the concepts of identity, social memory, ritual, and publicness. Ashure, which is at the heart of the performance, historically presents a ritual practice that symbolizes abundance, sharing, solidarity, mourning, togetherness, and the potential of different elements (ingredients, taste, narrative, and memory) to form a harmonious whole within a multicultural Anatolian geography and the wider Islamic world.

The public and collective performance of ashure as a ritual revives elements of past memory while also engaging with current social identity debates. Ersen recontextualizes ashure, a traditional sharing practice, within the framework of contemporary art's relational esthetic approach, transforming the viewer from a passive position into an active participant subject. Within the scope of the performance, the cooking and sharing of ashure evolves into a relational moment of sociality where participants share their own narratives, family recipes, and cultural identities along with the ingredients.

This process not only makes visible the fluidity of cultural identities and the current interpretation of social memory but also creates a temporary and negotiable "micro-public sphere." The study is based on a qualitative research design; a literature review of the artist was conducted, taking into account the conceptual continuity established by Ersen's Bauhaus-influenced educational background and early projects; visual and textual documents related to the performance were examined using the content analysis method; and the literature on relational esthetics was interpreted as the theoretical framework. Performance, while revealing promising participatory potential on the one hand, also raises questions about the tension between representation, hospitality, and symbolic equality and real social transformation on the other. In this context, the "Ashura" performance stands out as an art practice that intersects local cultural codes with international contemporary art discourses, creating a critical and multi-layered space for dialog.

Keywords: Esra Ersen, Aşure, relational esthetics, social memory, identity, public sphere, ritual.

Introduction

Contemporary art not only opens up space for esthetic experiences but also provides a critical ground that allows for the questioning of social structures, cultural codes, and collective memory. Art practices developed within the framework of the "Relational Esthetics" approach, particularly as conceptualized by Nicolas Bourriaud, not only remove the viewer from a passive position and make them an active participant in the process but also allow for the discussion of social issues thru art. In this context, Esra Ersen's 1998 performance "Ashura," one of Turkey's prominent figures in contemporary art, reinterprets a traditional ritual within the framework of contemporary art's relational esthetics, opening up discussions on the concepts of identity, memory, and publicness. Ashure, which is at the heart of the

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performance, is not only a food with intense historical and cultural significance but also a ritual that symbolically makes visible the coexistence of different beliefs, ethnicities, and lifestyles. In this performance, the aşure prepared and shared in public space revives elements of past social memory while also contributing to current identity debates. In this context, social memory is not limited to simply recalling the past; it also functions as a space where social identities are renegotiated.

Ersen's performance of "Ashure" stands out for creating a temporary yet effective micro-public space where individual and social identities can coexist. In this direction, the study analyzes the performance in question by examining the conceptual continuity the artist establishes with their educational background and early works; it aims to make visible their critical potential both in the context of artistic production and at the social level, in light of the relational esthetics literature.

Methods

The study is based on a qualitative research design; a literature review of the artist was conducted, taking into account the conceptual continuity established by Ersen's Bauhaus-influenced educational background and early projects; visual and textual documents related to the performance were examined using the content analysis method; and the literature on relational esthetics was interpreted as the theoretical framework.

Esra Ersen and Art Practice

Born in Ankara in 1970 and currently living in Berlin, artist Esra Ersen stands out in the contemporary art world for her works that question esthetic and conceptual boundaries, are participatory, and aim to reconstruct social memory. Art education has been shaped on a foundation influenced by the Bauhaus' interdisciplinary approach, and this influence has been deeply reflected in its practice. During her studies at Marmara University's Department of Ceramics, her interest in ceramic and non-figurative sculpture forms not only provided her with esthetic and technical skills but also laid the groundwork for her to develop a content-focused intellectual approach. During this period, Ersen began to transform her art thru concepts such as boundaries, tension, and pressure, drawing particular inspiration from Şeyma Reisoğlu Nalça, known for her experimental production line in the department, and her emphasis on the relationship between content and form. By taking courses from different departments, the artist expanded their artistic perspective and explored the connections between art and philosophy. Kadri Özayten, who offered a different program to his students after the disruption caused by conceptual art, and Nermi Uygur, who focused on the relationship between art and philosophy, shaped the fundamental intellectual building blocks of Ersen's artistic practice (Kosova, 2011:12-13). In 1993, with the support of the Goethe Institute, German artist Ernst Hesse was invited to the faculty to conduct a workshop, where his sculpture-based pedagogical approach encouraged students to confront social reality and responsibility. Kadıköy Ayrılıkçeşme Street was chosen as the research area for Hesse's project titled "dialogue"; its historical texture and neighborhood culture allowed students to base their productions on context. During field research, direct contact was established with street residents, and the resulting works were exhibited directly on the street itself. Thus, the specificity of the space has become the fundamental element determining both the content of the works and the conditions of their presentation (Kosova, 2011:13-15).

Ersen, who participated in Hesse's workshop, developed a conceptual line that included the conditions of the encounter, drawing on his conversation with street residents, especially an elderly woman, during the project preparation process, and the production process gained a relational dimension. Ersen's installation consisted of two groups of chairs positioned opposite each other: on one side were wooden chairs borrowed from neighborhood residents, and on the other side were mass-produced, modernly designed black metal chairs, with a transparent glass panel placed between them (Kosova, 2011:13-15). According to Kosova (2011:14-15), wooden chairs evoke a sense of history and contemplation, while

modern chairs represent the fast-paced urban life and the dynamics of the metropolis. The glass panel, on the other hand, not only made the separation between two different understandings of time and spatial character visible but also allowed for potential interactions. This study has created a relational space that directly aligns with the concept of "dialogue," which is the project's title.



Figure 1. Esra Ersen, Dialogues I, 1993 Art in public spaces, Chairs, glass pane, metal legs, Ayrılıkçeşme Street, Kadıköy, Istanbul.

The contrasts that emerge in Ersen's installation—wooden chairs versus modern chairs, neighborhood culture versus metropolitan life, past versus present—place the viewer at the intersection of different social experiences. The central glass panel emphasizes both separation and the possibility for the parties to observe each other thru its transparency. Thus, the audience is not merely an observer, but becomes an active subject in the experiential space where social relations and encounters are produced. This experience played a defining role in Ersen's artistic approach; art was shaped not only as an esthetic production but as a practice that interacts with the social fabric, relates to daily life, and gains visibility in the public sphere. This process, informed by Marmara University's educational experience and Hesse's relational pedagogical approach, laid the foundation for Ersen's public interventions and participatory art practices, which he would develop in later years.
The installation he developed, particularly in the Ayrılıkçeşme Street project, can be considered a foundation that prepared the conceptual underpinnings of the artist's 1998 "Ashure" performance. The concept of "dialogue", which is central to this project, encompasses not only the interaction between the residents and the artist but also the reimagining of public space as a place for gathering and negotiation. This approach is an early indication of the public space-based production models and the relational esthetic dimension frequently found in Ersen's artistic practice. In this context, the theoretical framework of the concepts of public space and relational esthetics becomes important for evaluating Ersen's practice.

Public space is more than just a physical location; it is a dynamic and variable phenomenon that fosters social interaction, democratic participation, and the emergence of pluralistic ideas, and where processes of collective engagement are generated. However, the shaping of public space is not determined solely by a spatial boundary; it is shaped by various factors such as forms of governance, education, democracy, traditions, social discourses, and the level of societal development. Contemporary art practices utilize this public space, which is based on its liberating and participatory nature, and reorganize it thru esthetic relationships to produce new forms of publicness (Alp, 2016:102,104).

As defined by Bourriaud, relational esthetics emphasizes an approach where the relationships between the viewer, the artwork, and the artist are shaped on the basis of mutual coexistence. According to this understanding, space and the actions associated with it are reshaped; the audience moves from a passive position to an active participant, and art ceases to be a form field, transforming into a space of encounter and social interaction. Bourriaud (2005: 45-74) defines the social dimension of art as consistently positioning itself in the production of social relations, and speaks of the social relationships this art will create among audiences and its function based on socialization models. Relational art not only implies the viewer's relationship with the artwork but also encompasses interactions extending to common forms of relationships and social action among viewers (Alp, 2016:104).

Relational esthetics, "instead of building a common world based on the absolute singularity of form, rearranges the objects and images of the already given common world, creating situations that can lead to changes in our perspective and attitude toward the environment" (Ranciere, 2012: 25) (as cited in Alp, 2016:104).

This conceptual framework provides a solid foundation for evaluating Ersen's Ayrılıkçeşme Sokağı installation and the subsequent "Aşure" performance he developed, considering both their artistic and social dimensions. Both studies stand out as examples of relational esthetics in practice, making it possible to reinterpret public space and make social interaction processes visible by centering audience and community engagement.

Shaping her work within the framework of fundamental dynamics such as spatiality, relationality, and contextuality, Ersen's installation titled "Dialogues II" (1994), created for the 15th Contemporary Artists Exhibition, along with her personal exhibition "Dialogues III" at the Basilica Cistern in 1995 and her installation "Encounter" at the 4th Istanbul Biennial, offers a multi-layered perspective ranging from neighborhood texture to urban belonging and global movements. These productions, as relational esthetics highlights, position the artwork not only as a space of form but also as a ground where social relations and practices of encounter are produced. The audience, in these processes, moves from a passive position to become the active subject of space, context, and encounters; thus, art transforms into an experiential field that is integrated into the fabric of daily life and enables social interactions. This approach establishes a direct parallel between Bourriaud's understanding of relational esthetics and Ersen's practice, creating a foundation that pre-shapes the ground for social sharing and public interaction in the "Ashure" performance.

Ashure Performance

It is evident that Esra Ersen's site-specific, relational, and contextual art approach, which she developed from the mid-1990s onward, intersects with cultural developments in the international art scene. In the artist's production, the connection established between local social memory and global mobility is shaped thru interactions and social experiences taking place in the public sphere. During this period, Ersen, drawing on neighborhood fabric, urban belonging, and everyday life practices in his work in Turkey, began to create spaces for dialog between different communities while also taking advantage of the new interaction opportunities offered by cultural policies in Europe.

In the second half of the 1990s, there was an increase in the focus of European art institutions' cultural policies on geographies defined as "other" and artists from different socio-cultural backgrounds; in line with this, the number of guest artist and production programs for young artists increased. Esra Ersen also participated in various programs in Germany during this process; after Weimar, Münster, and Wiepersdorf, she was invited by curator Robert Fleck to join the program of the ACC Galerie in Nantes, which was based on Ferdinand Tönnies' concepts of Gemeinschaft (community) and Gesellschaft

(society). The artist, located in the birthplace of Goethe and Schiller and the city where the Bauhaus was founded, observed that despite the high cultural heritage, social arrangements were working in reverse (Kosova, 2011:44-45).

One of the points that caught Ersen's attention is the proximity of the artist's residences to institutions such as the psychiatric clinic, shelter, nursing home, and cemetery, which are located on the outskirts of the city. In Weimar, a city that represents the spirit of German culture and was once a European Capital of Culture, identified with figures like Goethe and Schiller, the exclusion of social groups considered obstacles to the speed of capital circulation and urbanization from the city center, such as the elderly, individuals undergoing spiritual treatment, the dead, and artists, created a critical observation area for the artist. Ersen, drawing inspiration from this heterotopic human gathering, cooked "aşure," a dessert believed to be made from the fruits and grains that remained on Noah's Ark, with its origins in Middle Eastern cuisine. Shared among neighbors, it symbolizes social solidarity. In the artist's performance, the bowls of ashure distributed free of charge at a public gathering served as a kind of "being together" and a vehicle for a temporary experience of publicness (https-1).



Figure 2. Esra Ersen, Ashure, 1998, Performance, food, table, chairs Developed for ACC Galerie, Weimar, Germany

Ersen performed "Ashure" at the festival organized annually by ACC Galerie in the city center. Ersen invited his artist neighbors to the festival and asked them to bring chairs with them. Thus, different types of chairs were placed side by side at the event venue, making the relationships between the differences visible. This performance by the artist established an interaction both among the invited people and with them, as well as with the majority of the city's population who didn't want to see them out in public very often (Kosova, 2011:47). Just like aşure. Different elements have come together to create a harmonious and rich whole.



Figure 3. Esra Ersen, Ashure, 1998 Performance, food, table, chairs, Developed for ACC Galerie, Weimar, Germany

In this respect, performance, as described in Nicolas Bourriaud's relational esthetics theory, has created a temporary social bond and a platform for dialog by making viewers active participants rather than mere observers. In this context, ashura, which is placed at the center of performance, stands out as both a common sharing practice and a tool that embodies the idea of unity within cultural diversity, despite being prepared with varying ingredients in different societies.

Ashure, a multi-layered cultural practice with roots in the Sumerians and shaped by Jewish tradition, is noteworthy as it retained its ritualistic nature in pre-Islamic Arab society. In Islamic historical sources, the acceptance of Prophet Adam's repentance, the deliverance of Prophet Moses and the Israelites from Pharaoh's oppression, the grounding of Prophet Noah's ark on Mount Judi, and the event of Karbala have become central symbols of mourning and lamentation in the Shia tradition. In Turkish culture, while preserving its religious references, it continues to exist as a functional tool in strengthening social solidarity, sharing, and social consciousness (Polat, 2019: 461-462).

Over time, ashure has become more than just a food, evolving into a social symbol and being passed down thru generations as an important element of social memory. The preparation of food, in addition to its formal dimension, also lays the groundwork for the formation of social memory; its transmission thru oral culture is reinforced by religious motifs and rituals (Yanık, 2023: 217).

In this context, the ritualistic nature of ashura comes to the forefront. While rituals allow individuals or groups to express their values thru symbolic and repetitive behaviors, they also strengthen group consciousness and solidarity and serve as a bridge between the past and the future (Karaman, 2010:229).

Participants in the ritual focus on each other thru shared objects, actions, and communication while being in the same space, and they share a common emotional state. This process fosters a sense of group solidarity and belonging among participants, while also generating feelings of trust, empowerment, and enjoyment thru emotional energy. The symbols and expressions used in the ritual not only strengthen collective unity but also contribute to the development of sacred bonds and moral feelings among group members (Collins, 2004:48-49)(as cited in Karaman, 2010:230). Therefore, rituals emerge as a functional tool in regulating, maintaining, and ensuring social order by contributing to the elevation of group consciousness in each participating individual. Rituals are practices that strengthen the bond between individuals in daily life and ensure the continuity of social relationships (Karaman, 2010:229-232).

At this point, the example of aşure can be evaluated within the context of Halbwachs' theory of collective memory. Individuals learn and internalize the meanings conveyed thru the preparation, sharing, and rituals of ashure not only from their personal experiences but also from the cultural and religious

practices of the social groups they belong to. This process makes it possible both to transmit social memory from generation to generation and to create social memories that strengthen individuals' sense of belonging.

According to Maurice Halbwachs, individuals shape, position in their memories, and recall their memories not only from personal experiences but also thru their membership in social groups—particularly thru kinship, religious, and class ties (Connerton, 1999:60).

Within this framework, the "Ashura" performance not only offers participants a meal but also creates an arena for encounter and interaction as described in Bourriaud's relational esthetics, bringing individuals together in a temporary yet effective sense of community thru a ritual that embodies social memory. The created space for encounters and interactions presents itself as a public area.

Arendt (1994: 69-258) emphasizes the distinctions between work, labor, and action in the model of the public sphere based on ancient Greece; while the private sphere is an area filled with inequalities where work and labor are necessary, the public sphere is defined as a political space where free individuals participate in equality and difference-based participation thru action. In this context, public space is seen as a utopian space where liberation thru action is possible and where there is no obligation to work and labor. Habermas (2012: 98-116), on the other hand, emphasizes that in 18th-century Europe, the public sphere of bourgeois society took shape around intellectual discussions held in salons in France and coffee houses in England, and that developments in the press and publishing had a significant impact on this process; according to him, the public sphere serves as a space for peer-to-peer idea generation and discussion, functioning as the fundamental tool of democracy (Alp, 2016:103).

However, with modernism, time and space were reorganized, and consequently, the structure and functions of the public sphere also underwent change. In modern capitalist society, making the public sphere function equally and without status for everyone seems impossible today due to ethnic, religious, sectarian, and different community structures. In post-modern processes, dynamics such as the separation of time from space, the influence of media and social networking sites, multi-centricity and the reorganization of center-periphery relations, and the weakening of neighborhood relationships are increasing individualization and social alienation, and limiting the liberating function of the public sphere. New liberal policies, on the other hand, highlight differences, narrow the public sphere, and encourage individuals to retreat into their private spaces (Alp, 2016:103).

Ersen's observations in Weimar reveal the exclusion of groups considered "dysfunctional" from the city center, in line with the principles of capitalist productivity, economic functionality, and bureaucratic rationality of the modern state (Kosova, 2011:45). Based on these observations, Ersen aimed to bridge both linguistic and social distances, and with her "Ashure" performance, she used public space as an environment where the liberating and creative acts of art could take place.

According to Rancière (2009: 23-24), the liberating power of art manifests itself in the blurring of the boundary between those who act and those who observe, between the individual and members of the social structure; space and time allow for the "here and now" redistribution of labor and leisure. This approach offers an alternative to some contemporary art forms that are competitive and inaccessible to audiences due to the influence of global capital (Alp, 2016:103). In Ersen's practice, this liberating function parallels the logic of the public sphere among equals; the fundamental emphasis is on the coexistence of similarity and equality. Thus, by leaving their specialized and autonomous field, the artist makes it possible to establish a direct relationship with the audience and the community.

Ersen, drawing on personal experience, brings the ritual and social functions of ashure into contemporary art practice. By sharing ashure with the community during the performance, it demonstrated that this dish is not merely a means of individual satisfaction, but also an element that

transforms social relationships, strengthens the sense of community, and reinforces memory. Ersen's approach concretely demonstrates how individual experiences can transform into a public practice and the role of participatory esthetics in strengthening social interactions (Kosova, 2005:45).

Thus, the meaning that ashure has gained within its historical and social framework becomes concretely visible thru the transformation of individual practices into social practices. The public space where the performance takes place – a park, square, or open street – is not only a physical location but also an ideological ground where public discourses, norms, and regimes of visibility are produced. The relocation of Ashura to this space can be read as a form of resistance against the normative understanding of public space. Beyond being a structure shaped by the majority's voice, public space transforms into a space for negotiation where minority voices, suppressed identities, and alternative historical narratives can also find a place. This transformation is not only about the physical use of space, but also about questions of who can speak within that space, what can be represented, and which memories can be shared.

With this performance, Ersen addresses the issue of visibility not only on a representational level but also as a material and sensory action, while simultaneously demonstrating that art can be a space for political and social intervention. The Ashura performance is an example of how Ersen's understanding of social dialog and participation is embodied in the public sphere, combining local and global contexts. The performance makes social memory and participatory esthetics visible by integrating a multicultural tradition into contemporary art practice. Ersen's work demonstrates how individual and social participation can come together thru food and ritual, while also revealing the power of art's social and public dimension.

Result

Esra Ersen's Aşure performance stands out as a powerful example that embodies the social function of contemporary art at the intersection of identity, memory, and publicness. Performance demonstrates that ashura is not just a food, but a ritual tool that embodies social memory, strengthens sharing and belonging, and shows that individual experiences can be reproduced in a social context. Participants become active subjects in a space where the public sphere is redefined, experiencing both the ritual dimension of food and engaging in social interaction. Social practices observed by Ersen in Weimar, such as the exclusion of certain social groups from public space in line with the capitalist and bureaucratic rationality of the modern state, are reversed in the Ashure performance; the artist aims to overcome both linguistic and social distances, transforming public space into a space for participatory interaction and social dialog. Performance, by transforming the physical and ideological dimensions of space, creates a micro-public sphere where not only the majority but also minority voices, suppressed identities, and alternative historical narratives can become visible. Thus, performance facilitates the strengthening of social belonging and shared experience by making both local social memory and cultural diversity visible. By transforming individual experience into public practice within a social context, the artist makes visible the potential of participatory esthetics to strengthen social interactions and reconstructs public space as both a place of sharing and a platform for the reproduction of social memory. Thus, performance goes beyond being merely an artistic activity and emerges as an exemplary form of social intervention and the production of collective experience.

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DEPOLITICIZED DEMOCRACY: ELECTORAL INVINCIBILITY AND THE EROSION OF ACCOUNTABILITY IN ALBANIA (2013–2025)

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ABSTRACT

This paper explores the phenomenon of depoliticization in Albania's political sphere, focusing on the period marked by the unbroken dominance of the ruling Socialist Party from 2013 to 2025. Drawing conceptually on Pierre Manent's reflections on modern democracy and political representation, the study argues that Albania exhibits a form of systemic depoliticization, wherein the mechanisms of political competition no longer produce real alternatives or accountability. The ruling party appears electorally invincible, transforming elections into ritualistic confirmations rather than genuine contests of power. Consequently, it bears little to no accountability to the electorate. Simultaneously, the opposition, chronically fragmented and electorally ineffective, also escapes democratic responsibility, as it is not perceived as a credible governing alternative. This mutual detachment from electoral accountability produces a hollowing out of the political field, where democratic forms persist but the substance of political contestation erodes. The paper situates this Albanian experience within broader concerns about the decline of political life in contemporary democracies, as theorized by Manent, and calls for a critical reassessment of institutional incentives that perpetuate this political stagnation.

Keywords: Albania, Depoliticization, Democratic accountability, Electoral dominance, Political opposition, Political representation, Party system stagnation

FRENKEL THERMOPOLAR EFFECTIN SOLID SOLUTION $In_{0.93}$ $Sm_{0.07}$ Se

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ABSTRACT

Modern development of electronics requires new advanced materials. In this regard, rare earth components are added to InSe single crystals. Rare earth elements in semiconductors have low solubility and cleaning ability, which is associated with a decrease in the concentration of uncontrolled impurities and an increase in the mobility of charge carriers. Replacing indium atoms with rare earth elements atoms in crystals increases the number of donor-type levels, which creates conditions for the formation of n-type conductivity. To measure electrical parameters, the samples were prepared in a sandwich variant, the external electric field was applied across the layers of the single crystal, i.e. along the C axis. For low-temperature studies, the samples were placed in a special cryostat with liquid nitrogen vapor. The temperature was measured with a chromel-copel thermocouple, the junction of which was on the surface of the sample. The temperature dependences of electrical conductivity and volt-ampere characteristics in the region of high electric fields in layered $In_{0.93}Sm_{0.07}Se$ single crystals were studied. The experimental data are in a good agreement with the Frenkel thermionic ionization theory. It was found that Ohm's law is satisfied in substances when the carrier concentration n and electron mobility μ do not depend on the field strength F. However, theory and experiment data show that in the region of high electric fields n and μ in materials depend on the electric field. The essence of this effect lies in the decrease in the activation energy of local levels by the electric field, which leads to an increase in the concentration of current carriers in semiconductors. Based on this theory, the Frenkel coefficients were determined at T=110 K, $\beta=5\cdot10^{-2}[cm/V]^{1/2}$, at T=200 K, $\beta=6.3\cdot10^{-2}[cm/V]^{1/2}$, at T=294 K, $\beta=5.9\cdot10^{-2}[cm/V]^{1/2}$; The concentrations of the traps are respectively equal to at T=110K $N_t=5.83\cdot10^{15}$ $cm^{-3,}$ at T=200K $N_t=6.18\cdot10^{14}$ cm^{-3} and at T=294K $N_t=2.4\cdot10^{14}$ cm^{-3}. The shapes of the potential wells of the electron traps are respectively equal to: at T=110K, $\varphi(x)=1\cdot10^{-2}$ eV, at T=200K, $\varphi(x)=2.56\cdot10^{-2}$ eV and at T=294K, $\varphi(x)=3.33\cdot10^{-2}$ eV. The mean free paths of the current carriers were, respectively: at T=110 K, $\lambda=4.74\cdot10^{-6}$ cm, at T=200K, $\lambda=1.1\cdot10^{-5}$ cm. and at T=294K, $\lambda=1.3\cdot10^{-5}$cm. It was found that strong compensation takes place in $In_{0.93}Sm_{0.07}Se$ single crystals.

Keywords: Frenkel thermal-field effect, trap concentrations, rare earth elements, potential wells, mean free paths

Introduction

InSe crystals belong to the layered crystals of the A^3B^6 group. Due to their unique properties, these crystals are suitable for creating solar cells [1,2], optical modulators [3,4], X-ray detectors [5], devices for radioactive measurements in nuclear reactors [6,7], pressure sensors [8].

According to [9], rare earth elements (REE) in semiconductors have low solubility and cleaning ability, which are associated with a decrease in the concentration of uncontrolled impurities and an increase in the mobility of charge carriers. Replacing indium atoms with REE atoms in crystals leads to an increase in the number of donor-type levels, which creates conditions for the formation of n-type conductivity.

Experiment and discussion of results

In InSe, the coordination number of In atoms is 4, and the coordination number of Se atoms is 3. Accordingly, 4-coordinated In atoms form a tetrahedral bond with 3-coordinated Se atoms. Some In atoms are hybridized with sp^3 based on s^2p electrons [7]. To study the electrophysical properties, it is necessary to obtain hemogenic samples of $In_{0.93}$ $Sm_{0.07}Se$. We used the direct synthesis method. To obtain these materials, we used elements with the following brands: In 000, Se B-3, Sm M-1. Chemical elements In, Se, Sm were crushed and immersed in quartz ampoules, which were evacuated to a pressure of 10^{-5} Pa. The speed of movement of the ampoule in the furnace was 0.3 cm/h. To measure the current-voltage characteristics, contacts to the samples were created with silver paste to the opposite surfaces (sandwich structures). The thickness of the studied single crystals was 200 μm, and the contact areas were equal to $2 \cdot 10^{-2} cm^{-2}$. For low-temperature studies, the samples were placed in a special cryostat operating in liquid nitrogen vapor. The temperature was measured with a chromel-copel thermocouple, the junction of which was on the surface of the sample. The temperature dependences of the current-voltage characteristic (CVC) in the region of strong electric fields in solid solutions $In_{0.93}Sm_{0.07}Se$ at different temperatures were determined (Fig.1). The Frenkel coefficients were determined at different temperatures and the dependences of the current density on voltage (Fig.2).

It is known that the Frenkel coefficient is determined by the formula $\sigma=\sigma_o \exp(\beta\sqrt{F})$

Where σ is the electrical conductivity, β - is the Frenkel coefficient.

These data are in good agreement with the theory of thermionic ionization of the Frenkel coefficient [10]. β is calculated using the following formula.

$$\beta = \frac{\sqrt{e^3}}{KT\sqrt{\pi\varepsilon_0\,\varepsilon}}, \qquad (1)$$

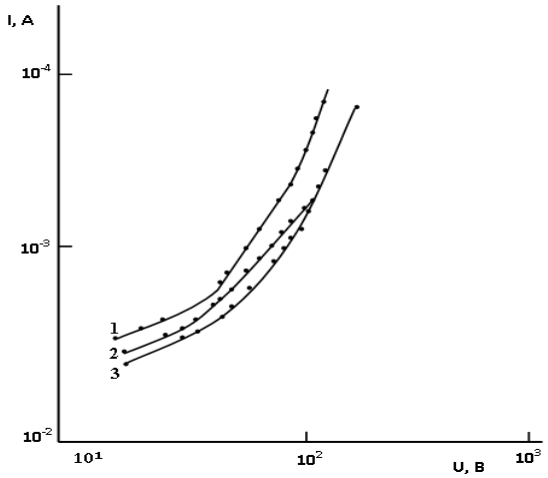


Fig. 1. I-V characteristics of $In_{0.93}Sm_{0.07}Se$ solid solutions at different temperatures. Curves 1, 2 and 3 are determined at temperatures T_1=294K, T_2= 200K, T_3 -100K.

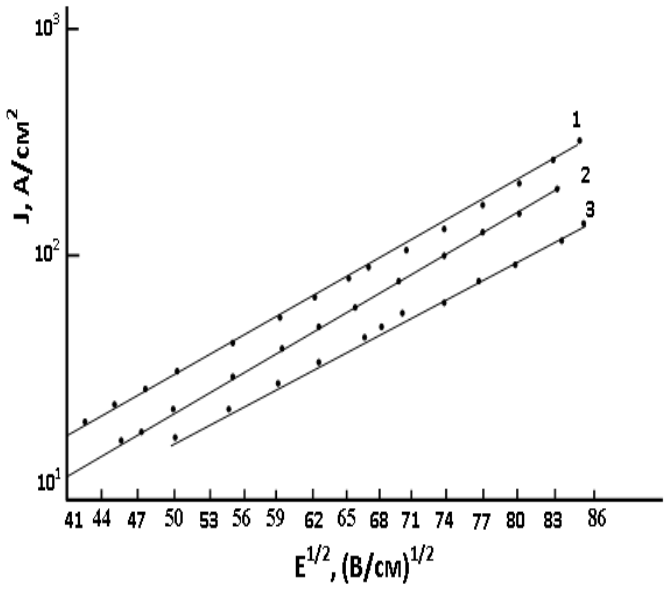


Fig. 2. Frenkel coefficients at different temperatures, T, K: 1-294, 2-200, 3-100.

where e is the electron charge, ε is the permittivity, ε_0 is the permittivity, k is the Boltzmann constant, and T is the absolute temperature. The agreement between these data and the Frenkel theory developed in [11] allows us to accurately estimate the trap concentration in $In_{0.93}Sm_{0.07}Se$ solid solutions. The following formula accurately determines the trap concentrations:

$$N_t=(\frac{2e}{KT\beta}\sqrt{F_{cr}})^3, \qquad (2)$$

Under the action of F_{cr}, Ohm's law is violated.

The trap concentrations for different temperatures are shown in the table.

To determine the shape of the potential well in solid solutions, we estimated the potential energy function (Fig. 3).

The estimates of potential wells for different temperatures are shown in the table.

Given the shape of the potential energy curve for interaction with a specific center, information can be obtained on the structure of the centers, the capture. From the work [12] it is shown that electrons leave the center, for the condition $E>E_0-\Delta U$. where E_0 is the depth of the level in which the electrons are localized, ΔU is the decrease in the potential barrier in the electric field. It is necessary that the electrons retain energy until the moment when it passes the saddle point and does not lose its thermal collisions. This takes place only in those cases when the mean free path of the electron is greater than the effective dimensions of the potential well. In this case, the mean free path of the current carriers is determined by the formula [12].

The mean free path of the electron λ in $In_{0.93}Sm_{0.07}Se$ single crystals is calculated from the experimental data. Which are shown in the table

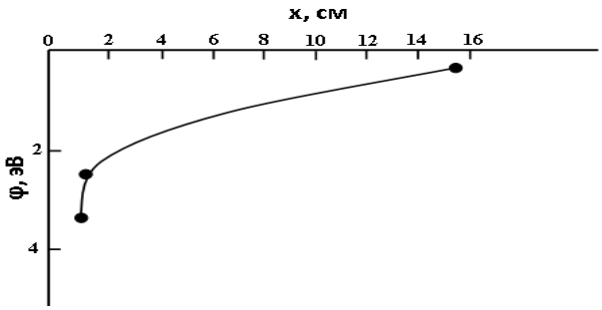


Fig. 3. Dependences of the potential well of electron benches on the distance of impurity states in the solid solution $In_{0.93}Sm_{0.07}Se$ at different temperatures T = (294, 200, 100)K.

Table

Some electrical parameters of $In_{0.93}Sm_{0.07}Se$ single crystals

T, K	β, (см/V)$^{1/2}$	N_t,см$^{-3}$	λ, см	φ, eV
100	$5\cdot10^{-2}$	$5{,}83\cdot10^{15}$	$4{,}74\cdot10^{-6}$	$1\cdot10^{-2}$
200	$6{,}3\cdot10^{-2}$	$6{,}18\cdot10^{14}$	$1{,}1\cdot10^{-5}$	$2{,}56\cdot10^{-2}$
294	$5{,}9\cdot10^{-2}$	$2{,}4\cdot10^{14}$	$1{,}3\cdot10^{-5}$	$3{,}33\cdot10^{-2}$

Conclusions:

It is shown that in $In_{0.93}Sm_{0.07}Se$ single crystals the I-V characteristics in the region of strong fields correspond to the fact that the current in the nonlinear region of the volt-ampere characteristic is caused by the Frenkel effect. The Frenkel coefficients are determined at temperatures T_1=294K, T_2=200K, T_3=100K.Accordingly, $\beta=5.9\cdot10^{-2}$[cm/V]$^{1/2}$, $\beta=6.3\cdot10^{-2}$[cm/V]$^{1/2}$, $\beta=5\cdot10^{-2}$[cm/V]$^{1/2}$, the trap concentrations at temperatures T_1=294K, T_2=200K, T_3=100K. Accordingly, $N_t=5.83\cdot10^{15}$cm^{-3}, $N_t=6.18\cdot10^{14}$cm^{-3}, $N_t=2.4\cdot10^{14}$cm^{-3}, the shapes of the potential well of the electron trap in the $In_{0.93}Sm_{0.07}Se$ solid solution at temperatures T_1=294K, T_2=200K, T_3=100K. Accordingly, φ (x)=$1\cdot10^{-2}$ eV, φ (x)=$2.56\cdot10^{-2}$ eV, φ (x)=$3.33\cdot10^{-2}$eV and the mean free paths of current carriers at temperatures T_1=294K, T_2=200K, T_3=100K. Accordingly, λ =$1.3\cdot10^{-5}$ cm, λ =$1.1\cdot10^{-5}$ cm, λ =$4.74\cdot10^{-6}$ cm.

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AN OVERVIEW OF REPAIRING ACHILLES TENDON RUPTURE

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ABSTRACT

Background: Achilles tendon rupture is a common and debilitating injury, particularly among athletes and active individuals. Achilles tendon rupture affects mobility and quality of life, making surgical repair preferred for younger, active patients. This review explores surgical techniques, rehabilitation protocols, and outcomes, emphasizing the importance of understanding these approaches for informed clinical decision-making.

Aim of Study: This study provides an in-depth review of Achilles tendon rupture repair techniques, graft augmentation strategies, and post-operative rehabilitation protocols, aiming to update clinicians on available options and their effectiveness. The summary provides clinicians with an updated understanding of available options and their effectiveness, including return to sport rates, complication rates, and patient-reported outcome measures.

Methodology: A literature search was conducted using electronic databases to review studies on Achilles tendon rupture repair, surgical techniques, rehabilitation protocols, and clinical outcomes. Relevant systematic reviews, meta-analyses, randomized controlled trials, and large observational studies were included. Data extraction focused on surgical approaches, rehabilitation protocols, outcome measures, and complication rates.

Results: The review identifies various surgical techniques for Achilles tendon rupture repair, including minimally invasive and percutaneous methods, graft augmentation, and accelerated rehabilitation protocols. These techniques offer potential benefits like reduced complications and faster recovery, but their optimal use remains a subject of ongoing research.

Discussions: Achilles tendon rupture repair has evolved significantly in recent years, with a trend towards less invasive surgical techniques and accelerated rehabilitation protocols. The choice of surgical technique and rehabilitation strategy should be individualized based on patient factors, rupture characteristics, and surgeon experience.

Conclusion: This overview provides a valuable resource for clinicians seeking to provide evidence-based care for patients with this common injury. While minimally invasive techniques offer potential advantages, long-term outcomes and comparative effectiveness data are still needed. Further research is warranted to optimize rehabilitation protocols and to identify predictors of successful outcomes following Achilles tendon rupture repair.

Keywords: Achilles tendon rupture, surgical repair, rehabilitation, outcomes, minimally invasive.

Introduction

Repairing an Achilles tendon rupture (ATR) is among the most frequently conducted orthopaedic procedures in the world; however, there is limited research on the risk factors that predispose patients to hospital readmissions. The Achilles tendon is crucial for explosive activities, but athletes with ATRs

perform fewer games and at lower levels. Recent studies suggest ATRs occur due to fatigue failure. and they have focused on comparing modes of fixation under dynamic loading to recreate this mechanism (Mansfield et al., 2022). This study aims to identify those risk factors. The Achilles tendon, the largest and strongest human body tendon, is the most frequently injured lower extremity tendon, with an incidence of 18 per 100,000, largely due to older age participation, particularly untrained and recreational athletes, cause sudden pain, worsened physical function, and require prolonged recovery, resulting in a 10%-30% reduction in calf strength and endurance (Pedowitz & Kirwan, 2013). While many ATR repairs occur in outpatient settings, complications from these surgical interventions can sometimes lead to readmissions. Surgical patients face similar comorbidities and risk of adverse outcomes, but surgical interventions carry higher complications, prolonged hospital stays, and early readmissions, which surgeons can mitigate (Sweeney, 2013).

It is crucial for healthcare providers to recognize patients at higher risk for postoperative complications to mitigate unexpected readmissions following ATR repair. Previous studies have suggested that factors like diabetes, hypertension, and substance abuse may elevate the risk of complications post-surgery, but the existing data on this topic remains sparse (Pean et al., 2018; Stavenuiter et al., 2019). The epidemiology of individuals who typically sustain this injury has been documented well over the last 15 to 20 years, indicating that these injuries predominantly affect middle-aged males engaged in various weekend activities. Overuse injuries, affecting over 25% of collegiate athlete injuries, are more prevalent among female athletes, necessitating further research to define and quantify these injuries (Yang et al., 2012). Overuse injuries and overtraining syndrome can lead to musculoskeletal damage and systemic consequences, causing decreased performance, increased injury risk, and derangement of various systems, contributing to burnout in youth sports (Brenner & Watson, 2024). Individuals suffering from such injuries are often described as leading predominantly sedentary lifestyles. Sedentary lifestyles negatively impact lipid, muscle, and carbohydrate metabolism, leading to decreased cardiac output, blood flow, insulin sensitivity, and vascular function, increasing cancer incidence and mortality (Park et al., 2020).

There is a lack of studies addressing any racial predisposition to this injury, with most supporting evidence being anecdotal from clinical settings. Recent qualitative data from interviews with physicians in training and faculty attendings suggests a critical analysis of medicine's culture and political economy.

Researchers must ensure adequate remuneration, particularly clinical services, is available to potential research participants from these groups to reduce the likelihood of onerous research requirements (George, 2014). Basketball players frequently suffer ankle and knee injuries, with ankle sprains being more common, influenced by jumping biomechanics, sudden direction changes, and physical demands (Aksović et al., 2024).

Tendons, including the Achilles, can heal spontaneously if immobilized, yet the recovery process is often prolonged, irrespective of whether surgical intervention is undertaken. Furthermore, residual effects typically persist. Research into tendon repair stimulation remains largely confined to animal studies. Tendon repair is generally described as progressing through distinct phases, including an inflammatory phase followed by a formative phase and finally remodelling (Aspenberg, 2007). Early identification of Achilles tendon risk factors aids in personalized prevention strategies, reducing ruptures, while research and clinical advancements further enhance the prevention and management of Achilles tendon injuries (Sankova, et al., 2024). Several intrinsic and extrinsic factors—such as local conditions, biomechanics, histology, genetics, and medications—can impact the risk of ATR. A 13-year study analyzed clinical diagnostic tests for subcutaneous Achilles tendon rupture, finding high positive predictive values across all tests, with no significant differences (Maffulli, 1998).

In ambiguous cases regarding rupture extent or location, and in all instances of bilateral ATR, ultrasonography is utilized for diagnosis confirmation. Ultrasound imaging is a noninvasive, cost-effective method for early differentiation of inflammatory arthritis, reducing disease activity and preventing joint damage, improving patient outcomes (Kaeley et al., 2020). Objective factors tied to ATR repair were also assessed, focusing on differences in outcomes from various procedures. Complications were classified into major and minor categories (Čretnik & Košir, 2023).

The exact mechanism behind fluoroquinolone (FQ) -induced tendon ruptures is still unclear, but incorporating in vivo tendinopathy and tendon rupture models with FQ administration could clarify pathological processes closer to clinical situations, in relation to tendons, despite the unknown order of tendon tissue and resident cells alterations (Duman et al., 2025).

Although certain risk factors for tendon rupture, such as advancing age, male gender, obesity, diabetes, corticosteroid use, and recreational sports participation, have been identified), there remains a need for a deeper understanding of these factors to identify individuals at risk and minimize potential harm (Morales et al., 2019). This study seeks to provide a thorough overview of the risk factors associated with Achilles tendon ruptures, with a particular emphasis on key trends to help avoid degenerative changes that could lead to rupture.

Methodology

Search Methods for Identification of Studies:

A systematic review was conducted including Elsevier, Global Health, PubMed-NCBI, Embase, Medline, Scopus, ResearchGate, RSCI, Cochrane Library, Google Scholar, Scopus, and ScienceDirect databases. All types of research studies (including Randomized Control Trials, Cohort studies, Case-control studies, and Cross-sectional studies) pertaining to ATR were included. Eligibility criteria mandated that studies be published in English and involve populations of men and/or women, including both athletes and non-athletes, as well as healthy individuals and patients. Risk factors for Achilles tendon injuries and ruptures were examined, including both modifiable and non-modifiable factors.

Discussion & Results

Currently, data concerning the predisposing risk factors for complications following ATR repairs is limited. A study examining 30-day all-cause readmission rates among AMA discharges in the US found that AMA discharge is an independent predictor of hospital readmission within 30 days, with a 25.6% readmission rate, despite the implementation of the Hospital Readmission Reduction Program (Spooner et al., 2020). Race emerged as a potential factor contributing to the occurrence of Achilles tendon ruptures, a finding not previously documented in the literature. It is widely accepted that nearly all Achilles tendon ruptures arise from tendons exhibiting clinically silent degenerative tendinopathy. The interplay between tendon degeneration and the failure of muscle overload inhibition may contribute to both Achilles tendon ruptures and tendon ruptures in general. Discovering biochemical variations could enhance understanding of the underlying pathology of Achilles tendon ruptures.

Due in large part to the biomechanical pressures associated with basketball, including forced plantarflexion, frequent jumping, and pivoting, the passage finds a strong association between Achilles tendon ruptures and basketball activities (Alegre et al., 2021). The incidence of ACL injuries and ankle sprains is higher in female players and during higher playing levels and games compared to training. (Stojanović et al., 2023).

Patient-specific factors such as older age, higher BMI, female gender, involvement of the retinaculum, and current smoking status were identified as risk factors for adverse outcomes post-quadriceps tendon repair. Additional studies are necessary to identify modifiable risk factors that could aid in setting patient expectations and enhancing outcomes (Coladonato et al., 2024). The risk factors for ATR identified in this study diverged from those observed in the general population, revealing a higher risk in women compared to men, which contradicts some studies that reported a greater incidence in men or found no gender differences (Erickson et al., 2014).

Another study found men have a higher incidence of sports-related ATR, with poorer functional outcomes and increased likelihood of postoperative complications and revision surgery (Hartman et al., 2024). A higher tendon rupture incidence in black individuals in the US, possibly due to factors like recreational activity, sports participation, overuse, age-related degeneration, genetics, and corticosteroids was found in a study (Berkay et al., 2023). Other studies have identified associations between ATR and the use of fluoroquinolones and corticosteroids (Claessen et al., 2014). The prevalence of fluoroquinolone and corticosteroid use in the ESRD population may partially explain the elevated ATR incidence in this group. However, fluoroquinolones have been linked to a higher likelihood of tendinopathy and Achilles tendon rupture, particularly in patients over 60 years of age (Briones-Figueroa, 2021). Tendinitis, a tendon rupture condition, may lead to rupture in patients on FQ therapy, with ultrasound and MRI aiding assessment, strongly correlated with FQ use (Kim, 2010), but the findings remain limited and may warrant further investigation. Additionally, results indicated a rising trend in socioeconomic status (SES) reporting over the decades examined, but the lack of statistical analysis precluded definitive conclusions regarding the significance of this trend (Talaski et al., 2024). Certain cam-walkers can be adjusted to alter the ankle angle, thus impacting immobilization positioning. After Achilles tendon repair, immobilization closer to neutral plantarflexion can reduce atrophy and stiffness but may cause damage, while a 1-inch heel lift can minimize plantar-flexor activity during walking (Akizuku et al., 2001). Predicting ankle torques and Achilles forces during normal, non-immobilized walking is inherently less precise due to the loss of isometric contractions. Achilles tendon ruptures are typically conservatively treated, with surgery being optimal for chronic partial ruptures due to trauma-related factors causing inflammation, degenerative changes, and plasma protein leakage (Kvist, 1994).

Conclusions

Achilles tendon rupture repair has evolved significantly in recent years, with a trend towards less invasive surgical techniques and accelerated rehabilitation protocols. This overview provides a valuable resource for clinicians seeking to provide evidence-based care for patients with this common injury. This study corroborated previous findings that higher BMI, smoking, and elevated total cholesterol levels are associated with an increased risk of ATR. Hyperuricemia may also play a role in the development of ATR, suggesting that adjunctive tests for total cholesterol and uric acid in blood biochemistry could be useful for risk prediction. The study supports the assertion that Achilles tendon ruptures occur more frequently among black individuals compared to non-black individuals, with a substantial number of injuries occurring during basketball-related activities. Black patients were found to be at a significantly greater risk of sustaining Achilles ruptures, even when age was controlled as a variable. The underlying reasons for this heightened risk remain unclear. Future research could investigate racial microbiological differences in discarded tendons from Achilles tendon repairs, as well as in hamstring harvesting for anterior cruciate ligament repair. Achilles tendon repairs are generally associated with a low rate of complications within 30 days and a low rate of revision surgeries within two years. Factors linked to postoperative complications include hyperlipidaemia, hypertension, female

gender, obesity, and diabetes. Conditions associated with the necessity for revision surgery comprise female gender, hypertension, obesity, and any postoperative complications, with female gender, diabetes, complications, and revision surgery presenting the highest associated costs. The choice of surgical technique and rehabilitation strategy should be individualized based on patient factors, rupture characteristics, and surgeon experience. While minimally invasive techniques offer potential advantages, long-term outcomes and comparative effectiveness data are still needed. Further research is warranted to optimize rehabilitation protocols and to identify predictors of successful outcomes following Achilles tendon rupture repair.

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UNDERSTANDING GENDER GAPS AND THEIR ECONOMIC IMPACT: THE CASE OF ALBANIA (2000–2021)

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ABSTRACT

This paper examines the economic consequences of gender inequality in Albania by exploring disparities across education, labor force participation, fertility rates, and political representation from 2000 to 2021. Utilizing indicators drawn from the Gender Inequality Index, such as female enrollment in primary and secondary education, women's labor participation, fertility trends, and the share of women in parliamentary seats, the study assesses their effects on GDP growth per capita. Employing time series econometric analysis, the findings reveal that higher female labor participation significantly drives economic growth through enhanced productivity and human capital utilization. However, gender parity in education appears to exert a delayed negative impact on growth, suggesting challenges in translating educational gains into economic outcomes due to labor market mismatches. Meanwhile, increased political representation for women is associated with short-term economic costs, as the transition toward more inclusive governance often entails shifts in budget allocations and policy priorities, particularly toward social welfare and equality measures that, while essential for long-term development, may temporarily moderate GDP growth. The decline in fertility rates further influences labor supply dynamics, carrying implications for long-term growth. Overall, the results emphasize the necessity for comprehensive policies to address gender inequalities, ensuring that progress in education and political participation effectively contributes to Albania's sustainable economic development, particularly in the context of European integration.

Keywords: gender inequality, economic growth, education, labor force participation, fertility, political representation.

Introduction

Economic growth is widely recognized as a key driver of national development, enhancing living standards and fostering prosperity. However, sustained and inclusive economic growth cannot be achieved without addressing social disparities, particularly gender inequality. As a multidimensional issue, gender inequality manifests in various forms, including disparities in labor force participation, wage gaps, access to education, and representation in decision-making positions. These factors do not only undermine social justice but can also hinder a country's economic potential. Globally, gender inequality persists in the workforce and leadership roles, which has significant implications for economic growth. According to LinkedIn data (2024), women account for only 42% of the global workforce and 31.7% of senior leadership roles, highlighting a persistent gender gap across nearly every industry and economy. These figures illustrate the challenges faced by women in advancing their careers, which in turn affects economic productivity and national development.

On January 1, 2023, the population of Albania was 2,761,785, of which 1,366,921 were men and 1,394,864 were women. In 2022, women made up 50.5% of the total population, making it essential for all stakeholders to engage in ensuring an equal environment for half of society.

According to the Global Gender Gap Report 2024, published by the World Economic Forum, Albania ranks 23rd in the world, dropping 6 places compared to 2023.In the 2024 Global Gender Gap Report, the overall gender gap index (which measures gender equality in areas such as Economic participation and Opportunity, Educational Attainment, Health and Survival, and Political Empowerment) was recorded at 0.78, marking a slight decrease from 0.79 in both 2023 and 2022. However, it remains higher than the 0.77 reported in 2020 and 2021.

In the figure 1 are presented the values of Global Gender Gap Index and its components for Albania for the period 2020-2024.

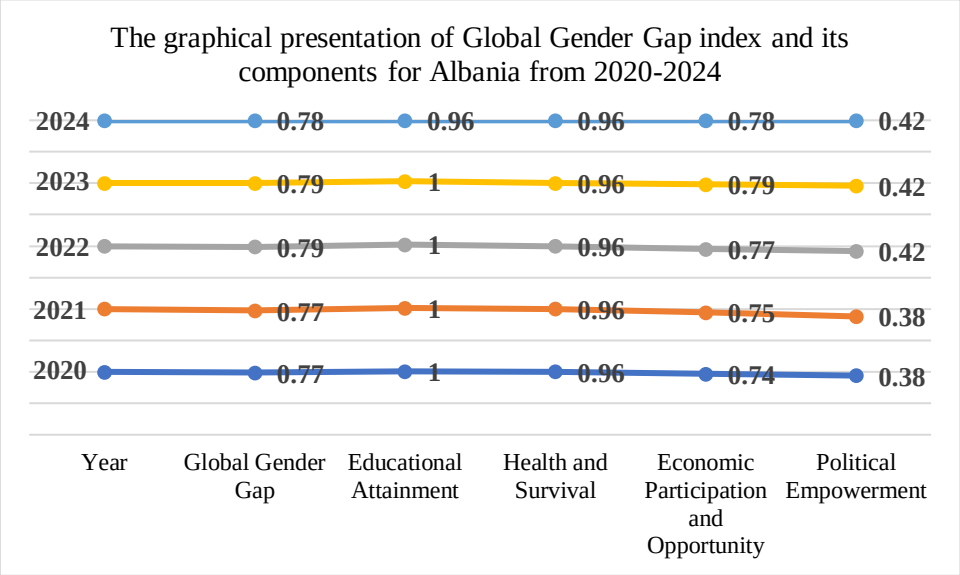


Figure 1. Values of Global Gender Gap Index and its components from 2020-2024

Between 2020 and 2024, Albania has shown consistent strengths in Health and Survival as well as Educational Attainment. The Health and Survival indicator remained stable over the five-year period, consistently achieving a high score of 0.96 each year, reflecting sustained progress in this dimension. Educational Attainment demonstrated excellent performance from 2020 to 2023, maintaining a perfect score of 1.00. However, in 2024, there was a slight decrease to 0.96, which, despite the minor decline, still indicates a strong level of educational achievement relative to gender parity. In terms of Economic Participation and Opportunity, Albania recorded a score of 0.78 in 2024, a slight decrease from 0.79 in 2023. Nonetheless, this indicator has shown an overall positive trend compared to earlier years, improving steadily from 0.74 in 2020, to 0.75 in 2021, and 0.77 in 2022. Political Empowerment continues to be the area where Albania faces the most significant challenges. In 2024, the score remained at 0.42, the same as in 2023. Although progress in this area has plateaued in recent years, it still represents a notable improvement from the 0.38 recorded in 2020 and 2021.So, while Albania has made commendable strides in health, education, and economic participation, further efforts are needed to accelerate progress in political empowerment to close the gender gap more comprehensively.

According to recent statistics, in 2022, women constitute approximately 66.7% of Albania's workforce (Instat, 2023), reflecting a steady increase in female labor force participation. According to the reasons

for inactivity, women remain out of the labor force mainly because they are pupils, students, in further training, unpaid work experience (18.3 %) or fulfilling household duties (16.9 %). Only 0.8 % of men have the fulfillment of household duties as the reason for their inactivity, and 25.0 % of them are students or pupils. However, significant disparities persist in terms of employment opportunities, earnings, and access to decision-making roles.

Women in Albania are more educated than men. In 2022, 43.8% of women from 25-39 years old have completed the tertiary education compared to 29.8 % of men. For the same age group, 35.4 % of women have completed the basic education, compared to 31.4 % of men

Most of diplomas in tertiary education were obtained for both genders in the field of study "Business, Administration and Law" (27.5 % for women and 26.7 % for men). Analyzed for each field separately, the fields of study in which most females are graduated comparatively to males are "Education" (80.4 %), followed by "Arts and Humanities" (80.1 %) and "Social Sciences, Journalism and Information" (78.8 %). The fields of study in which more males are graduated compared to females are "Services" (64.8 %), "Engineering, Manufacturing and Construction" (62.9 %) and "Information and Communication Technologies" (58.2 %).

Despite this, their higher education attainment does not translate into equal employment opportunities or pay equity.

Women in Albania continue to earn less than men across most professions. In 2022, women were paid on average 6.2% less than men, a widening gap compared to 4.5% in 2021.According to the distribution of wages by economic activity, women earned more than men only in three sectors:

1.Construction, where they received 8.8% more than men.

2.Real estate activities; Professional, scientific and technical activities; administrative and support service activities, where they received 0.85% more than men

3. Arts, entertainment and recreation, repair of household goods and other services, where they received where they received 2.1% more than men.

In this year, the economic sector, in which the gender gap in wages is higher, is the Production sector, where the value of GPG reaches 21.3 %.

Albania ranks among the top countries globally for women's representation in government. By the end of 2023, women held 67% of ministerial positions, placing Albania first worldwide, ahead of Finland and Spain.

While women dominate in government leadership, they remain underrepresented in managerial roles within the labor market. In 2022, women held 35% of managerial positions in public administration, a slight decrease from 35.5% in 2021 (Euronews Albania, 2024). The percentage of women owners or administrators in 2022 has slightly increased compared to 2020, both in terms of businesses with productive economic activity and the service sector from 31.1% to 31.2%.

The persistence of inequalities particularly in employment opportunities, wage equity, and leadership representation, raises critical questions about their impact on Albania's economic trajectory. Does gender inequality slow down economic growth by limiting human capital development and productivity? Or could reducing gender disparities serve as a catalyst for sustained economic expansion?

This paper aims to investigate the effect of various dimensions of gender inequality on economic growth in Albania, examining key indicators such as women's labor force participation, fertility rates, access to education, and political representation. By employing a quantitative approach, the study will explore the extent to which gender disparities influence economic performance and discuss potential policy measures to foster a more inclusive and sustainable growth model.

Objectives:

1.Investigate the effects of key gender inequality indicators on GDP growth.

2.Estimate short-run and long-run relationships using the ARDL approach.

3. To interpret the short-run and long-run dynamics between gender-related indicators and GDP growth based on the results of the ARDL model.

The findings of this research will contribute to the broader discourse on gender and economic development, providing insights into how gender-inclusive policies can enhance Albania's economic prospects in the context of European integration and global competitiveness.

Literature review

Gender equality has increasingly been recognized as a fundamental driver of economic development, inclusive growth, and societal well-being. A robust body of literature highlights the multifaceted ways in which gender parity, particularly in economic participation and leadership, contributes to macroeconomic stability, productivity, and sustainable development.

As evidenced across the literature, gender equality emerges as a fundamental component of economic growth, stability, and resilience. Naveed et al. (2023) provide empirical support for this relationship through a comprehensive panel data analysis of 171 countries over the period 1960–2016. Their study finds that women's economic rights positively affect economic growth, although the magnitude of the impact varies across different economies. Notably, their spatial analysis suggests that 75% of the spillover effect of women's economic rights passes through neighboring countries, reinforcing the importance of regional and collaborative approaches to promoting gender equality. These findings align with European Union policies advocating for joint efforts in advancing women's economic empowerment as a pathway to sustainable development.

Gopinath (2022), in her remarks at the Korea Gender Equality Forum, argues that closing gender gaps in labor force participation is not only an issue of fairness but also an economic necessity. She highlights that ensuring equal opportunities for women can catalyze faster recovery from economic shocks and act as a powerful engine of growth. Gender equality, she notes, is closely linked to macroeconomic and financial stability, improved private and public sector performance, and reduced income inequality.

The World Bank Group (2024) further emphasizes the role of expanding economic opportunities for women in driving inclusive growth. While educational access between genders has nearly equalized, female labor force participation has remained stagnant at 53%, compared to 80% for men, since 1990. Importantly, the World Bank notes that women's leadership is associated with long-term economic, environmental, and social benefits. Firms with more women in decision-making roles demonstrate higher net profit margins and lower CO2 emissions, underlining the intersection of gender equality with broader development outcomes.

The Global Gender Gap Report (Pal et al., 2024) presents a sobering assessment of the pace and scale of progress toward gender parity. Despite gains in women's representation at entry-level positions across sectors, there remains a significant drop in representation at higher leadership levels, with women holding less than one-quarter of C-suite positions globally. The report also highlights persistent gender gaps in science, technology, engineering, and mathematics (STEM), with women making up only 28.2% of the STEM workforce. Although the representation of women in AI engineering has more than doubled since 2016, gender parity in critical future skills such as AI, big data, programming, and cybersecurity remains elusive. These disparities not only limit women's career advancement but also hinder inclusive technological and economic transitions.

UN Women (2024) echoes these concerns by documenting persistent global wage gaps and barriers to entrepreneurship. Women globally earn approximately 80% of what men earn, and the motherhood wage penalty exacerbates these disparities. In entrepreneurship, women face significant obstacles, with lower rates of both start-up activity and established business ownership compared to men. These findings point to systemic barriers that impede women's economic participation and highlight the importance of addressing inequalities throughout the entire economic cycle—from labor force entry to leadership and entrepreneurship.

Bertay, Dordevic, and Sever (2020) delve deeper into how gender inequality constrains economic growth at the industry level. Their study demonstrates that reducing gender disparities enables better allocation of female labor to more productive sectors, particularly in industries with higher female employment shares. The authors conclude that gender inequality negatively affects real economic outcomes and that targeted policies to reduce these disparities can enhance productivity and growth.

Aldan (2021) offers additional insights from a regional analysis of Turkey, examining the relationship between female labor force participation and the gender wage gap. Although Turkey has experienced increasing female labor force participation, it still lags behind developed countries. Interestingly, Aldan finds that rising participation is associated with an increase in both raw and unexplained gender wage gaps. This is partly attributed to the entry of women with lower unobservable skills or career motivation into the labor market. The study highlights the complex relationship between participation rates and wage equality, suggesting the need for policies that not only increase participation but also ensure quality and equitable employment opportunities.

Pervaiz et al. (2023) provides further empirical support for the positive impact of gender equality on economic growth in developing countries. While gender equality is often promoted on the basis of fairness and social justice, their study emphasizes its instrumental value in fostering economic development. Using panel data, they find a significant and positive effect of gender equality on economic growth, reinforcing its importance as a policy priority for sustainable and inclusive development.

As evidenced across the literature, gender equality emerges as a fundamental component of economic growth, stability, and fostering sustainable development. Closing gender gaps in labor force participation, leadership, wages, and skills, particularly in high-growth sectors such as technology and AI, can drive inclusive growth, enhance institutional resilience, and improve social outcomes. However, literature also underscores the need for context-specific and targeted policy interventions that address both the quantity and quality of women’s economic engagement. Achieving gender parity is not only a matter of fairness but also a strategic imperative for long-term economic prosperity.

Albanian context related the key indicators of gender equality considered in this paper

To measure gender equality and its influence on economic development in Albania, this study incorporates four key indicators: access to education, female labor force participation, fertility rates, and women's representation in decision-making bodies. These indicators are widely recognized by international organizations such as the World Bank, OECD, UNDP, and UN Women as essential dimensions of gender equality that directly impact a country's economic performance.

Access to education: Educational attainment for women is a fundamental driver of gender equality and has a direct impact on economic development. Higher education enrollment increases women's skills and productivity, leading to greater labor market participation and overall economic growth. Enrollment of women in primary and secondary education, more specifically GPI in primary and secondary education is used as proxy to measure this variable. Why? Although secondary education is typically a

more telling indicator for gender inequality, especially in long-term human capital development, the time series properties of the data (being integrated of order 2) made its direct use incompatible with the ARDL bounds testing approach, which requires variables to be I(0) or I(1). Therefore, to ensure statistical robustness and valid model estimation, the combined GPI for primary and secondary education, which is I(1), was selected. But what is GPI (gender Parity Index) in Education?

Definition: GPI is the ratio of female to male enrollment rates in education.

A GPI of 1 means gender parity (equal numbers of girls and boys), less than 1 indicates female disadvantage, and more than 1 indicates male disadvantage.

It's a standard indicator used by: UNESCO Institute for Statistics (UIS), World Bank Education Statistics (EdStats), UNDP Human Development Reports (HDR). The Gender Parity Index (GPI) data for primary and secondary education enrollment in Albania for the period 2000–2021 were sourced from CEIC Data available at: https://www.ceicdata.com/en/albania/social-education-statistics/al-gender-parity-index-gpi-secondary-school-enrollment-gross.

Due to the unavailability of data for the years 2002 and 2003, interpolation using the average method was applied to estimate the missing values.

Labor Participation (%): Women's labor force participation is a direct indicator of their economic empowerment. Greater participation contributes to higher household incomes, economic productivity, and national GDP growth. The data about Labor Participation for the period 2000-2021 are taken from World Bank website: https://genderdata.worldbank.org/en/economies/albania

Fertility Rate (number of births per women) Lower fertility rates are often associated with increased gender equality, as women have greater access to education and employment, and more control over reproductive choices. This demographic transition contributes to economic growth (the demographic dividend). The data about Fertility Rate are taken from the database of Federal Reserve Economic Data: https://fred.stlouisfed.org/series/SPDYNTFRTINALB

GDP Growth/capita (%) is used as proxy to measure economic development. GDP per capita growth is a quantitative measure that signals whether the country's economy is expanding in a way that potentially benefits individuals. The data about this variable are taken from World Bank web site: https://data.worldbank.org/indicator/NY.GDP.PCAP.KD.ZG?locations=AL

In 2024, Albania's economy grew by 3.96%, reflecting a moderate but steady pace of expansion. This growth was supported by strong performance in some sectors, while others faced notable challenges. The construction sector stood out as a key driver, growing by 5.86% and continuing its positive trend, supported by public and private investments. Tourism-related activities also played an important role, with trade, transport, accommodation, and food services increasing by 5.69%, indicating strong seasonal demand and a recovery in both domestic and international tourism. On the other hand, the industrial sector faced significant difficulties, shrinking by 6.78%, with manufacturing alone declining by 7.49%. These results point to persistent structural challenges within production and energy-related industries. Agriculture also continued its downward trajectory, recording a 1.15% drop, likely due to ongoing sectoral inefficiencies and possibly unfavorable climatic conditions. Meanwhile, the information and communication sector, which had seen rapid growth in previous years, experienced a slight decline of 2.52%, suggesting a temporary slowdown in digital activities. Despite these mixed signals, the positive momentum in construction and tourism helped to sustain overall economic growth during the year (INSTAT, 2024).

Despite steady economic growth, Albania continues to face several structural challenges. A large informal economy weakens fair competition and reduces tax revenues (EC, Albania 2024 Report). Key fiscal reforms remain incomplete, including the finalization and implementation of a Medium-Term

Revenue Strategy and improvements in fiscal risk management and transparency, particularly in state-owned enterprises.

While tourism and investment have driven recent growth, the export of goods remains underdeveloped, and financial intermediation is weak. Youth unemployment is still high, and gaps in infrastructure, education quality, especially vocational training and digitalization limit Albania's competitiveness. To improve the situation, the European Commission recommends that Albania strengthen tax policy and administration, enhance fiscal transparency and accountability, invest in digital infrastructure and cyber resilience, and improve the alignment of education and vocational training with labor market needs.

Continued reform is essential to ensure sustainable growth and alignment with EU economic standards.

Seats held by women in Parliament/Decision Making (%) Women's participation in political decision making ensures that policies are more inclusive and address gender-specific issues. It is also an indicator of women's empowerment and gender equality in public life. Data about Seats held by women in parliament are also taken from World Bank website:

https://genderdata.worldbank.org/en/economies/albania

Research Methodology

To empirically analyze the effect of gender inequality on economic development, Autoregressive Distributed Lag Model is used, as the variables are mix orders of integration. So, the dependent variable GDP Growth per capita and the independent variable Fertility rate are I(0) while other three independent variables Labor Participation, Seats held by women in parliament and Gender Parity Index (primary and secondary) are I(1).

The general form of an ARDL (p,q) regression model is:

$$y_t = \beta_0 + \beta_1 y_{t-1} + \beta_2 y_{t-2} + \cdots \beta_p y_{t-p} + \alpha_0 x_t + \alpha_1 x_{t-1} + \alpha_2 x_{t-2} + \cdots + \alpha_q x_{t-q} + u_t \quad (1)$$

Based on AIC criteria, the appropriate number of time lags chosen is one for the dependent variable GDP Growth per capita, zero for independent variable fertility rate, and 2 for the independent variables GPI (primary and secondary), labour participation and seats in parliament, so the model specification is ARDL (1,0,2,2,2).

To examine the existence of a long-run equilibrium relationship between the variables, the Bounds Test for cointegration was applied. As the calculated F-statistic is 13.95, greater than the critical value for the upper bound I(1) equal to 3.49, than we reject the null hypothesis that the variables are not cointegrated and conclude that the variables are cointegrated, at 5% level of significance.

In this case, the estimated equation of ECM model, which explains short-run dynamics and how deviations from the long-run equilibrium are corrected over time, is:

$$\Delta \text{GDPGrowth/capita}_t = 46.84\Delta \text{GPI(primary and secondary)}_t + 187.71\Delta \text{GPI(primary and secondary)}_{t-1} + 1.19\Delta \text{LabourParticipation}_t - 0.47\Delta \text{LabourParticipation}_{t-1} + 0.08\Delta \text{SeatsParliament}_t + 0.26\Delta \text{SeatsParliament}_{t-1} - 2.25\text{ECT}_{t-1}$$

Table 1 presents data about the coefficients, standard errors, t-statistics and probabilities of the estimated equation of ECM model.

Variable	Coefficient	Standard Error	t-Statistic	Prob.
D(GPI primary and secondary)	46.838	32.680	1.433	0.190
D(GPI primary and secondary (-1))	187.715	34.485	5.443	0.001
D(Labor participation)	1.187	0.131	9.071	0.000
D (Labor participation (-1))	-0.468	0.111	-4.199	0.003
D (Seats held by women)	0.079	0.104	0.764	0.467
D (Seats held by women (-1))	0.261	0.122	2.142	0.065
CointEq(-1)	-2.248	0.193	-11.664	0.000

Table 1. Data about coefficients, standard errors, t-statistics and p-values in the estimated equation of ECM model

The estimated equation of the long-run ARDL (1,0,2,2,2) model is:

$\text{GDPGrowth/capita}_t = 55.64 - 1.25\text{GDPGrowth/capita}_{t-1} - 15.27 \cdot \text{FertilityRate}_t +$
$+46.84\text{GPI(primary and secondary)}_t + 67.61\text{GPI(primary and secondary)}_{t-1} - 187.71$
$\text{GPI(primary and secondary)}_{t-2} + 1.19\text{LaborParticipation}_t -$
$0.31\text{LaborParticipation}_{t-1} + 0.47\text{LaborParticipation}_{t-2} + 0.08\text{SeatsParliament}_t -$
$0.69\text{SeatsParliament}_{t-1} - 0.26\text{SeatsParliament}_{t-2}$

Table 2 presents data about the coefficients, standard errors, t-statistics and probabilities of the estimated equation of the long-run ARDL (1,0,2,2,2) model.

Variable	Estimated coefficient	S.E	t-statistic	P-value
C	55.645	49.477	1.125	0.293
GDP Growth/capita (-1)	-1.248	0.289	-4.320	0.003
Fertility Rate	-15.271	5.936	-2.573	0.033
GPI (primary & secondary)	46.838	67.646	0.692	0.508
GPI (primary & secondary) (-1)	67.607	53.033	1.275	0.238
GPI (primary & secondary) (-2)	-187.715	50.079	-3.748	0.006
Labor Participation	1.187	0.231	5.132	0.001
Labor Participation (-1)	-0.311	0.224	-1.388	0.203
Labor Participation (-2)	0.468	0.217	2.157	0.063

Seats in Parliament	0.079	0.177	0.447	0.666
Seats in Parliament (-1)	-0.690	0.209	-3.306	0.011
Seats in Parliament (-2)	-0.261	0.221	-1.181	0.272

Table 2. The results from the estimation of the ARDL (1,0,2,2,2) model

To validate the robustness of the model, several diagnostic tests were performed. Table 3 presents some important statistics such as D-W statistics, R-Square, F-statistic and the results from JB test for normality, BG LM test for serial correlation and BPG test for heteroscedasticity.

Diagnostic Test	**p-value**	**Result**
J-B Normality	0.57	The error terms are normally distributed
Breusch-Godfrey LM test for serial correlation	Prob.F(2,6)=0.077	No serial correlation of any order up to 2 between the error terms
Breusch-Pagan-Godfrey for homoscedasticity	Prob.F(1,8)=0.9695	Error terms are homoscedastic
Adjusted R-Square	0.737826	About 74% of the variability of GDP Growth/capita is explained by independent variables
Prob(F-statistic)	0.009331	The model is statistically significant
Ramsey RESET test	Prob.F statistic=0.145	The functional form is correctly specified

Table 3: Diagnostic tests results

Also, the cumulative sum (CUSUM) plot for the model ARDL (1,0,2,2,2) indicates stability in the coefficients over the sample period, as the blue line is within the bound at 5% significance level.

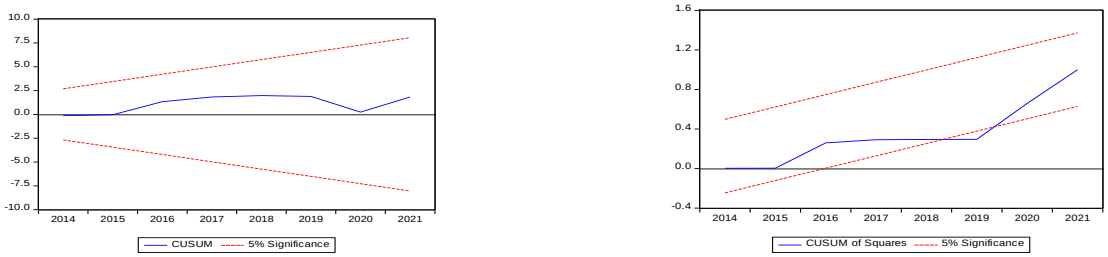


Figure 2. CUSUM plot and CUSUM of Squares for the coefficients' stability

From the table 2, results that the variables GPI(primary and secondary), GPI(primary and secondary)(-1), Labour Participation(-1), Labour Participation(-2), Seats in Parliament and Seats in Parliament(-2) are statistically insignificant while GDP Growth/capita(-1), Fertility Rate, Labour Participation, GPI(primary and secondary)(-2) and Seats held by women in Parliament(-1) are statistically significant.

Findings and discussion

The results of the ARDL (1,0,2,2,2) model reveal significant effects of gender-related variables on economic growth in Albania. Specifically:

Fertility rate has a statistically significant negative effect on GDP growth per capita. A 1% increase in fertility rate reduces GDP growth per capita by approximately 15.27 percentage points in the long run, indicating that high fertility may limit women's participation in the workforce and strain economic resources.

Female labor force participation demonstrates a positive and significant impact on economic growth. The immediate effect is strongly positive (1.19%), while the first and second lag variables are statistically insignificant.

The Gender Parity Index (GPI) for primary and secondary education shows a mixed effect: although current and one-period lag coefficients are not statistically significant, the second lag is negative and significant, which may reflect long-term inefficiencies in translating education into productive employment or gender based occupational segregation. Increasing girls' school enrollment might mean delayed entry into the labor market, especially if more girls pursue higher education. This delay could temporarily reduce the working age labor supply, thus reducing GDP growth in the short term. Also, although educational parity improves, labor market or economy may not be prepared to absorb newly educated women (due to structural barriers, limited job opportunities, or skill mismatch), so this could temporarily depress productivity or lead to underemployment. In other words, education gains without follow up integration into the labor market can create a lag where the potential of the educated population isn't utilized.

Political representation, measured as the proportion of parliamentary seats held by women, exhibits a significant negative effect with a one-period lag, whereas contemporaneous and two-period lag coefficients are insignificant. This suggests that increases in women's numerical presence in political bodies alone are insufficient to generate immediate economic effects. Instead, substantive participation and influence in policymaking processes are essential for translating representation into measurable economic outcomes.

Furthermore, periods during which Albania implemented gender quotas or electoral reforms often overlap with broader structural changes—including election cycles, fiscal adjustments, or EU accession-related reforms—that exert independent pressures on economic growth. Such overlapping events make it challenging to isolate and attribute any immediate economic impact specifically to increased women's political representation.

These findings underline the complexity of gender dynamics in Albania and their economic implications. While improvements in labor participation and fertility rate correlate positively with growth, education and political representation require further structural alignment with market and institutional mechanisms to maximize their economic benefits. In the context of education, while progress in achieving gender parity is essential, it must be effectively translated into equitable access to labor market opportunities. Despite attaining formal education, many women continue to encounter structural barriers when entering the workforce or securing quality employment. To bridge this gap, it is crucial to align educational pathways with labor market demands, actively promote women's participation in STEM and other high productivity sectors, and address skill mismatches through upskilling initiatives and career development programs. Evidence based policymaking, supported by strong collaboration between academia, government, and civil society, will be essential in ensuring that gender equality contributes meaningfully to sustainable economic growth, particularly as Albania advances in its path toward EU accession.

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PROTECTIVE EFFECTS OF GRAPE SEED PROANTHOCYANIDINS AT THE GENE LEVEL IN DIABETIC NEPHROPATHY

DİYABETİK NEFROPATİDE ÜZÜM ÇEKİRDEĞİ PROANTOSİYANİDİNLERİNİN GEN DÜZEYİNDEKİ KORUYUCU ETKİLERİ

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ABSTRACT

In recent years, natural functional foods containing bioactive compounds have become a subject of research due to the changing food preferences of society and the increasing burden of chronic diseases. It is emphasized that plant by-products, which are seen as waste in the food industry particularly, should be valorized for sustainable health strategies with the bioactive compounds they contain. The seeds that form of the grape *(Vitis spp.)* pulp, are a grape by-product rich in proanthocyanidins, a flavonoid group that exhibit anti-inflammatory and antioxidant activity. According to TUIK data (2022), 11.4% of individuals aged 15 and over in Türkiye have been reported to have diabetes. According to IDF data, the number of individuals with diabetes between the ages of 20-79 worldwide was 588.7 million in 2024 and this number is expected to reach 852.5 million in 2050. Lately, the economic burden of increasing diabetes and its complications on healthcare systems and the limitations of traditional medical treatments have led to an increased interest in functional and complementary treatment. Diabetic nephropathy is one of the most common complications of diabetes and is among the main causes of end-stage renal failure. Its pathogenesis involves hyperglycemia-mediated oxidative stress and tissue damage caused by inflammation. Grape seed proanthocyanidins have been shown to reduce proteinuria, suppress endoplasmic reticulum stress and regulate inflammatory response in experimental diabetic models. Recent studies have indicated that grape seed proanthocyanidins reduce kidney damage by strengthening the antioxidant defense system through activation of the Nrf2-ARE pathway and have protective effects at the gene level against the progression of diabetic nephropathy through different molecular pathways by suppressing the expression of genes associated with oxidative stress and apoptosis, such as p66Shc. This review aimed to investigate the epigenetic protective effects of grape seed proanthocyanidins against diabetic nephropathy together with their underlying effect mechanism.

Keywords: Diabetic Nephropathy, Gene, Grape Seed, Proanthocyanidin

ÖZET

Toplumun değişen besin tercihleri ve gittikçe artan kronik hastalık yükü, doğal olan ve biyoaktif bileşikler içeren fonksiyonel besinleri daha fazla gündeme getirmiştir. Özellikle gıda endüstrisinde atık olarak görülen bitkisel yan ürünlerin, içeriğindeki biyoaktif bileşikler nedeniyle sürdürülebilir sağlık stratejilerinde değerlendirilmesi gerekliliğine dikkat çekilmektedir. Üzümün (*Vitis spp.*) içerdiği posanın önemli bir kısmını oluşturan çekirdekler, anti-inflamatuar ve antioksidan aktiviteye sahip flavonoid grubundan olan proantosiyanidinler bakımından zengin yan üründür. TÜİK verilerine göre (2022) Türkiye'de 15 yaş ve üzeri bireylerin %11,4' ünde diyabet olduğu bildirilmiştir. Dünya genelinde ise Uluslararası Diyabet Federasyonu verilerine göre, 20–79 yaş arası diyabetli birey sayısının 2024

yılında 588,7 milyon, 2050 yılında ise 852,5 milyona ulaşması beklenmektedir. Bu artış, diyabet ve ilişkili komplikasyonlarına yönelik koruyucu ve terapötik yaklaşımların gerekliliğini vurgulamaktadır. Son yıllarda artan diyabet komplikasyonları insidansının sağlık sistemlerine getirdiği ekonomik yük ve geleneksel tıbbi tedavilerin sınırlılığı sebebiyle fonksiyonel ve tamamlayıcı tedavilere olan ilgi artmıştır. Diyabetik nefropati, diyabetin ciddi ve en sık görülen komplikasyonu olup, son dönem böbrek yetmezliğinin başlıca nedenleri arasında yer almaktadır. Diyabetik nefropatinin patogenezi, hiperglisemi aracılı oksidatif stres ve inflamasyonun sebep olduğu doku hasarını içermektedir. Bu doğrultuda üzüm çekirdeği proantosiyanidlerinin deneysel diyabet modellerinde proteinüriyi azalttığı, endoplazmik retikulumun stresini baskıladığı ve inflamatuar yanıtı düzenlediği gösterilmiştir. Diyabetik nefropati bağlamında son çalışmalar, üzüm çekirdeği proantosiyanidinlerinin Nrf2-ARE yolunu aktive ederek antioksidan savunma mekanizmalarını güçlendirdiğini ve p66Shc gibi genlerin ekspresyonunu baskılayarak oksidatif hasarı azalttığını dolayısıyla hastalığın ilerleyişine karşı gen düzeyinde koruyucu etki gösterebildiğini vurgulamıştır. Bu bağlamda, bu derlemede üzüm çekirdeği proantosiyanidinlerinin diyabet kaynaklı böbrek hasarı ve diyabetik nefropati gelişimine karşı koruyucu etkileri ile bu etkilerin altında yatan mekanizmaların incelenmesi amaçlanmıştır.

Anahtar Kelimeler: Diyabetik Nefropati, Gen, Üzüm çekirdeği, Proantosiyanidin

GİRİŞ

Diabetes mellitus, insülinin salınımdaki bozulmadan, insülin etkisindeki bozukluktan veya iki duruma da bağlı olarak hiperglisemi varlığı ile karakterize edilen kronik bir metabolik hastalıktır (Punthakee ve ark., 2018). Türkiye İstatistik Kurumu 2022 verilerine göre, Türkiye'de diyabet prevalansının %11,4 olduğu bildirilmiştir (TÜİK, 2023). Uluslararası Diyabet Federasyonu'nun (IDF) 2024 yılı raporuna göre, dünya çapında 588,7 milyon yetişkin diyabetli bulunduğu ve bu rakamın 2050 yılında 852,5 milyon olacağı ön görülmektedir (International Diabetes Federation, 2025). Diyabet insidansının artması, diyabetik nefropati gibi diyabet komplikasyonlarının görülme sıklığının artmasına neden olmuştur (Ding ve ark., 2020). Kronik ve son evre böbrek hastalığının başlıca nedeni olan diyabetik nefropati, tip 2 diyabet hastalarının %40'ında, tip 1 diyabet hastalarının %30'unda gelişmektedir (Hussain ve ark., 2021). Ayrıca diyabet, kardiyovasküler hastalık kaynaklı mortalite ve morbiditenin başlıca nedeni olup (Dal Canto ve ark., 2019) küresel sağlık sistemlerinde önemli ölçüde ekonomik yük oluşturmaktadır (Karugu ve ark., 2024). Diyabet yönetiminin küresel maliyetinin 2007 yılında 232 milyar ABD doları olduğu ve 2024 yılında 1 trilyon ABD dolarını aştığı bildirilmiştir (International Diabetes Federation, 2025). Bu sağlık harcamalarının önemli bir kısmını diyabet komplikasyonları tedavisinin oluşturduğu vurgulanmıştır (Williams ve ark., 2020). Bu nedenle, diyabetik nefropatinin prognozunu durdurmak için güncel tedavi yaklaşımlarının bulunması henüz karşılanmamış olan tıbbi bir ihtiyaç olup, araştırmacılar ve ilaç endüstrisinin önemli çalışma alanıdır (Lassén ve Daehn, 2020).

Dünya çapında en yaygın yetiştirilen meyvelerden biri olan üzüm (*Vitis spp.*), yılda yaklaşık 75 milyon ton kadar üretilmektedir (Unusan, 2020). Türkiye ise üzüm yetiştiriciliği için uygun yetiştirme ve iklim koşullarına sahip olduğundan geçmişten günümüze bağcılıkta önemli lokasyon haline gelmiş olup (Semerci ve ark., 2015) 2023/2024 yılında Türkiye'de 3,4 milyon dekar alanda 3,8 milyon ton üzüm üretimi gerçekleşmiştir (T.C. Tarım ve Orman Bakanlığı Tarımsal Ekonomi ve Politika Geliştirme Enstitüsü Müdürlüğü, 2024). Üzüm suyu ve şarap üretimi sonucu yüksek miktarda üzüm posasının bileşenleri olan kabuk, sap ve çekirdek gibi endüstriyel yan ürünler açığa çıkmaktadır (Rodríguez-Pérez ve ark., 2019). Şarap üretiminin artışı özellikle de büyük ölçekli işletmelerde, atık olan üzüm posası miktarını artırmaktadır. Posanın ısıl işlem kullanılarak bertaraf edilmesi, küresel ısınmaya yol açan faktörler arasında önemli bir yere sahiptir. Son yıllarda sürdürülebilir kalkınma hedefleri bağlamında yapılan çalışmalar, üzüm posasının içerdiği yüksek katma değerli biyoaktif bileşiklerin varlığını

vurgulamaktadır (Wang ve ark., 2024). Üzüm ağırlığının %20'sini oluşturan üzüm posası, ağırlıkça %52 üzüm çekirdeği içermektedir (Rodríguez-Pérez ve ark., 2019). Son araştırmalar, üzüm çekirdeklerindeki toplam flavonoid içeriğinin kabuk bileşeninden önemli ölçüde yüksek olduğunu göstermektedir (Tang ve ark., 2018). Özellikle proantosiyanidin bakımından zengin olan üzüm çekirdekleri, piyasadaki proantosiyanidin içeren ürünlerin ham maddesinin başlıca kaynağıdır (Qi ve ark., 2023). Proantosiyanidinlerin antioksidan, anti-inflamatuar aktivitelerine ve oksidatif stresle ilişkili hastalıkların tedavisinde terapötik bir ajan olarak kullanılma potansiyeline son yıllarda sıklıkla dikkat çekilmektedir (Ding ve ark., 2020). Diyabetik nefropatinin patogenezini oluşturan hiperglisemi aracılı oksidatif stres ve inflamasyon, böbrek dokusunda histopatolojik hasara ve son dönem böbrek yetmezliğine yol açmaktadır. Özellikle hücre ve molekül düzeyinde yapılan güncel araştırmalar, genetik ve epigenetik regülasyonların diyabetik nefropati patogenezinde büyük ölçüde rol oynadığını vurgulamaktadır (Lassén ve Daehn, 2020). Gen düzeyindeki regülasyonların yanı sıra mitokondriyal disfonksiyon gibi mekanizmaların anlaşılması, yeni ve alternatif tedavi yöntemlerinin geliştirilmesine olanak sağlamaktadır (Lin ve ark., 2018). Bu derlemede, üzüm çekirdeği proantosiyanidinlerinin diyabet kaynaklı böbrek hasarı ve diyabetik nefropati gelişimine karşı koruyucu etkileri ile bu etkilerin altında yatan gen düzeyindeki mekanizmaların incelenmesi amaçlanmaktadır.

DİYABETİK NEFROPATİ: PATOGENEZ VE MOLEKÜLER MEKANİZMALAR

Diyabetik nefropati mezengiyal genişleme, glomerül ve tübellerin bazal membranlarının kalınlaşmasının yanı sıra glomerülosklerozu gibi renal yapı değişiklikleri ve işlev bozuklukları ile karakterize bir hastalıktır. Albüminüri, kan basıncı artışı, azalmış glomerüler filtrasyon hızı (GFR), kardiyovasküler hastalıklara yatkınlık sebebiyle mortalite riskinin artışı, diyabetik nefropatinin klinik bulguları arasında yer almaktadır (Lin ve ark., 2018). Albüminüri hastalığın en belirgin klinik belirtisi olsa da (Lin ve ark., 2018), son yıllarda sıklıkla bazı diyabetli bireylerde albüminüri olmadan GFR'nin azaldığı ve böbrek işlevlerinde bozukluk olduğu tespit edildiğinden "diyabetik böbrek hastalığı" ifadesinin kullanımı yaygınlaşmıştır (T.C. Sağlık Bakanlığı Halk Sağlığı Genel Müdürlüğü, 2023). Diyabetik nefropatinin patogenezinde rol oynayan faktörler arasında oksidatif stres, inflamasyon, podositlerin otofajisi, böbrekte hemodinamik değişiklikler, hipoksi, anormal düzeyde aktive edilmiş renin-anjiyotensin-aldosteron sistemi (RAAS), mitokondriyal fonksiyon bozukluğu, epigenetik ve genetik regülasyonlar bulunmaktadır (Lv ve ark., 2020). Özellikle diyabet başlangıcında görülen ve prognozuna katkıda bulunan glomerül iç basıncının artışı ve hiperfiltrasyon, diyabetik nefropatinin patogenezinde hemodinamik faktörleri oluşturmaktadır (Sugahara ve ark., 2021).

Diyabette hiperglisemi aracılı protein kinaz C (PKC), poliol, heksoamin yolları ile ileri glikasyon ürünleri (AGE) üretimine neden olan yolların aktivasyonu reaktif oksijen türlerinin (ROS) oluşumuna yol açar (Sugahara ve ark., 2021). Pro-oksidanların antioksidanlar ile denge sınırını aştığı durumda ise oksidatif stres oluşmaktadır (Ajilore ve Ajilore, 2022). Moleküler seviyede diyabet gelişimine yol açan mekanizma ise hipergliseminin mitokondriyal elektron transfer zincirinde süperoksitlerin üretimine neden olmasıdır (Sugahara ve ark., 2021). Diyabette mitokondriyal disfonksiyon ve pro-oksidan olan NADPH oksidaz enzimi üretiminin artması da böbreklerde ROS seviyelerinde artışa neden olmaktadır (Sugahara ve ark., 2021). Ayrıca diyabette hiperglisemi, Janus Kinaz- Signal Transducer and Activator of Transcription (JAK-STAT) ile nükleer faktör kappa-B (NF-κB) aktivasyonunu indükler. NF-Kb'nin aktivasyonu ise adhezyon bileşiklerinin uyarılmasına ve makrofaj kemotaktik protein-1 (MCP-1), doku nekroz faktörü-α (TNF-α) ve interlökin-6 (IL-6) gibi pro-inflamatuar sitokinlerin yukarı yönde ifadesine neden olur. Tüm bu mekanizmalar diyabetik nefropatinin patogenezinde rol oynamaktadır (Sugahara ve ark., 2021). Hiperglisemi aracılı oksidatif stresin indüklediği ve diyabetik nefropatinin patogenezinde rol oynayan hücresel sinyal yollarından biri olan mitogenle aktive edilen kinaz (MAPK) aktivasyonu, podositlerin apoptozuna ve mezengiyal hücrelerin ekstraselüler matris üretimine yol açmaktadır (Sugahara ve ark., 2021). Bunun yanı sıra hiperglisemi ile üretilen ROS PKC, MAPK ve JAK/Stat sinyal

yollarının aktivasyonuna ve NF-κB gibi transkripsiyon faktörlerinin üretiminde artışa yol açarak renal hücrelerde TGF-β1 ile fibronektin seviyelerinin yükselmesine neden olmaktadır. Dolayısıyla bu olaylar ile oluşan ROS, ekstraselüler matris birikimine neden olur. Ayrıca ROS, glomerül boşluğu ve tübüllerde interstisyel genişlemeye yol açan ekstraselüler matris bölünmesinde ve tübül hücrelerinde epitel-mezenkimal geçişte rol oynamaktadır (Ajilore ve Ajilore, 2022). ROS, AGE ve reseptörleri (RAGE), anjiyotensin II tarafından da aktive edilebilen PKC yolu (Papadopoulou-Marketou ve ark., 2017) diyabette artış gösteren diasilgliserol (DAG) üretimi ile de uyarılabilir (Agarwal, 2021). Öte yandan ROS üretimine yol açan RAGE ekspresyonunun artışı da diyabetik komplikasyonların gelişiminde rol oynamaktadır (Ajilore ve Ajilore, 2022). Molekül ve hücre düzeyinde yapılan son çalışmalar, diyabetik nefropatinin gelişiminde podosit otofajisi, mitokondriyal disfonksiyon, genetik ve epigenetik regülasyonlarının rolünü vurgulamaktadır (Lin ve ark., 2018). Otofaji, hücre içindeki dengenin korunması için hücrenin organeller ve makromolekülleri yok ettiği "kendi kendini yeme" işlemidir. Podositlere özgü otofaji bozukluğu olan farelerde yüksek yağlı diyetten sonra podositlerin kaybı ve proteinüri artışı gözlemlenmiştir. Diğer bir deneysel çalışmada ise podosit otofajisini baskılayan mTORC1'in inhibasyonunun diyabetli farelerde diyabetik nefropatiye karşı koruyucu etki gösterdiği belirtilmiştir (Sugahara ve ark., 2021). Mitokondriyal disfonksiyon ise diyabette hipergliseminin ROS artışı, mitokondriyal bölünme ve mitokondriyal biyogenezin azalması ile mitokondriye direkt hasar vermesidir (Song ve ark., 2023). Genetik modifikasyonlar arasında ise nükleer faktör (eritroid türevi 2) benzeri 2 (Nrf2) üretiminin azalması bulunmaktadır. Bu transkripsiyon faktörü, ROS'un nötralizasyonu ve redoks dengesinde rol alarak hücresel antioksidan sistemi aktive etmektedir (Lin ve ark., 2018).

ÜZÜM ÇEKİRDEĞİ PROANTOSİYANİDİNLERİ

Flavonoid biyosentezinin oligomer ve polimer formundaki ürünleri olan proantosiyanidinler, kateşin ve epikateşin monomerlerinden oluşmaktadır (Rauf ve ark., 2019). Polimerizasyon derecesi yüksek olan proantosiyanidinlerin stabilitesi daha düşük olup, yoğunlaşma ve çökme eğilimi daha fazla iken oligomerik formlar 2-6 pH'ta daha kararlı yapı göstererek ısı ve ışığa daha dirençlidir (Qi ve ark., 2023). Bileşimindeki hidroksil grupları nedeniyle güçlü polariteye sahiptirler (Qi ve ark., 2023) ve bu sebeple polaritesi yüksek olan çözücülerde daha iyi çözünebilirler (An ve ark., 2023). Kondanse tanenler olarak da tanınan proantosiyanidinler, açık kırmızıdan koyu kırmızıya kadar değişen renk skalası ile birçok tahıl ve meyvede bulunmaktadır (Qi ve ark., 2023). Kararlılığı yüksek olmayan üzüm çekirdeği proantosiyanidinleri ısı, ışık ve pH ile parçalanabildiğinden, çeşitli uygulama ve ekstraksiyon zorlukları barındırmaktadır (An ve ark., 2023).

Üzüm çekirdeğinde gallik asit grubu taşıyan veya taşımayan B tipi proantosiyanidinler bulunmaktadır ve bu bileşikler flavon-3 ol monomerlerinin C4→C6 veya C4→C8 pozisyonlarından bağlanması ile oluşmaktadır (Rodríguez-Pérez ve ark., 2019). Üzüm çekirdeğindeki proantosiyanidin içeriği, 37 farklı üzüm çeşidinden çıkarılan çekirdeklerde ortalama 159 mg/kg olarak bulunmuştur (Rodríguez-Pérez ve ark., 2019). Özellikle oligomerik proantosiyanidinler anti-inflamatuar aktivitesi yüksek, vücut dengesini koruyan, güvenli ve etkinliği yüksek antioksidanlar olarak bilinmekte olup E vitamininden 50 kat, C vitamininden ise 20 kat yüksek antioksidan kapasiteye sahiptir (Qi ve ark., 2023). İnsan vücudunda biyoyararlanımı %85 olup tüketiminden sonra 20 dakika içinde emilirler (An ve ark., 2023). Üzümün kabuğunda bulunan proantosiyanidinlerin polimerizasyon seviyesi çekirdeklerinde bulunandan daha yüksektir, dolayısıyla bu polimerik proaantosiyanidinler sindirime uğramadan kolonda birikir ve parçalanmadan dışkıyla atılır. Dimer ve trimer gibi oligomerik formdaki proantosiyanidinler ise sindirimde kararlılık göstererek vücutta daha verimli emilebilir (An ve ark., 2023). Hayvan modelleri ve hücre kültürü çalışmaları, üzüm çekirdeğinde bulunan proantosiyanidinlerin antimikrobiyal, antiobezite, antidiyabetik, antioksidan, antikanserojen, nörodejeneratif hastalıklar ile osteoartriti önleyici, kalp ve göz gibi organlara karşı koruyucu etkilerini vurgulamaktadır. Dolayısıyla proantosiyanidinlerin çeşitli kronik hastalıklar üzerindeki koruyucu potansiyeli gıda endüstrisi ve

sağlıkla ilişkili kamu kurumlarının ilgi odağı haline gelmiştir (Qi ve ark., 2023). Gıda endüstrisinde etler ve içecekler gibi birçok gıdaya eklenerek renk canlılığı, antioksidatif etki ve antiseptik özellikler sağlayarak gıdaların kalitesi artırılmaktadır. Özellikle işlenmiş etlere eklenen nitrite doğal bir alternatif olarak kullanılması ile, mikrobiyal açıdan güvenli ve duyusal olarak kabul edilebilir et ürünleri elde edilmektedir (An ve ark., 2023). Üzüm çekirdeği ekstresinde bulunan biyoaktif bileşikler besinlere eklendiğinde tat değişikliği, acı tat gibi olumsuz duyusal özelliklere neden olabilir. Ayrıca sindirim sürecine, ışığa, ısıya ve pH'a karşı hassasiyeti nedeniyle gıdaların işlenmesi sırasında stabilite kayıpları olabilir. Bu bağlamda yapılan bir çalışmada süte fermente edilmeden önce %1 oranında mikrokapsüle formda üzüm çekirdeği özütü eklenmesi yoğurtların toplam fenolik içeriğini ve antioksidan aktivitesini önemli ölçüde artırmış olup renk, aroma, viskozite, asitlik ile probiyotik bakterilerin canlılığı kontrol grubuna benzer bulunmuştur. Kapsüllenmemiş formun eklediği yoğurt ise daha düşük duyusal kabul ve fenolik bileşik stabilitesi göstermiştir (Yadav ve ark., 2018). Üzüm çekirdeğinden ekstrakte edilen özütler ultra küçük toz haline getirildiğinde daha verimli bir şekilde sindirilip emildiği, bu formun kullanılması halinde bütün özüt kütlesinin kullanılabildiği ve dolayısıyla olumlu sağlık etkilerini daha iyi gösterebildiği belirtilmiştir (Chen ve ark., 2020). Toz formuna ek olarak doğrudan izole edilip nutrasötik formunda veya yağ formunda da kullanılabilir. Bu formlar süt ürünleri, işlenmiş etler, unlu mamullere katkı maddesi olarak eklenerek kalite parametreleri, antioksidan özellikler ile besin bileşimini olumlu yönde etkilemektedir (Georgiev ve ark., 2016).

Güvenlik Profili

Üzüm çekirdeği ekstresi ABD Gıda ve İlaç Dairesi (FDA) tarafından "Genel Olarak Güvenli Tanınan Madde" kabul edilmiş olup (FDA, 2003) **EAFUS** (Everything Added to Food in the United States) listesinde yer almaktadır (FDA, 2022). Hayvanlar üzerinde yapılan çalışmalarda üzüm çekirdeği özütünün olumsuz etkisi bildirilmemiş dozu dişiler için 1501 mg/kg/gün, erkekler için ise 1410 mg/kg/gün olarak belirlenmiştir. Bu çalışma sürecinde hayvanların hiçbirinin ölmediği bildirilmiştir (Yamakoshi ve ark., 2002). İnsan çalışmalarında da güvenliği vurgulanan üzüm çekirdeği özütünün, 4 hafta boyunca 29 sağlıklı Japon yetişkine 2500 mg/gün uygulanması ile önemli bir yan etkiye yol açmamıştır (Sano, 2017). Tunus Bizerte bölgesindeki kronik böbrek hastalarının dahil edildiği klinik bir çalışmada ise (Müdahale:30, kontrol:10) 6 ay boyunca yüksek dozda (1g/kg/gün) verilen üzüm çekirdeği unu takviyesi ile, plasebo grubuna kıyasla GFR'de önemli ölçüde iyileşme, ürik asit, proteinüri ve üre seviyelerinde azalma saptanmış olup hiçbir olumsuz yan etki gözlemlenmemiştir (Bejaoui ve ark., 2022). Öte yandan üzüm çekirdeği özütünün uzun süre boyunca yüksek miktarda tüketiminin çeşitli besin bileşenleriyle ve ilaçlarla etkileşime neden olabileceği veya gastrointestinal enzimler üzerinde olumsuz etki gösterebileceği de düşünülmektedir. Bu nedenle başta çocuklar olmak üzere hassas gruplarda güvenli kullanımı için gerekli çalışmaların yapılması gerekmektedir. Ancak önerilen miktarlarda kullanımının genellikle güvenli ve tolere edilebilir olduğu da belirtilmektedir (Unusan, 2020).

DİYABETİK NEFROPATİDE ÜZÜM ÇEKİRDEĞİ PROANTOSİYANİDİNLERİNİN GENETİK VE MOLEKÜLER DÜZEYDE TERAPÖTİK HEDEFLERİ

Nrf2 Aktivasyonu

Nrf2, Kelch benzeri ECH ile ilişkili protein 1 (Keap1) ve antioksidan yanıt elemanları (ARE) antioksidan sistemin yanıt regülasyonunda önemli rol oynayan hücre bileşenleridir (Magesh ve ark., 2012). Antioksidan sistemin önemli bir bileşeni olan Nrf2, antioksidan proteinlerin ekspresyonunu artırarak oksidatif stresin olumsuz etkilerini engeller (Ding ve ark., 2020). Nrf2 geninin baskılandığı diyabetik farelerde ciddi böbrek hasarı gözlemlenmiş olup bu genin aktive edilmesinin diyabetik nefropati gelişimini önlediği belirtilmiştir (Ding ve ark., 2020). Antioksidan sistemi yukarı yönde regüle etmesinin yanı sıra Nrf2, AGE'lerin ve Nf-Kb'nin inhibasyonu ile de ROS üretimini ve inflamasyonu

azaltabilir. Buna ek olarak karbonhidrat ve yağ metabolizması ile mitokondriyal fonksiyon üzerinde olumlu etki gösterir ve insulin duyarlılığını artırır (Tanase ve ark., 2022). Bu yüzden Nrf2'nin aktivasyonu diyabetik nefropati tedavisi için terapötik bir hedef haline gelmiştir (Ding ve ark., 2020).

Mitokondriyal Biyogenez

Diyabette mitokondriyal disfonksiyon, hipergliseminin mitokondri hasarına neden olarak ROS oluşumuna, mitokondriyal bölünmeye ve mitokondriyal biyogenezde düşük verime yol açmasıdır. Özellikle Mitofusin 1 (MFN1) gibi füzyon ve dinaminle ilişkili protein 1 (Drp1) gibi fisyon proteinlerinin mitokondride denge dinamiklerinin düzenlenmesinde önemli olduğu belirtilmiştir (Song ve ark., 2023). Ayrıca Sirtuin 1 (SIRT1) - Peroksisom proliferatörle aktive edilen reseptör-γ koaktivatör-1α (PGC-1α) yolu, mitokondriyal transkripsiyon faktörü A (TFAM) ve nükleer solunum faktörü (NRF1) de mitokondriyal biyogenezin düzenleyicisi olarak aktivite göstermektedir (Song ve ark., 2023). Son çalışmalarda böbrek tübüllerinde oksidatif stres belirteci olan p66shc'nin ekspresyonunun diyabetik nefropati hastalarında önemli ölçüde arttığı bildirilmiştir (Zheng ve ark., 2020). Yüksek glikoz ortamında p66shc, serin aminoasidinde fosforile olarak mitokondriye taşınır ve sitokrom c salınımını indükleyerek elektron transfer zincirini olumsuz etkiler. Öte yandan SIRT1 ekspresyonunun regülasyonu yoluyla da mitokondriyal biyogenezi etkileyebilir. Dolayısıyla ROS oluşumunu artırır, mitokondri fonksiyonlarını olumsuz etkiler ve apoptozu tetikler (Song ve ark., 2023).

ERS-Kaspaz-12 Apoptoz Yolu

Toksik bileşikler, hipoksi ve yüksek glukoz toksisitesi dahil olmak üzere çeşitli strese neden olan faktörler endoplazmik retikulum işlevlerini olumsuz yönde etkileyerek anormal protein birikimi ve kalsiyum iyon dengesinin bozulmasına neden olarak endoplazmik retikulum stresine (ERS) yol açmaktadır. ERS seviyesi yükseldiğinde endoplazmik retikulumun özgül bileşeni olan kaspaz-12 aktif hale gelerek ERS aracılı apoptozu indükler. Ayrıca bu süreçte GRP78 ve p-ERK de ERS göstergesidir (Gao ve ark., 2018).

p38 MAPK ve NF-kB İnhibasyonu

Apoptoz, hücre çoğalması ve farklılaşması gibi hücresel işlevlerin regülasyonunda önemli rol oynayan Mitojenle Aktive Olan Protein Kinazın (MAPK) yolakları arasında yer alan p38 MAPK diyabet ve diyabetik nefropati patogenezine katkı sağlamakta olup podosit apoptozuna neden olmaktadır. Yüksek glikoz düzeylerinin etkisiyle p38 MAPK yolunun aktif hale gelmesi, pankreas β-hücrelerinde apoptoz süreciyle ilişkilendirilmiştir. Diyabetik nefropatinin başlangıcında bu yolun aktive olduğu ve zamanla podositlerin kaybı, albümin atılımında artış ve glomerüloskleroz gelişiminin ardından böbrek dış tabakasında bu etkinliğin devam ettiği rapor edilmiştir (Gong ve ark., 2022). Buna ek olarak NF-κβ ifadesinin baskılanması da inflamasyonu engelleyerek diyabetik nefropatide terapötik hedef stratejisi olabilir (Suryavanshi ve Kulkarni, 2017).

Deneysel Çalışmalar ile Gen Düzeyinde Koruyucu Etkiler

Hücre kültürü ve hayvan modelleriyle yapılan son çalışmalar farklı dozlarda üzüm çekirdeği proantosiyanidinlerinin Nrf2 sinyal yolunun aktivasyonu ile Nrf2 ve ilişkili HO-1 ve NQO1 gibi alt genlerin mRNA ifadesinde önemli ölçüde artış gösterdiğini vurgulamıştır (Ding ve ark., 2020; Li ve ark., 2023). Streptozotosin (STZ) ile indüklenen diyabetli sıçanlara 8 hafta boyunca yüksek (n:10, 250 mg/kg/gün) ve düşük doz (n:10, 125 mg/kg/gün) üzüm çekirdeği proantosiyanidin özütü tedavisinin (GSPE), özellikle yüksek dozda uygulanması böbrekte yapısal hasarı, açlık glukozunu, kreatin, ürik asit, kan üre azotu (BUN) ve malondialdehit (MDA) düzeylerini önemli ölçüde azaltmıştır. Ayrıca antioksidan enzimler (GSH, SOD) ile toplam antioksidan kapasitede artış gözlenmiş olup bu olumlu etkiler Nrf2 aktivasyonu ile ilişkilendirilmiştir (Ding ve ark., 2020). Gong ve ark.'nın çalışmasında da Nrf2 ekspresyonunun artışının yanı sıra p38 MAPK ekspresyonunun azalması vurgulanmış olup

kadminyum ile oluşturulan diyabetik nefropati modelinde dört hafta boyunca 5 mg/kg oligomerik üzüm çekirdeği proantosiyanidin tedavisinin etkileri incelenmiştir (Gong ve ark., 2022). Diğer bir çalışmada ise diyabetik sıçanlara 16 hafta boyunca günlük 250 mg/kg dozda GSPE uygulanması, serumda BUN ve kreatinin seviyelerini etkilemese de böbrek indeksi ve albüminüriyi önemli ölçüde azaltmıştır. Bu çalışmada GSPE tedavisinin, ERS belirteçleri olan GRP78 ve p-ERK ile kaspaz-12 ekspresyonunu diyabetik gruba kıyasla azalttığı bildirilmiştir ($p < 0.05$) (Gao ve ark., 2018). Song ve ark. tarafından yapılan in vitro ve in vivo bir çalışmanın bulguları ise GSPE tedavisinin apoptozu engellemede p66shc susturulması ile benzer etkinik gösterdiğini ve apoptoz belirteci olan proteinlerin (cleaved kaspaz-3, sitokrom c ve DIABLO) ekspresyonunu azalttığını vurgulamaktadır. P66shc ifadesinin artışı mitokondriyal biyogenezi (SIRT1, PGC-1α, NRF1 ve TFAM) ve dinamikleri (MFN1) olumlu etkileyen proteinlerin ekspresyonunu azaltırken, GSPE tedavisi bu durumu tersine çevirerek mitokondriyal bölünmeyi teşvik eden Drp1 ile p66shc ekspresyonunu azaltmıştır (Song ve ark., 2023).

Ayrıca diyabetik nefropatide GSPE, likopen ve kombinasyonlarının uygulandığı bir çalışmada GSPE uygulanması açlık glukozu, kreatinin ve albüminüriyi azaltmada likopen tedavisinden daha etkili bulunmuştur. Bütün tedavi gruplarında antioksidan enzimlerin aktiviteleri artarken MDA düzeyleri azalmıştır ve bu etki azalan TGFβ1, NFκB gibi genlerin ekspresyonuna ($p < 0,05$) atfedilmiştir (Li ve ark., 2025). Yine 24 hafta boyunca günde 250 mg/kg GSPE, AGEs/RAGE yolunun ekspresyonunu azaltarak ve nefrin ekspresyonunu artırarak diyabetik sıçanlarda böbrek hasarını hafifletmiş, idrarla albümin atılımını azaltmıştır (Li ve ark., 2017).

SONUÇ VE ÖNERİLER

Diyabetik nefropati, diyabetin önemli komplikasyonlarından biridir ve oksidatif stres, inflamasyon ile mitokondriyal disfonksiyon gibi çoklu mekanizmaları içermektedir. Üzüm çekirdeği proantosiyanidinleri bu patolojik süreçte yer alan sinyal yolaklarını antioksidan, antienflamatuar ve gen ekspresyonunu düzenleyici etkilerle modüle edebilme potansiyeline sahiptir. Hücre ve hayvan deneylerinde GSPE'nin özellikle p66Shc, SIRT1 ve Nrf2 gibi yollar üzerinde etkili olduğu gösterilmiştir. Klinik çalışmalarla desteklenmesi gereken bu bulgular, GSPE'nin moleküler düzeyde koruyucu etkilerini anlamada önemlidir. Ancak, düşük biyoyararlanım ve sınırlı farmakokinetik veriler, klinik kullanıma geçişte önemli engeller oluşturmaktadır. Bu nedenle, farklı formülasyonlarla biyoyararlanımın artırılmasına yönelik araştırmalara ihtiyaç vardır. Öte yandan, üzüm çekirdeği gibi bitkisel atıkların değerlendirilmesi, sürdürülebilirlik açısından da önem taşımaktadır.

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TWO CONTINENTAL FACES OF PUBLIC ARCHAEOLOGY: A COMPARATIVE PERSPECTIVE FROM TÜRKİYE AND THE UNITED STATES

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ABSTRACT

Public archaeology is a participatory discipline that seeks to make the past accessible and meaningful not only to academic circles but also to broader communities. This study offers a comparative analysis of public archaeology practices in Turkey and the United States, focusing on their historical, cultural, and legal frameworks. While both countries aim to preserve cultural heritage, foster social identity, and increase public access to archaeological knowledge, the methods and approaches they adopt differ significantly. In Turkey, public archaeology is generally framed around academic excavation projects. Although local communities may engage with these projects, participation is often passive and limited. The Çatalhöyük excavations, for example, have introduced educational workshops and heritage awareness programs to involve local residents. In contrast, the United States presents a more grassroots and community-driven model, especially through its engagement with Native American communities and the legal infrastructure provided by acts like the Native American Graves Protection and Repatriation Act (NAGPRA). Institutions such as the Crow Canyon Archaeological Center demonstrate an inclusive model where community participation and educational outreach are central components. This comparative analysis argues that the relationship between archaeology and society is not only cultural but also inherently political. For public archaeology to be effective, each country must develop context-specific participatory models that reflect its social fabric and historical experience. In doing so, archaeological knowledge can function not merely as scientific output, but as a shared instrument of collective memory and identity.

Keywords: Public archaeology, cultural heritage, participatory methods, archaeology in Turkey, archaeology in the USA

1. Introduction

Public archaeology is a broad umbrella term describing the interaction of archaeological practice with the public. While at its most basic level it involves sharing the results of archaeological research with the public (Papadopoulos & Anzalone, 2019), this simple definition conceals the complex power relations and philosophical debates underlying the field. Particularly when viewed from non-Anglo-Saxon perspectives, the concept of "the public" itself becomes problematic. "The public" should not be seen as a homogeneous, passive mass awaiting information, but as a structure composed of numerous different communities with their own agendas, knowledge, and connections to the past. Therefore, public archaeology is increasingly evolving from a one-way transfer of information to a multi-directional process of dialogue and collaboration among different stakeholders.

The foundations of the concept of public archaeology cannot be reduced solely to the discipline's efforts to communicate with the public. Habermas's theory of the "public sphere" (Öffentlichkeit) helps us understand the relationship of public archaeology with the principles of transparency in knowledge production, a culture of critical debate, and democratic participation. Benedict Anderson's "imagined

communities" approach, on the other hand, reveals how archaeological heritage creates a shared historical narrative in the context of nation-state identity building.

Representations of archaeology in popular culture, such as the Indiana Jones films, National Geographic documentaries, or viral excavation images on social media, create a perception of archaeology among the general public that is both romanticized and often detached from reality. This perception reinforces the tendency to see archaeology only as an exotic and mysterious exploration of the past, while rendering its social, political, and ethical dimensions invisible. Consequently, public archaeology assumes the responsibility not only of transferring information but also of developing a critical discourse against such reductionist representations.

This evolution acknowledges that the interpretation of the past is not a neutral act but contains deep politics. The relationships between heritage, identity, and community are always a contested area, and archaeological practices are part of these contests (Tully, 2007). The current development of public archaeology is proceeding along two main axes. The first is the understanding of participatory democracy and local ownership, where local communities are given a voice and decision-making power over heritage sites. The second is the critical heritage approach, which accepts that the past is not independent of power relations and questions by whom and for what purpose historical narratives are constructed.

This article will examine how these two axes have been shaped in different socio-political contexts like Turkey and the United States, how they have evolved through historical turning points, and how they are trying to meet the new opportunities and risks brought by the digital age.

2. Method

This study employs a comparative case study methodology to analyze public archaeology practices in Turkey and the United States. The analysis is based on a qualitative approach to reveal the developments, motivations, and practical differences in public archaeology in the two countries. The data collection process involved a review of relevant academic literature (articles, books), legal texts (Law No. 2863 on the Protection of Cultural and Natural Assets in Turkey; NAGPRA in the U.S.), and reports on selected pioneering case studies from both countries (e.g., projects at Çatalhöyük and with the Amah Mutsun Tribal Band). These two countries were chosen because they represent contrasting models for heritage management: a centralized approach (Turkey) versus a rights-based, decentralized approach (U.S.). The analysis aims to show how public archaeology practices are shaped by their respective political and cultural contexts by comparing the underlying power relations, definitions of the public, and methods of participation in the two models.

3. Results

3.1. The Turkish Perspective: National Identity, Centralized Heritage, and the Search for Participation

In Turkey, archaeology has played a central role in the construction of national identity since the founding of the Republic. Archaeological heritage has been seen as a tool to historically prove the Turkishness of Anatolian lands and to legitimize its place within Western civilization (Abi, 2021). This state-focused approach has created a centralized legal and institutional structure that defines archaeological assets as the absolute property of the state. The Law on the Protection of Cultural and Natural Assets No. 2863 forms the most important legal basis for this understanding. Within such a structure, public archaeology has mostly developed as a top-down model, acting with the mission of enlightening the public and conveying accurate historical information to them.

Most community archaeology practices in Turkey remain a side activity of academic excavation projects, and the meaningful participation of the local population in the process is limited (Altay, Ateş, & Mania, 2022). While such efforts increase interest in archaeology, they often fall short of creating a

critical dialogue environment, sometimes featuring a sensationalized and simplified presentation (Şahin, 2018).

Post-1980 neoliberal policies led to the greater prominence of tourism-oriented development strategies in cultural heritage management. Especially in the promotion of sites inscribed on the UNESCO World Heritage List, international visibility and tourism revenues have often taken precedence over local participation. This situation has often caused the balance between the economic value and the social value of heritage to be disrupted in favor of the economic.

Despite this, there are also examples that question the centralist tendency and develop more participatory models. Community archaeology initiatives show how archaeological heritage can be a catalyst for rural development and local ownership. These initiatives aim to understand the expectations of the local people and their relationship with the heritage by establishing a direct dialogue, thus going beyond the one-way transfer of information in heritage management (Özrili, 2023).

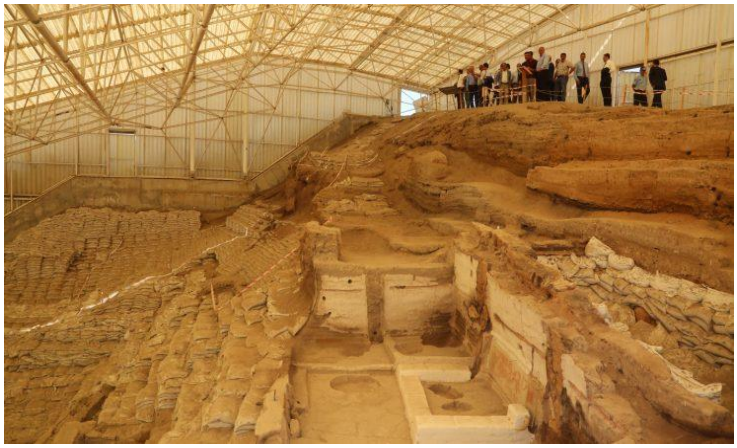


Figure 1. A public archaeology event held in an archaeological site in Çatalhöyük with the participation of the local community. Such projects encourage communities to take an active role in heritage preservation (Photo by DHA, 2017).

3.2. The U.S. Perspective: Decolonization, Collaboration, and Rights-Based Archaeology

The development trajectory of public archaeology in the United States is fundamentally different from the model in Turkey. At the core of this difference lies the centuries-long struggle for civil rights and sovereignty by Indigenous communities. For Indigenous peoples, archaeology was long seen as a colonial discipline that disturbed the graves of their ancestors, took their sacred objects, and redefined their past from its own perspective. This deeply traumatic relationship began to be questioned from the second half of the 20th century, and archaeologists accepted the necessity of critically evaluating their own practices and establishing a new form of relationship with Indigenous communities.

One of the most important philosophical foundations of this transformation is the Indigenous Archaeology and Community-Based Participatory Research (CBPR) approaches (Atalay, 2019). These approaches go beyond standard participatory models by centering Indigenous knowledge systems and community sovereignty. The goal is not just to conduct research *about* Indigenous people, but to conduct research *with* and *for* them (Atalay, 2020). Thus, archaeology is attempted to be decolonized, that is, purified from colonial forms of knowledge production and power relations.

The legal ground for this philosophical change was strengthened by the Native American Graves Protection and Repatriation Act (NAGPRA), which came into force in 1990. NAGPRA and similar laws have created a mandatory framework for collaboration between archaeologists and Indigenous communities and have significantly shifted the balance of power (Wright, 2015). NAGPRA granted

Indigenous communities legal say over the human remains and cultural items of their ancestors and initiated official processes for the repatriation of these items.

In practice, however, this collaboration does not always proceed smoothly. In some cases, universities and museums have difficulty determining the origin of cultural objects in their inventories or slow down the repatriation process with bureaucratic obstacles (Baram, 2011). Nevertheless, NAGPRA has been a turning point that has profoundly changed the influence of Indigenous communities on archaeology.



Figure 2. An excavation took place on Amah Mutsun tribal land in the Santa Cruz mountains in 2017. The project involved a tribal steward inside the excavation pit, accompanied by another tribal member and a UC Berkeley archaeology graduate student (Photo by Kent Lightfoot, 2017).

At the methodological level, oral history studies have become an important way to include the memories, traditions, and knowledge of the past of Indigenous communities in the research process, alongside Western scientific data collection methods. In this way, the past can be reconstructed not only through material culture but also through community memory.

4. Discussion

When comparing public archaeology practices in Turkey and the United States, it is seen that the fundamental distinction emerges in the way the ownership of heritage is defined and in the nature of community participation. The Turkish model is based on a centralist understanding that sees heritage as the absolute property of the state. In this model, the public is not the direct rights-holder of the heritage but its beneficiary. Participation is mostly provided through information, education, and popularization activities. In contrast, the U.S. model defines heritage as part of the cultural and legal rights of Indigenous communities. Here, the concept of the public refers to communities with a specific legal status that have the right to dispose of their own cultural heritage. Participation does not remain at the level of information but includes collaboration, consultation, and joint research processes.

The following comparison summarizes the structural differences in the public archaeology approaches of the two countries:

Comparison Criterion	Turkish Model	United States Model
Owner of Heritage	The State (Law No. 2863); the public is a beneficiary.	Descendant communities (NAGPRA); heritage is a subject of rights.
Primary Motivation	National identity building, tourism, public education.	Social justice, decolonization, community sovereignty.
Power Relationship	Vertical: Expert → Public.	Horizontal: Partnership and mandatory collaboration.
Definition of Public	Abstract public or local people.	Communities with specific rights.
Method of Participation	Information, education, popularization.	Collaboration, consultation, joint research, oral history.

Table 1. Structural differences in the public archaeology approaches of the two countries.

These differences reveal that archaeological practices are fed not only by scientific preferences but also by legal, political, and cultural contexts. In Turkey, the boundaries of public archaeology are largely determined by state policies, national identity construction, and tourism goals. In the U.S., the rights struggles of Indigenous communities and legal regulations are the most important factors determining the direction of this field.

The rise of the digital age has transformed the methods of public archaeology in both countries. Digital tools have the potential to increase public participation in archaeology (Richardson & Dixon, 2017), and new media like video games are changing how the past is represented (Perry & Beale, 2015). Virtual museums, three-dimensional modeling, online excavation diaries, and social media-based heritage projects stand out as tools that democratize access to archaeological information (Reilly, 2015). However, these developments also bring new problems, such as digital barriers to democratic heritage (Taylor & Gibson, 2016) and the rise of AI in archaeology (Mantovan & Nanni, 2020; Bellat et al., 2025).



Figure 3. Digital archaeology, while using technologies like 3D modeling and virtual reality to make heritage more accessible to the public, also introduces new ethical challenges, such as "digital colonialism" (Photo by Giacomo Landeschi, 2023).

In particular, the concept of "digital colonialism" offers a critical framework that questions by whom, by what methods, and for whom digitized heritage data is produced. From the perspective of Indigenous and local communities, the control of digital heritage projects by external actors can pose serious risks to cultural sovereignty. Therefore, for the opportunities offered by digitalization to be used in a fair and inclusive manner, it is necessary to define ethical principles as strongly as the technological infrastructure.

5. Conclusion

This study has shown that public archaeology cannot be reduced to a universal definition or a standard model, but rather is a unique practice shaped within each country's own historical, legal, and social context. In Turkey, public archaeology is progressing on the tension line between the strong centralist heritage management tradition and innovative initiatives aimed at increasing the participation of local communities. The policies of the state using heritage for national identity construction often take precedence over local participation in the management of archaeological sites, limiting the active role of communities over heritage. However, examples show that by including the local population in the process, both the protection of heritage and social benefit can be increased.

In the United States, on the other hand, public archaeology has undergone a radical transformation as a result of the long-term rights struggles of Indigenous communities. Legal regulations like NAGPRA have redefined power relations in the field of archaeology, moving Indigenous communities from being passive objects of heritage to active subjects. This model has placed concepts such as social justice, community sovereignty, and cultural continuity at the center of public archaeology, moving research processes to an egalitarian and collaborative ground.

Both countries hold important lessons that they can learn from each other. Practitioners in Turkey can be inspired by the rights-based and partnership-based models in the U.S. to stop seeing local communities merely as masses to be informed. Participatory planning processes, consideration of local knowledge systems, and increasing community representation in decision-making mechanisms are concrete steps that can be taken in this direction. Practitioners in the U.S., by better understanding the

complex relationships between national identity, historical narratives, and heritage management in regions with multi-layered cultural heritage like Turkey, can enrich their own models with these experiences.

The digital age creates both opportunities and risks in both contexts. Although technology has the potential to increase access to archaeological information and participation, this potential cannot be fully realized without resolving ethical issues such as digital colonialism, data control, and cultural representation problems. Therefore, the legitimacy of public archaeology in the 21st century will be measured not only by scientific achievements but also by its ability to make the past fair, inclusive, and meaningful for all communities that live it.

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THE ROLE OF ROBOTICS COMPETITIONS IN ENHANCING MIDDLE SCHOOL SCIENCE LEARNING: A QUALITATIVE STUDY ON TEACHER PERSPECTIVES

ROBOTİK YARIŞMALARININ ORTAOKUL FEN ÖĞRENİMİNİ GELİŞTİRMEDEKİ ROLÜ: ÖĞRETMEN GÖRÜŞLERİ ÜZERİNE NİTEL BİR ÇALIŞMA

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ABSTRACT

The significance of technological integration and 21st-century skills in education is progressively increasing. Robotics competitions offer substantial opportunities to cultivate these skills within a constructivist learning environment. This study aims to thoroughly investigate the cognitive and affective changes in middle school students participating in robotics competitions and the contribution of these competitions to the science teaching process, through the perspectives of their teachers. Employing a qualitative case study design, the participants comprised five science teachers in Kayseri, Turkey, whose students have participated in robotics competitions. Semi-structured interviews were conducted with participants selected via maximum variation sampling, and the data were subjected to content analysis. The findings indicate that teachers regard robotics competitions as a critical tool for enriching the instructional process. According to teacher observations, students participating in competitions demonstrated marked improvements in problem-solving, teamwork, entrepreneurship, and psychomotor skills. Furthermore, an increase in students' interest in science courses and STEM-oriented careers was identified. It was emphasized that robotics experiences particularly facilitate learning in units such as "electricity" and "simple machines." Due to these positive observed outcomes, teachers reported actively encouraging all students to participate in competitions. The study reveals that robotics competitions are effective in translating theoretical knowledge into practice in science education and underscores the necessity for curriculum integration and teacher training.

Keywords: Robotics Competitions, Science Education, Teacher Perspectives, STEM, 21st-Century Skills, Case Study

** This study is a product of the doctoral research conducted by the first author under the academic supervision of the second author.*

ÖZET

Teknolojik entegrasyonun ve 21. yüzyıl becerilerinin eğitimdeki önemi giderek artmaktadır. Robotik yarışmaları, bu becerileri yapılandırmacı bir öğrenme ortamında geliştirmek için önemli fırsatlar sunmaktadır. Bu araştırma, robotik yarışmalarına katılan ortaokul öğrencilerindeki bilişsel ve duyuşsal değişimleri ve bu yarışmaların fen bilimleri öğretim sürecine katkılarını öğretmen görüşleri aracılığıyla derinlemesine incelemeyi amaçlamaktadır. Nitel araştırma yöntemlerinden durum çalışması deseniyle yürütülen çalışmanın katılımcıları, Kayseri ilinde görev yapan ve öğrencileri robotik yarışmalara katılmış beş fen bilimleri öğretmeninden oluşmaktadır. Maksimum çeşitlilik örneklemesi ile belirlenen katılımcılarla yarı yapılandırılmış görüşmeler yapılmış ve veriler içerik analizi ile çözümlenmiştir. Bulgular, öğretmenlerin robotik yarışmalarını öğretim sürecini zenginleştiren kritik bir araç olarak

değerlendirdiğini göstermektedir. Öğretmen gözlemlerine göre, yarışmalara katılan öğrencilerin problem çözme, takım çalışması, girişimcilik ve psikomotor becerilerinde belirgin bir gelişim yaşanmaktadır. Ayrıca, öğrencilerin fen bilimleri dersine ve STEM odaklı kariyerlere yönelik ilgilerinde artış tespit edilmiştir. Robotik deneyimlerin özellikle "elektrik" ve "basit makineler" gibi ünitelerin öğrenilmesini kolaylaştırdığı vurgulanmıştır. Öğretmenler, gözlemlenen bu olumlu çıktılar nedeniyle tüm öğrencileri yarışmalara katılmaya teşvik ettiklerini belirtmişlerdir. Çalışma, robotik yarışmalarının fen eğitiminde teorik bilgiyi pratiğe dönüştürmede etkili olduğunu ortaya koymakta ve müfredata entegrasyonu ile öğretmen eğitimlerinin gerekliliğini vurgulamaktadır.

Anahtar Kelimeler: Robotik Yarışmaları, Fen Bilimleri Eğitimi, Öğretmen Görüşleri, STEM, 21. Yüzyıl Becerileri, Durum Çalışması

**Bu çalışma, birinci yazar tarafından, ikinci yazarın akademik danışmanlığı altında yürütülen doktora araştırmasının bir ürünüdür.*

GİRİŞ

Dijital dönüşümün ve Endüstri 4.0'ın şekillendirdiği küresel dizayn, eğitim sistemlerini temelden yeniden düşünmeye ve dönüştürmeye zorlamaktadır. 21. yüzyılın ekonomik ve sosyal dinamikleri, öğrencilerin yalnızca temel akademik bilgileri edinmelerinin ötesinde; eleştirel düşünme, problem çözme, yaratıcılık, iş birliği ve dijital okuryazarlık gibi üst düzey becerilerle donatılmasını zorunlu kılmaktadır (P21, 2019; Coşkun ve Filiz, 2023). Bu bağlamda, geleneksel, öğretmen merkezli pedagojilerin yerini, öğreneni bilgi tüketicisi konumundan bilgi üreticisi ve anlam yapılandırıcısı konumuna taşıyan yapılandırmacı ve inşacı öğrenme yaklaşımları almaktadır (Perkins, 1999). Özellikle Seymour Papert'in öncülüğünü yaptığı inşacı öğrenme teorisi, öğrencilerin somut, paylaşılabilir eserler (örneğin robotlar, programlar) üreterek en derin öğrenmeyi gerçekleştirdiğini savunur. Bu teoriye göre, zihinsel yapıların inşası, fiziksel dünyadaki yapıların inşasıyla güçlü bir paralellik gösterir (Papert, 1980).

Bu pedagojik dönüşümün en güçlü katalizörlerinden biri, şüphesiz eğitimde teknoloji entegrasyonudur. Teknolojik araçlar, doğru kullanıldığında, soyut kavramları somutlaştırma, disiplinlerarası bağlantılar kurma ve otantik öğrenme deneyimleri sunma potansiyeli taşır (Ertmer, 1999). Bu teknolojik uygulamalar arasında, özellikle STEM (Fen, Teknoloji, Mühendislik ve Matematik) disiplinlerinin entegrasyonu için sunduğu imkanlar nedeniyle eğitim robotları öne çıkmaktadır. Eğitim robotları, öğrencilere mekanik, elektronik ve yazılım prensiplerini bir araya getiren somut projeler üzerinden öğrenme fırsatı sunarak, Papert'in (1980) inşacı öğrenme vizyonunu hayata geçiren ideal platformlar olarak kabul edilmektedir (Alimisis vd., 2007). Literatür, robotik uygulamalarının öğrencilerin problem çözme becerilerini (Kaya, Korkmaz ve Çakır, 2020), bilimsel süreç becerilerini (Sullivan, 2008; Çavaş vd., 2012) ve bilgi işlemsel düşünme yeteneklerini (computational thinking) geliştirdiğini gösteren zengin bulgular sunmaktadır (Bers, 2010). Wang ve arkadaşlarının (2023) yürüttüğü kapsamlı bir meta-analiz çalışması da eğitim robotlarının öğrenme çıktıları üzerindeki genel etkililiğini istatistiksel olarak teyit etmiştir.

Eğitim robotlarının potansiyelini bir adım öteye taşıyan uygulama ise rekabete dayalı robotik yarışmalarıdır. TEKNOFEST, FRC (FIRST Robotics Competition), WRO (World Robot Olympiad) ve FLL (FIRST LEGO League) gibi ulusal ve uluslararası düzeyde düzenlenen bu yarışmalar, öğrencilere yalnızca teknik beceriler kazandırmakla kalmaz, aynı zamanda onları otantik, karmaşık ve zaman baskısı altında problem çözmeye teşvik eden ekosistemler sunar (Aroca vd., 2016). Bu yarışmalar, öğrencileri takım çalışması, proje yönetimi, liderlik ve kriz anında karar verme gibi profesyonel hayatta kritik öneme sahip sosyal ve duyuşsal becerileri geliştirmeye yöneltir (Welch & Huffman, 2011). Ayrıca, bu tür etkinliklerin öğrencilerin STEM alanlarına yönelik kariyer ilgilerini ve motivasyonlarını

artırdığına dair güçlü kanıtlar bulunmaktadır (Aydın, 2021; Nugent, Barker, & Grandgenett, 2012). Ancak, mevcut literatürün önemli bir kısmı, robotik uygulamalarının etkilerini nicel yöntemlerle ve genellikle öğrenci çıktılarına odaklanarak incelemiştir. Robotik yarışmaları gibi karmaşık ve çok katmanlı bir öğrenme deneyiminin, öğretim sürecinin merkezindeki aktörler olan öğretmenler tarafından nasıl algılandığı, yorumlandığı ve deneyimlendiği konusu görece daha az araştırılmıştır.

Öğretmenler, teknoloji entegrasyonunun başarıya ulaşmasında kilit bir role sahiptir ve onların inançları, deneyimleri ve pedagojik yaklaşımları, bir eğitimsel müdahalenin etkililiğini doğrudan belirler (Kim, Kim, Lee, Spector, & DeMeester, 2013; Ertmer, 1999). Özellikle fen bilimleri gibi deneysel ve uygulamalı bir alanda, öğretmenlerin robotik yarışmalarını müfredatla nasıl ilişkilendirdiği, öğrencilerin bilişsel ve duyuşsal gelişimlerini nasıl gözlemlediği ve bu süreci nasıl yönettikleri, hem teorik hem de pratik açıdan büyük önem taşımaktadır. Türkiye bağlamında, 2000'li yılların başından itibaren yapılandırmacı yaklaşıma geçiş (MEB, 2006) ve son yıllarda artan teknoloji ve STEM odaklı eğitim politikaları göz önüne alındığında, robotik yarışmalarının fen bilimleri öğretimindeki yerini öğretmen perspektifinden inceleyen nitel çalışmalara ihtiyaç duyulmaktadır. Bu çalışma, literatürdeki bu boşluğu doldurmayı hedeflemektedir.

Bu araştırmanın temel amacı, ortaokul düzeyinde robotik yarışmalarına katılan öğrencilerin fen bilimleri öğretmenlerinin gözünden, bu yarışma sürecinin öğrencilerin bilişsel ve duyuşsal gelişimlerine, fen bilimleri dersine yönelik tutumlarına ve öğretim sürecine olan katkılarını derinlemesine analiz etmektir. Bu genel amaç doğrultusunda, aşağıdaki araştırma sorularına yanıt aranacaktır:

i. Fen bilimleri öğretmenleri, robotik yarışmalarının öğretim süreçlerine ve öğrenci motivasyonuna katkısını nasıl değerlendirmektedir?

ii. Öğretmenlerin gözlemlerine göre, robotik yarışmaları öğrencilerin fen bilimleri dersiyle ilişkili bilişsel (problem çözme, eleştirel düşünme vb.) ve duyuşsal (takım çalışması, özgüven, girişimcilik vb.) becerilerini nasıl şekillendirmektedir?

iii. Öğretmen perspektifinden, robotik yarışmaları fen bilimleri müfredatındaki hangi spesifik konu alanlarının (örneğin, elektrik, basit makineler, enerji dönüşümleri) öğrenilmesine somut avantajlar sağlamaktadır?

iv. Fen bilimleri öğretmenlerinin, öğrencileri robotik yarışmalarına katılım için teşvik etme yaklaşımları ve bu süreçteki motivasyon kaynakları nelerdir?

Bu sorulara verilecek yanıtlar aracılığıyla elde edilecek nitel bulguların, Türkiye'deki eğitim politikalarının ve müfredat geliştirme süreçlerinin kanıta dayalı bir şekilde yönlendirilmesine, öğretmenlere yönelik hizmet içi eğitim programlarının tasarlanmasına ve robotik uygulamalarının fen eğitimine daha etkin bir şekilde entegre edilmesine yönelik somut ve uygulanabilir öneriler sunması beklenmektedir.

YÖNTEM

Bu bölümde araştırmanın deseni, katılımcıların seçim süreci, veri toplama araçlarının geliştirilmesi ve uygulanması, verilerin analizi, araştırmanın inandırıcılığını sağlamak için izlenen stratejiler ve etik hususlar ayrıntılı olarak sunulmuştur.

Araştırma Deseni

Bu çalışma, fen bilimleri öğretmenlerinin robotik yarışmaları deneyimlerini ve bu deneyimlere atfettikleri anlamları derinlemesine keşfetmeyi amaçladığından, nitel araştırma yaklaşımı benimsenmiştir. Nitel araştırma, bireylerin sosyal dünyayı nasıl yorumladıklarını ve deneyimlediklerini kendi doğal ortamları içinde anlamaya odaklanır (Creswell & Poth, 2018). Bu yaklaşım kapsamında, araştırma problemi için en uygun desenin bütüncül çoklu durum deseni olduğuna karar verilmiştir.

Durum çalışması, belirli bir "durumun" veya "sınırlı bir sistemin" kendi gerçek yaşam bağlamı içinde, derinlemesine ve çok yönlü bir bakış açısıyla incelenmesine olanak tanır (Yin, 2018). Bu araştırmadaki "durum" robotik yarışmalarının fen bilimleri öğretim sürecine entegrasyonu fenomenidir. Her bir katılımcı öğretmen, bu fenomene ilişkin kendi özgün deneyimleri, bakış açıları ve bağlamları (okul türü, mesleki deneyim vb.) ile ayrı birer "durum" (vaka) olarak ele alınmıştır. Çoklu durum deseninin tercih edilmesi, farklı durumlar arasında karşılaştırmalı bir analiz yapma imkânı sunarak bulguların daha sağlam, genellenebilir ve güvenilir olmasını sağlar (Yin, 2018). Bu desen, "Robotik yarışmaları fen eğitimini nasıl etkiler?" gibi "nasıl" ve "neden" sorularını içeren keşifsel araştırma sorularını yanıtlamak için özellikle uygundur.

Katılımcılar ve Örneklem Seçimi

Araştırmanın katılımcı grubunu, 2022-2023 eğitim-öğretim yılında Türkiye'nin Kayseri ilindeki farklı ortaokullarda görev yapan ve en az bir defa öğrencisi bir robotik yarışmasına (örn. TEKNOFEST, MEB Robot, FLL vb.) katılım göstermiş olan fen bilimleri öğretmenleri oluşturmaktadır.

Katılımcıların belirlenmesinde, nitel araştırmanın doğasına uygun olarak olasılıklı olmayan örnekleme yöntemlerinden amaçlı örnekleme ve bu kapsamda maksimum çeşitlilik örneklemesi stratejisi kullanılmıştır. Maksimum çeşitlilik stratejisi, incelenen fenomene ilişkin olası farklılıkları ve ortak örüntüleri ortaya çıkarmak amacıyla, belirli kriterler açısından heterojen bir grup oluşturmayı hedefler (Patton, 2015). Bu doğrultuda, katılımcıların mesleki deneyim süresi, görev yaptıkları okul türü (devlet/özel) ve cinsiyet gibi demografik değişkenler açısından farklılık göstermesine özen gösterilmiştir. Bu çeşitlilik, robotik yarışmaları deneyiminin farklı bağlamlarda nasıl şekillendiğine dair zengin ve çok katmanlı bir anlayış geliştirilmesine katkı sağlamıştır.

Katılımcı seçiminde aşağıdaki dahil etme kriterleri gözetilmiştir:

i. **Deneyim Ölçütü:** Aktif olarak fen bilimleri öğretmenliği yapıyor olmak ve öğrencisi bir robotik yarışmasına katılmış olmak.

ii. **Çeşitlilik Ölçütü:** Farklı okul türlerinde (devlet/özel) ve farklı mesleki deneyim sürelerinde olmak.

iii. **Gönüllülük Ölçütü:** Araştırmaya katılmaya istekli olmak ve bilgilendirilmiş onam formunu imzalamak.

Bu kriterler doğrultusunda 2'si devlet, 3'ü özel okulda görev yapan, 2 ila 12 yıl arasında mesleki deneyime sahip, 4'ü kadın ve 1'i erkek olmak üzere toplam 5 fen bilimleri öğretmenine ulaşılmıştır. Katılımcıların gizliliğini sağlamak amacıyla kendilerine FÖ1'den FÖ5'e kadar takma adlar verilmiştir. Katılımcıların demografik bilgileri Tablo 1'de sunulmuştur.

Tablo 1. Fen Bilimleri Öğretmenlerinin Demografik Profili

Kod	Cinsiyet	Yaş	Mesleki Deneyim	Okul Türü
FÖ1	Kadın	39	10 yıl	Özel
FÖ2	Kadın	32	6 yıl	Özel
FÖ3	Kadın	29	2 yıl	Özel
FÖ4	Kadın	36	12 yıl	Devlet
FÖ5	Erkek	34	11 yıl	Devlet

Veri Toplama Aracı ve Süreci

Araştırmanın verileri, nitel araştırmalarda derinlemesine bilgi toplamaya olanak tanıyan yarı yapılandırılmış görüşme tekniği ile toplanmıştır. Bu teknik, belirli temalar etrafında odaklanmayı sağlayan önceden hazırlanmış sorular ile görüşme sırasında ortaya çıkan yeni konuları keşfetme esnekliğini bir arada sunar (Merriam & Tisdell, 2016).

Araştırmacılar tarafından geliştirilen görüşme formu, üç aşamalı bir süreçten geçirilerek geçerliliği ve güvenilirliği sağlanmıştır. İlk aşamada, robotik eğitimi, STEM, öğretmen görüşleri ve yarışma psikolojisi alanlarındaki güncel literatür (25 makale) taranarak bir soru havuzu oluşturulmuştur. İkinci aşamada, oluşturulan taslak form, uzman görüşüne sunulmuştur. Bu kapsamda bir Türkçe öğretmeni (dil ve anlatım anlaşılırlığı), doktora derecesine sahip bir fen bilimleri öğretmeni (alan ve kapsam geçerliliği) ve bir eğitim teknolojileri uzmanı (pedagojik uygunluk) formdaki soruları değerlendirmiş ve geri bildirimleri doğrultusunda gerekli revizyonlar yapılmıştır. Son aşamada formun nihai hali, çalışma grubuna benzer özellikler taşıyan iki öğretmen ve iki öğrenci ile bir pilot uygulama gerçekleştirilerek test edilmiştir. Bu pilot çalışma soruların açıklığı, anlaşılırlığı ve görüşme süresinin uygunluğu gibi pratik unsurların kontrol edilmesini sağlamıştır.

Nihai görüşmeler, katılımcıların tercihlerine bağlı olarak yüz yüze okul ortamında veya çevrim içi olarak Zoom platformu üzerinden gerçekleştirilmiştir. Her bir görüşme ortalama 25-30 dakika sürmüş ve katılımcıların izniyle ses kaydına alınmıştır. Toplamda yaklaşık 140 dakikalık ses kaydı elde edilmiş, bu kayıtlar daha sonra veri analizinin güvenirliğini artırmak amacıyla bir yazılım aracılığıyla kelimesi kelimesine olarak yazıya dökülmüştür.

Verilerin Analizi

Görüşmelerden elde edilen metin verilerinin analizinde, nitel veri analiz yöntemlerinden tümevarımsal içerik analizi kullanılmıştır. Tümevarımsal analiz, önceden belirlenmiş kategoriler olmaksızın, kodların ve temaların doğrudan verinin kendisinden türetildiği bir süreçtir (Elo & Kyngäs, 2008). Bu yaklaşım, katılımcıların perspektiflerini ve deneyimlerini ön plana çıkarmak için tercih edilmiştir.

Veri analiz süreci, Miles, Huberman ve Saldaña'nın (2014) önerdiği aşamalar takip edilerek sistematik bir şekilde yürütülmüştür:

1. **Kodlama:** Araştırmacılar, transkriptleri defalarca okuyarak veriye bütüncül bir bakış açısı geliştirmişlerdir. Ardından, metin içindeki anlamlı ifadelere ve veri parçalarına (cümleler, paragraflar) kodlar atanmıştır.

2. **Kategorilerin Oluşturulması:** Birbiriyle ilişkili kodlar bir araya getirilerek daha üst düzey ve soyut olan kategoriler altında gruplandırılmıştır. Örneğin, "liderlik etme," "sorumluluk alma," "ortak karar verme" gibi kodlar "Takım Çalışması Becerileri" kategorisi altında toplanmıştır.

3. **Temaların Belirlenmesi:** Analizin son aşamasında, araştırma sorularıyla da ilişkili olarak, kategoriler birleştirilerek verinin bütününü açıklayan kapsayıcı temalar oluşturulmuştur. Örneğin, "Bilişsel Gelişim," "Duyuşsal Gelişim" ve "Öğretim Sürecine Katkı" gibi ana temalara ulaşılmıştır.

Analiz sürecinin güvenirliğini artırmak için iki araştırmacı kodlamaları bağımsız olarak yapmış, ardından bir araya gelerek kodlamalar ve kategoriler üzerinde fikir birliğine varmışlardır. Uyuşmazlık yaşanan noktalarda ortak bir karara varılana dek tartışmalar sürdürülmüştür.

Araştırmanın İnandırıcılığı

Nitel araştırmalarda pozitivist bir kavram olan geçerlik ve güvenilirlik yerine, araştırmanın kalitesini ve titizliğini ifade etmek için inandırıcılık kavramı kullanılır. Bu çalışmanın inandırıcılığını sağlamak amacıyla Lincoln ve Guba'nın (1985) önerdiği stratejiler sistematik olarak uygulanmıştır:

- İnanılırlık: Bulguların gerçeklikle örtüşme derecesini artırmak için iki temel strateji izlenmiştir. Birincisi, uzman incelemesi kapsamında, analiz süreci ve ortaya çıkan temalar, nitel araştırma alanında deneyimli bir akademisyenle paylaşılarak geri bildirim alınmıştır. İkincisi, katılımcı teyidi yoluyla, analiz sonuçlarından elde edilen özetler ve yorumlar katılımcılarla paylaşılarak onların da onay ve düzeltmeleri alınmıştır.
- Aktarılabilirlik: Bulguların başka bağlamlara ne ölçüde uygulanabileceğine okuyucunun karar verebilmesi için zengin ve ayrıntılı betimleme tekniği kullanılmıştır. Bu amaçla, katılımcıların görüşlerinden doğrudan alıntılara bulgular bölümünde bolca yer verilmiş ve araştırma süreci şeffaf bir şekilde raporlanmıştır.
- Tutarlılık: Araştırmanın süreçlerinin tutarlı ve tekrarlanabilir olmasını sağlamak amacıyla denetim izi oluşturulmuştur. Veri toplama, analiz ve yorumlama süreçlerinin tüm aşamaları (ham veriler, transkriptler, kod listeleri, tema haritaları vb.) ayrıntılı olarak kayıt altına alınmıştır.
- Teyit Edilebilirlik: Bulguların araştırmacının öznelliğinden ziyade, doğrudan veriye dayandığını güvence altına almak amacıyla, tutarlılık için izlenen denetim izi ve inanılırlık için yürütülen uzman incelemesi stratejileri kullanılmıştır. Bu sayede bulguların veriden kaynaklandığı teyit edilebilir hale getirilmiştir.

Etik Hususlar

Araştırma, en üst düzeyde etik ilkelere bağlı kalınarak yürütülmüştür. Çalışmaya başlamadan önce, Erciyes Üniversitesi Sosyal ve Beşerî Bilimler Etik Kurulu'ndan 25.01.2023 tarih ve 12 sayılı karar ile etik onay alınmıştır. Katılımcılara araştırmanın amacı, süresi, gönüllülük esası, ses kaydı alınacağı ve verilerin bilimsel amaçlarla nasıl kullanılacağı hakkında detaylı bilgi verilmiş ve kendilerinden bilgilendirilmiş yazılı onam alınmıştır. Katılımcıların kimliklerinin gizliliğini korumak amacıyla takma adlar kullanılmış ve kişisel bilgileri raporlanmamıştır. Toplanan veriler (ses kayıtları ve transkriptler) şifrelenerek güvenli bir bulut hesabında saklanmış ve bu verilere yalnızca araştırma ekibinin erişimi sağlanmıştır.

BULGULAR

Yarı yapılandırılmış görüşmelerden elde edilen verilerin tümevarımsal içerik analizi sonucunda, araştırmanın temel amaçlarına yanıt veren üç ana tema ortaya çıkmıştır. Bu temalar: (1) Robotik yarışmalarının öğrenci gelişimi üzerindeki çok yönlü etkileri, (2) Robotik uygulamalarının fen bilimleri müfredatıyla kurduğu köprü ve (3) Robotik yarışmalarının öğretmenler tarafından bir pedagojik araç olarak benimsenmesi ve teşvik edilmesi olarak kavramsallaştırılmıştır. Bu bölümde, her bir tema altında yer alan kategori ve kodlar, katılımcıların ifadelerinden doğrudan alıntılarla desteklenerek sunulmuştur.

Tema 1: Öğrenci Gelişimine Çok Yönlü Etkiler: Bilişsel ve Duyuşsal Kazanımlar

Analizler, tüm katılımcı öğretmenlerin, robotik yarışmalarına katılımın öğrenciler üzerinde hem bilişsel hem de duyuşsal alanlarda dönüştürücü bir etki yarattığı konusunda hemfikir olduğunu göstermektedir. Öğretmenler, bu sürecin öğrencilerin akademik becerilerinin ötesinde, 21. yüzyıl yaşam becerilerini de geliştirdiğini vurgulamışlardır. Bu tema altında öne çıkan bilişsel ve duyuşsal değişimler Tablo 2'de özetlenmiştir.

Tablo 2. Öğretmen Gözlemlerine Göre Robotik Yarışmalarının Öğrenciler Üzerindeki Bilişsel ve Duyuşsal Etkileri

Kategori	Kodlar	Frekans (f)	Katılımcılar
Duyuşsal Gelişim	Derse ve STEM'e Yönelik İlgi Artışı	5	FÖ1, FÖ2, FÖ3, FÖ4, FÖ5

	Girişimcilik ve İnisiyatif Alma	5	FÖ1, FÖ2, FÖ3, FÖ4, FÖ5
	Takım Çalışması ve İş Birliği	5	FÖ1, FÖ2, FÖ3, FÖ4, FÖ5
	Özgüven Artışı	3	FÖ1, FÖ2, FÖ5
	Liderlik Becerileri	2	FÖ1, FÖ3
Bilişsel Gelişim	Problem Çözme Becerisi	4	FÖ1, FÖ2, FÖ3, FÖ4
	Yaratıcılık ve İnovatif Düşünme	4	FÖ1, FÖ2, FÖ4, FÖ5
	Psikomotor Beceriler	4	FÖ1, FÖ2, FÖ3, FÖ5
	Planlama ve Organizasyon	2	FÖ1, FÖ2

Duyuşsal Gelişim: Öğretmenlerin tamamı (f=5), robotik yarışmalarının öğrencilerin duyuşsal gelişimine katkılar sağladığını ifade etmiştir. Özellikle takım çalışması, tüm öğretmenler tarafından en çok vurgulanan kazanım olmuştur. FÖ1, yarışma sürecinin öğrenciler arasında organik bir iş birliği ve liderlik dinamiği oluşturduğunu şu şekilde betimlemiştir:

"Bir grup çalışmasında ekip ruhu ve liderlik, yarışmaya katılan öğrencilerde çok güzel gözlemleniyor. Arkadaşlarına, 'Biz bir kere böyle şeyler yapmıştık, işte şunu da yaparsak daha iyi olur' gibi söylemleri oluyor. Grubu yönlendirebiliyorlar."

Bu gözlem, öğrencilerin pasif birer üye olmaktan çıkıp, kolektif başarı için sorumluluk alan ve akranlarını yönlendiren aktif bireylere dönüştüğünü göstermektedir. Ayrıca, tüm öğretmenler (f=5) öğrencilerin fen dersine ve genel olarak STEM alanlarına yönelik ilgilerinde ve girişimcilik yönelimlerinde belirgin bir artış olduğunu belirtmiştir. FÖ4, bu durumu öğrencilerin sorduğu sorulardaki niteliksel değişim üzerinden şöyle açıklamıştır:

"Ders kapsamında verilen araştırma ödevlerine ilgileri daha da arttı. 'Yeni ürün ne yapabiliriz, bunu nasıl sunabiliriz?' gibi sorularla girişimci yönlerini ortaya koydular."

Bilişsel Gelişim: Katılımcıların dördü (f=4), robotik yarışmalarının öğrencilerin problem çözme becerilerini somut bir şekilde geliştirdiğini belirtmiştir. Öğrencilerin, karşılaştıkları mekanik veya yazılımsal bir sorunu aşmak için deneme-yanılma, sistematik hata ayıklama ve analitik düşünme gibi stratejiler geliştirdiklerini gözlemlemişlerdir. FÖ3, bu becerilerin sadece yarışma alanında kalmadığını, aynı zamanda fen dersindeki akademik faaliyetlere de transfer edildiğini şu sözlerle ifade etmiştir:

"Öğrenciler robotik kodlamayı yaparken problem çözme becerisi, psikomotor becerileri geliştiği için bunları fen dersinde soru çözümüne ya da laboratuvarda yapılan deneylere aktarabiliyorlar."

Bu ifade, robotik uygulamalarının disiplinler arası bir beceri transferine olanak tanıdığını göstermektedir. Benzer şekilde, öğretmenler öğrencilerin yaratıcılık (f=4) ve planlı olma (f=2) gibi yeteneklerinde de artış olduğunu rapor etmişlerdir.

Tema 2: Müfredatla Köprü Kurma: Robotik Uygulamalarının Fen Konularının Öğrenimine Katkısı

Bulgular, robotik yarışmalarının fen bilimleri müfredatındaki soyut konuları somut ve ilgi çekici deneyimlere dönüştürerek öğrenmeyi kolaylaştıran güçlü bir köprü görevi gördüğünü ortaya koymaktadır. Öğretmenler, robotik projeleri sayesinde öğrencilerin belirli konularda daha yüksek motivasyon ve daha derin bir kavramsal anlama düzeyine ulaştıklarını belirtmişlerdir. Robotik uygulamalarının öğrenilmesinde avantaj sağladığı belirtilen konular Tablo 3'te sunulmuştur.

Tablo 3.Robotik Yarışmalarının Öğrenilmesinde Avantaj Sağladığı Gözlemlenen Fen Bilimleri Konuları

Konu Alanı	**Frekans (f)**	**Katılımcılar**
Elektrik (Devreler, Motorlar)	5	FÖ1, FÖ2, FÖ3, FÖ4, FÖ5
Basit Makineler (Makaralar, Kaldıraçlar)	3	FÖ1, FÖ3, FÖ5
Asitler ve Bazlar	2	FÖ3, FÖ5
Hücre Bölünmesi (Mitoz, Mayoz)	2	FÖ1, FÖ5
Yenilenebilir Enerji ve Işığın Soğurulması	1	FÖ4

Tüm katılımcılar (f=5), robotların temelini oluşturan elektrik devreleri konusunun, bu süreçte en çok fayda sağlanan alan olduğunu ifade etmiştir. FÖ1, robotik deneyimi olan öğrencilerin, bu bilgiyi diğer laboratuvar çalışmalarına taşıyarak sürekli bir sorgulama ve proje geliştirme çabası içine girdiklerini şu örnekle aktarmıştır:

"Ben başka bir konu için dahi laboratuvara öğrencileri indirdiğimde, 'Hocam makara neredeydi? Çıkrık neredeydi? Hocam motoru şuraya taksam fan döner mi?' gibi devamlı bir soru yağmuruna tutuluyorum. Kendi projelerini üretme çabasına giriyorlar."

Bu ifade, öğrencilerin bilgiyi bağlamlar arasında transfer etme ve yeni problemlere uygulama yeteneğinin gelişimini göstermektedir. Benzer şekilde, FÖ4, öğrencilerinin güncel bir toplumsal sorundan yola çıkarak "Yenilenebilir Enerji" ünitesi kapsamında bir proje geliştirdiğini belirtmiştir:

"Öğrenciler deprem döneminde elektrik kesintilerinden dolayı çadırlara güneş paneli olan robotlar, ışık sensörleri yerleştirip yenilenebilir enerji ile ilgili bir proje yapmışlardı."

Biyoloji gibi farklı alanlarda dahi robotik uygulamaların öğrenmeyi kolaylaştırdığı görülmüştür. FÖ5, soyut bir konu olan hücre bölünmesini, öğrencilerinin tasarladığı robotik tabanlı bir oyunla nasıl somutlaştırdığını şöyle anlatmıştır:

"Robotik yarışmalarına katılan öğrencilerim mitoz ve mayoz bölünme konusunda bir oyun geliştirmişlerdi. Robotik alt yapılı bir oyundu ve öğrencilerimle zevk alarak oynadık ve öğrenmelerine katkı sağladı."

Tema 3: Pedagojik Bir Araç Olarak Robotik: Öğretmenlerin Teşvik Yaklaşımları ve Motivasyonları

Araştırmanın bu temasında, öğretmenlerin robotik yarışmalarına yönelik genel tutumları ve öğrencilerini bu sürece katılım için nasıl motive ettikleri incelenmiştir. Görüşme yapılan öğretmenlerin tamamı (f=5), gözlemledikleri olumlu gelişimler nedeniyle diğer öğrencilerini de robotik yarışmalarına katılmaları yönünde "kesinlikle teşvik edeceklerini" ifade etmişlerdir.

Öğretmenlerin teşvik motivasyonlarının temelinde, bu etkinliklerin öğrencilere kazandırdığı çok yönlü faydalara olan güçlü inançları yatmaktadır. FÖ2, teşvik etme nedenini, önceki temalarda belirtilen kazanımları özetleyerek şu şekilde dile getirmiştir:

"Tabii ki ederim. Bu kadar güzel şey saydık. Öğrencilerimizin özgüvenini, yaratıcılıklarını, psikomotor becerilerini, ekip çalışmasındaki durumlarından bahsettik. Öğrencilerimizin faydasına olan bu tarz etkinliklerin sayısının artarak devam etmesini diliyorum."

Bu ifade, öğretmenlerin teşvik etme kararının, gözleme dayalı kanıtlardan beslenen bilinçli bir pedagojik tercih olduğunu göstermektedir. FÖ1 ise teşvik etme yaklaşımının, geleneksel öğretmen-öğrenci hiyerarşisini aşan, iş birlikçi ve karşılıklı öğrenmeye dayalı bir ilişki kurmaktan geçtiğini çarpıcı bir şekilde ortaya koymuştur:

"Tabii ki de ederim. Hatta onlara, 'Öğrendiğiniz şeyleri bana da öğretin' diyorum. Bu ifadem onların çok hoşlarına gidiyor. Bence çok parlak gelecekleri var ve mutlular, kendileri de öyle diyorlar."

Bu yaklaşım, öğrencileri bilgi ve becerileriyle gurur duyan, özgüvenli bireyler olarak konumlandırmakta ve öğrenme sürecindeki rollerini güçlendirmektedir. Öğretmenlerin bu tutumu, robotik yarışmalarını sadece bir müsabaka olarak değil, aynı zamanda öğrencilerin potansiyelini ortaya çıkaran ve onları geleceğe hazırlayan değerli bir eğitim aracı olarak gördüklerini teyit etmektedir.

TARTIŞMA, SONUÇ VE ÖNERİLER

Bu bölümde, araştırmadan elde edilen temel bulgular özetlenmekte, bu bulgular ilgili ulusal ve uluslararası literatür ışığında tartışılarak yorumlanmakta ve son olarak öneriler sunulmaktadır.

Bu çalışma, fen bilimleri öğretmenlerinin perspektifinden, robotik yarışmalarının ortaokul öğrencilerinin gelişimi ve fen öğrenme süreçleri üzerindeki etkilerini nitel olarak incelemiştir. Analizler, öğretmenlerin bu yarışmaları, öğrencilerin bilişsel ve duyuşsal becerilerini geliştiren, fen bilimleri müfredatındaki soyut konuları somutlaştıran ve öğrencileri STEM kariyerlerine yönelten güçlü bir pedagojik araç olarak gördüklerini ortaya koymuştur. Bulgular, robotik yarışmalarının geleneksel sınıf ortamının sınırlarını aşan, çok boyutlu bir öğrenme ekosistemi sunduğunu teyit etmektedir. Öğretmenler bu süreci, öğrencilerin sadece teknik bilgi edinmekle kalmayıp, aynı zamanda 21. yüzyılın gerektirdiği temel yaşam becerilerini de içselleştirdikleri gerçek bir deneyim olarak tanımlamışlardır.

Bu araştırmanın en belirgin bulgularından biri, öğretmenlerin robotik yarışmalarına katılan öğrencilerde problem çözme, takım çalışması, girişimcilik ve yaratıcılık gibi üst düzey becerilerde gözlemlediği anlamlı gelişimdir. Bu bulgu, Papert'in (1980) inşacı öğrenme teorisiyle tam bir uyum içerisindedir. Bu teoriye göre öğrenciler, bir robot gibi somut ve paylaşılabilir bir ürün ortaya koyma sürecinde en kalıcı öğrenmeyi gerçekleştirirler. Yarışma ortamının doğası gereği karşılaşılan karmaşık ve "iyi yapılandırılmamış" problemler, öğrencileri tek bir doğru cevabın olmadığı senaryolarda yaratıcı çözümler üretmeye zorlamaktadır. Bu durum, Kaya, Korkmaz ve Çakır'ın (2020) oyunlaştırılmış robotik etkinliklerinin problem çözme becerilerine olumlu katkı sağladığı yönündeki bulgularını desteklemekle kalmayıp, bu becerilerin yarışma gibi rekabetçi ve zaman baskısı altındaki bir bağlamda nasıl geliştiğine dair nitel bir derinlik sunmaktadır.

Öğretmenlerin tamamının vurguladığı takım çalışması becerisi, bu öğrenme ortamlarının bir diğer kritik çıktısıdır. FÖ1'in "ekip ruhu ve liderlik" gözlemi, bu ortamların sadece görev paylaşımının ötesinde, Lave ve Wenger'in (1991) "meşru çevresel katılım" olarak tanımladığı sosyal bir öğrenme sürecini tetiklediğini göstermektedir. Öğrenciler, ortak bir hedef doğrultusunda çalışırken birbirlerinden öğrenir, müzakere eder ve kolektif bir zekâ oluştururlar. Bu sosyal dinamik, öğrencilerin özgüven ve liderlik gibi duyuşsal özelliklerinin gelişimine zemin hazırlamaktadır. Bulgular, Çatlak, Tekdal ve Baz'ın (2015) programlama öğrenmenin sosyal becerileri geliştirdiği yönündeki sonuçlarıyla paralellik göstermektedir.

Öğretmenlerin, robotik uygulamalarının özellikle "elektrik" ve "basit makineler" gibi konuların öğrenilmesini kolaylaştırdığına yönelik ifadeleri, bu teknolojinin soyut bilimsel prensipleri somutlaştırma gücünü ortaya koymaktadır. Öğrenciler, bir robotun motorunu çalıştırırken

veya bir kol mekanizması tasarlarken, ders kitabındaki teorik bilgiyi doğrudan gözlemleyip değiştirme imkânı bulurlar. Bu durum, bilginin sadece ezberlenmesi yerine, bağlam içinde anlamlandırılarak içselleştirilmesini sağlar. FÖ5'in "mitoz bölünme" konusunu robotik bir oyunla öğretmesi, bu yaklaşımın biyoloji gibi farklı fen alanlarına dahi ne denli yaratıcı bir şekilde uyarlanabileceğinin çarpıcı bir örneğidir.

Öğretmenlerin tamamının öğrencilerde STEM mesleklerine yönelik artan bir ilgi gözlemlemesi, araştırmanın en önemli sonuçlarından biridir. FÖ3'ün aktardığı "yazılım mühendisi olmak, bilgisayar mühendisi olmak istiyorlar" ifadesi, bu deneyimin öğrencilerin gelecek vizyonlarını ve kariyer planlarını doğrudan etkilediğini göstermektedir. Bu bulgu, Hendricks ve diğerlerinin (2012) ve Welch ve Huffman'ın (2011) robotik yarışmalarının STEM kariyer ilgisini artırdığına yönelik nicel bulgularıyla örtüşmektedir. Bu çalışma, bu etkinin altında yatan mekanizmaya nitel bir ışık tutmaktadır: Robotik yarışmaları, öğrencilerin kendilerini birer mühendis, programcı veya bilim insanı olarak hayal etmelerine olanak tanıyarak onların STEM kimliği gelişimini desteklemektedir (Carlone & Johnson, 2007). Öğrenciler, bu süreçte başarılı oldukça, "Ben bu işi yapabilirim" algısını geliştirerek STEM alanlarına yönelik aidiyet duygularını güçlendirirler.

Öneriler

- Fen bilimleri öğretmenleri, robotik uygulamalarını sadece bir yarışma aktivitesi olarak değil, özellikle soyut konuları somutlaştırmak ve öğrencilerin üst düzey düşünme becerilerini geliştirmek için ders planlarına entegre edilecek bir pedagojik araç olarak kullanmalıdır.
- Okul yönetimleri, öğrencilerin bu tür etkinliklere daha geniş katılımını sağlamak için robotik kulüpleri veya seçmeli dersler oluşturmayı teşvik etmeli ve bu alanlar için gerekli materyal ve altyapı desteğini sağlamalıdır.
- Öğretmenler, FÖ1'in "Öğrendiğiniz şeyleri bana da öğretin" yaklaşımında olduğu gibi, öğrencileri bilgi tüketicisi konumundan üretici ve akran eğiticisi konumuna taşıyan iş birlikçi öğrenme ortamları yaratmalıdır.

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THE ROLE OF MATRIX METALLOPROTEINASES IN DEVELOPMENT OF INTERSTITIAL CYSTITIS

İNTERSTİSYEL SİSTİT GELİŞİMİNDE MATRİKS METALOPROTEİNAZLARIN ROLÜ

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ABSTRACT

Interstitial cystitis (bladder pain syndrome) is a syndrome characterized by irritative symptoms that may last longer than 6 months. Although the exact etiology of interstitial cystitis is unknown, various factors such as chronic and subchronic infection, autoimmunity, and genetic susceptibility may be responsible for the initiation of the inflammatory response in this disease. It is known that interstitial cystitis syndrome is associated with other unknown pain syndromes such as fibromyalgia and irritable bowel syndrome, but since the genetic basis of the disease has not been fully elucidated, a specific molecular pathway and potential therapeutic targets for treatment have not yet been identified. The extracellular matrix is a dynamic system that provides a structural scaffold for cells in humans and can interact with cells to affect functions such as proliferation, growth, differentiation, migration, adhesion and survival. Cells can also regulate or influence the extracellular matrix around them. Regulation of extracellular matrix-cell interaction is extremely important in maintaining the physiological microenvironment and homeostasis. As a result of disorders that occur in this regulation, various pathological processes may develop. Matrix Metalloproteinases (MMPs) play an important role in physiological and pathological processes as zinc-dependent endopeptidase enzymes. MMPs, which are important in maintaining extracellular matrix homeostasis, are effective in extracellular matrix degradation. Due to their wide activity range, it is thought that MMPs are used as diagnostic or prognostic markers and therapeutic targets in clinical settings. It is thought that many MMPs may have potential diagnostic and prognostic benefits when evaluated alone or in conjunction with existing diagnostic tests and imaging modalities. Due to the varying functions of different MMPs, it may be possible to increase the efficacy and reduce the adverse effects associated with broad-spectrum anti-MMP therapy through targeted inhibition of specific MMPs. We aimed to investigate the role of matrix metalloproteinases in the development of interstitial cystitis disease, since the inflammatory response is observed to be high and the extracellular matrix rearrangement processes that increase in the post-inflammatory processes are actively involved

in the pathophysiology of interstitial cystitis. This study is a preliminary study of the TUBITAK project and was supported as a 2023 2nd Term project with the project number 1919B012326129 within the scope of the TUBITAK 2209-A University Students Research Projects Support Program.

Keywords: Interstitial cystitis, extracellular matrix, matrix metalloproteinases, inflammation

ÖZET

İnterstisyel sistit (mesane ağrısı sendromu), 6 aydan uzun sürebilen irritatif semptomlarla karakterize bir sendromdur. İnterstisyel sistitin kesin etiyolojisi bilinmemekle birlikte, kronik ve subkronik enfeksiyon, otoimmünite ve genetik yatkınlık gibi çeşitli faktörler bu hastalıkta inflamatuvar yanıtın başlamasından sorumlu olabilir. İnterstisyel sistit sendromunun fibromiyalji ve irritabl bağırsak sendromu gibi daha önce bilinmeyen ağrı sendromlarıyla ilişkili olduğu bilinmektedir, ancak hastalığın genetik temeli tam olarak aydınlatılamadığından, tedavi için spesifik bir moleküler yol ve potansiyel terapötik hedefler henüz belirlenememiştir. Hücre dışı matriks, insanlardaki hücreler için yapısal bir iskele sağlayan ve hücrelerle etkileşime girerek çoğalma, büyüme, farklılaşma, göç, yapışma ve hayatta kalma gibi işlevleri etkileyebilen dinamik bir sistemdir. Hücreler ayrıca etraflarındaki hücre dışı ki düzenleyebilir veya etkileyebilir. Hücre dışı matriks-hücre etkileşiminin düzenlenmesi, fizyolojik mikro çevrenin ve homeostazın korunmasında son derece önemlidir. Bu düzenlemede meydana gelen bozukluklar sonucunda çeşitli patolojik süreçler gelişebilir. Matriks Metalloproteinazlar (MMP'ler), çinko bağımlı endopeptidaz enzimleri olarak fizyolojik ve patolojik süreçlerde önemli rol oynarlar. Ekstraselüler matriks homeostazının korunmasında önemli olan MMP'ler, ekstraselüler matriks degradasyonunda etkilidir. Geniş aktivite aralığına sahip olmaları nedeniyle MMP'lerin klinik ortamlarda tanısal veya prognostik belirteçler ve tedavi hedefleri olarak kullanıldığı düşünülmektedir. Birçok MMP'nin tek başına veya mevcut tanı testleri ve görüntüleme yöntemleriyle birlikte değerlendirildiğinde potansiyel tanısal ve prognostik yararlar sağlayabileceği düşünülmektedir. Farklı MMP'lerin farklı işlevleri nedeniyle, belirli MMP'lerin hedefli inhibisyonu yoluyla geniş spektrumlu anti-MMP tedavisiyle ilişkili etkinliği artırmak ve olumsuz etkileri azaltmak mümkün olabilir. İnterstisyel sistit (mesane ağrı sendromu) hastalığının patofizyolojisinde inflamatuvar cevabın yüksek olduğu ve postinflamatuvar süreçlerde artan ekstraselüler matriks yeniden düzenlenme süreçlerinin aktif olarak rol aldığı gözlendiğinden, bu hastalığın gelişiminde matriks metalloproteinazların rolünü araştırmayı amaçladık. Bu çalışma TÜBİTAK projesinin ön çalışması olup TÜBİTAK 2209-A Üniversite Öğrencileri Araştırma Projeleri Destekleme Programı kapsamında 1919B012326129 proje numarasıyla 2023 2. Dönem projesi olarak desteklenmiştir.

Anahtar kelimeler: İnterstisyel sistit, ekstraselüler matriks, matriks metalloproteinazları, inflamasyon

GİRİŞ

İnterstisyel sistit (mesane ağrısı sendromu) kronik bir mesane sendromudur. Hastalığın mekanizması tam olarak anlaşılamamasına ragmen, hastalık patogenezinde mesanenin koruyucu glikozaminoglikan tabakasının hasarı, sinir büyüme faktörü, artmış sitokin düzeyleri gibi çeşitli mekanizmaların etkili olduğu düşünülmektedir. Son yıllarda gerçekleştirilmiş çalışmalarda doku yeniden modellenmesi ve bağ dokusu yıkımı gibi süreçlerde önemli rol oynayan enzimler olarak matriks metalloproteinazların (MMP'ler) interstisyel sisitit gelişiminde etkili olabileceği düşünülmektedir (Theoharides ve ark., 2001).

MMP'ler çinko bağımlı endopeptidazlar ailesi olarak ekstrasellüler matriks proteinlerinin parçalanmasından sorumludurlar. Normal fizyolojik süreçlerde yara iyileşmesi, anjiyogenez, doku onarımı gibi süreçlerde etkili olabilen bu enzimler, aktivitelerindeki dengesizlikler sonucunda fibrosis, inflamasyon gibi patolojik süreçlerde de önemli rol oynamaktadırlar. İnterstisyel sistit durumunda

mesane duvarında fibrosis ve inflamasyon gözlendiğinden, bu süreçlerde MMP'lerin anormal aktivitesinin mesane dokusunda yapısal değişikliklere neden olabileceği bildirilmiştir (Theoharides ve ark., 2001).

MMP'ler arasında yer alan, jelatinazlar olarak bilinen MMP-2 ve MMP-9 bazal membran kollajenlerini parçalayabilmektedir. İnterstisyel sistit gelişen hastaların idrar ve mesane dokularında artmış MMP-2 ve MMP-9 düzeyleri belirlenmiştir. Böylece mesane epitelinin geçirgenliği artabilmekte ve altta yatan dokuya irritan maddelerin sızması gerçekleşebilmektedir (Theoharides ve ark., 2001). Diğer bir MMP olan, matrilisinler olarak bilinen MMP-7 ise epitel hücrelerin yayılması ve migrasyonu ile ilişkilendirilmiştir. İnterstisyel sistit gelişen hastaların mesane dokularında da artmış MMP-7 ekspresyon düzeyleri tespit edilmiştir. Artmış MMP-7 düzeyleri mesane yüzeyindeki epitel tabakanın bozulmasına katkıda bulunmakta ve patogenezi hızlandırabilmektedir (Kwon ve ark., 2011). Kollajenazlar olarak bilinen MMP-1, MMP-3, MMP-13 enzimleri fibriler kollajeni parçalamaktan sorumludur. Bu MMP'lerin kronik inflamasyon ve fibrosis arasında aktive olduğu bildirilmiştir. Hayvan modelleri ile gerçekleştirilmiş çeşitli çalışmalarda mesane fibrozisinin gelişiminde bu kollejenazların etkili oldukları düşünülmektedir. MMP aktivitelerinin kontrol altına alınamaması sonucunda mesane duvarı kalınlaşabilmekte ve elastikiyet kaybına uğrayarak fonksiyonu bozulabilmektedir (Saito ve ark., 2005).

Aşırı MMP aktivitelerinin mesane epitelinin bütünlüğünün bozulmasına ve fibrozisin ilerlemesine katkıda bulunma yoluyla hastalık semptomlarını şiddetlendirdiği göz önüne alındığında, bu çalışmada interstisyel sistit hastalığı gelişiminde MMP'lerin rolünü incelemeyi amaçladık.

İNTERSTİSYEL SİSTİT

İnterstisyel sistit (mesane ağrı sendromu) 6 aydan uzun sürebilen irritatif semptomlar ile karakterize bir sendromdur. Bilinen bir nedeni olmaksızın genellikle genç ve orta yaşlı kadınlarda ortaya çıkan interstisyel sistit bir dışlama tanısını temsil etmektedir. İnterstisyel sistit prevalansı kadın popülasyonda 52-500 / 100.000 ve erkek popülasyonda 8-41 / 100.000 olarak rapor edilmiştir (Davis ve ark., 2014; Homma ve ark., 2009; Neuhaus ve ark., 2021). Tekrarlayan ve kronik idrar yolu enfeksiyonlarının interstisyel sistit patogenezinde etkili olduğu bildirilmiştir. Bu hastaların çoğunda gizli enfeksiyonlar meydana geldiğinden ve idrar mikrobiyomunun değişmesinden dolayı, enfeksiyonlar hastalık patogenezinde önemli faktörler olarak kabul edilmektedir. İnterstisyel sistit kesin etiyolojisi bilinmemesine rağmen, bu hastalıkta inflamatuar yanıtın başlatılmasından sorumlu olabilecek kronik ve subkronik enfeksiyon, otoimmünite, genetik duyarlılık gibi çeşitli faktörler etkili olabilmektedir. Kronik yorgunluk sendromu olan ikizlerde ve dizigotik ikizlerle karşılaştırıldığında monozigotik ikizlerde interstisyel sistit daha yaygın olarak gözlenmiştir. Ayrıca yetişkin kadınların birinci derece akrabalarında interstisyel sistit prevalansının genel popülasyonda bulunana kıyasla 17 kat daha fazla olduğu bildirilmiştir. Bu yüzden hastalığın patogenezinde genetik faktörlerin etkili olduğu düşünülmektedir. İnflamasyon da mesane fonksiyonu üzerinde doğrudan etkisi olan bir faktör olarak bilinmektedir. Akut inflamasyon vazodilatasyon ve artmış damar permeabilitesi, lökositlerin yaralanma bölgesine invazyonuna ve böylece çeşitli mediyatörlerin salınmasına neden olabilen biyokimyasal inflamasyon durumunun aktivasyonu ile karakterizedir. Akut inflamasyon durumlarında inflamatuar mediyatörlerin salınması yoluyla ürotelyal hasar ve mesane duvarı tahrişi gelişebilmektedir. Bu inflamatuar değişiklikler dizüri, sık idrara çıkma, noktüri, ateş gibi klinik belirtilerden sorumlu tutulmaktadır. Akut inflamasyonda kısa süreli olabilen bu değişiklikler, zararlı uyaranlar ortadan kaldırıldığında yok olabilmektedir. Daha uzun süre devam eden zararlı uyaranlar sonucunda ise kronik inflamasyon gelişebilmekte ve mesane mukozasında tekrarlayan yaralanmalar ve fibrozis gibi disfonksiyonel patolojiler ortaya çıkmaktadır. Bu patolojik değişiklikler de sık idrara çıkma, dizüri, Hunner ülserlerinin sistoskopik bulguları gibi klinik semptomlarla ilişkilendirilmiştir. Kronik

inflamasyon ise makrofajlar, lenfositler, eozinofiller, mast hücreleri, plazma hücreleri gibi hücrelerin infiltrasyonu yoluyla geri dönüşümsüz doku tahribatı, fibrozis ve zayıf uyum gibi disfonksiyonel patolojiler, alt idrar yolu semptomlarının zayıflama semptomlarından sorumlu hiperaljezi durumları ile karakterize edilmektedir. İnterstisyel sistit sendromunda kronik inflamasyonun kısır döngüsünü kırabilecek multimodal tedavi önerilmektedir. Fibrozis gibi geri dönüşü mümkün olmayan patolojilerin geliştiği vakalarda ise cerrahi tedavi yöntemleri uygulanmaktadır (Grover ve ark., 2011; Neuhaus ve ark., 2021).

MATRİKS METALLOPROTEİNAZLAR

Ekstrasellüler matriks insanlarda hücreler için yapısal bir iskele sağlayan, hücrelerle etkileşime girerek proliferasyon, büyüme, farklılaşma, migrasyon, adhezyon, sağkalım gibi fonksiyonları etkileyebilen dinamik bir sistemdir. Hücreler de çevrelerindeki ekstrasellüler matriksi düzenleyebilmekte ya da etkileyebilmektedirler. Ekstrasellüler matriks-hücre etkileşiminin düzenlenmesi ise fizyolojik mikroçevrenin ve homeostazının korunmasında son derece önemlidir. Bu düzenlemede ortaya çıkan bozukluklar sonucunda çeşitli patolojik süreçler gelişebilmektedir. Matriks Metalloproteinazlar (MMP'ler) çinkoya bağımlı endopeptidaz enzimler olarak fizyolojik ve patolojik süreçlerde önemli rol oynamaktadırlar. Transkripsiyonel düzeyde düzenlenen MMP ekspresyonu mRNA stabilitesinin modüle edilmesi ile ilişkilendirilmiştir (Alkanli ve ark., 2023). Estrasellüler matriks homeostazının korunmasında önemli olan MMP'ler ekstrasellüler matriks degradasyonunda etkilidir. Yapıları, fonksiyonları ve düzenlemeleri açısından benzerlik gösteren MMP'ler jelatinazlar (MMP-2, MMP-9), kollajenazlar (MMP-1, MMP-8, MMP-13), matrilisinler (MMP-7, MMP-26), stromelisinler (MMP-3, MMP-10, MMP-11, MMP-12), membran tipi MMP'ler (MMP-14, MMP-15, MMP-16, MMP-17, MMP-24, MMP-25) ve diğer MMP'ler (MMP-12, MMP-19, MMP-20, MMP-21, MMP-22, MMP-23, MMP-28) olmak üzere sınıflandırılmaktadır (Ay ve ark., 2021; Gonzalez-Avila ve ark., 2020; Kader ve ark., 2007) (Tablo 1).

Tablo 1. Matriks metalloproteinazların sınıflandırılması (Gonzalez-Avila ve ark., 2020).

Jelatinazlar	MMP-2 (Jelatinaz-A) MMP-9 (Jelatinaz-B)
Kollajenazlar	MMP-1 (Kolajenaz-1) MMP-13 (Kolajenaz-3) MMP-8 (Kolajenaz-2) MMP-18 (Kolajenaz-4)
Stromelisinler	MMP-3 (Stromelisin-1) MMP-10 (Stromelisin-2) MMP-11 (Stromelisin-3)
Matrilisinler	MMP-7 (Matrilisin-1) MMP-26 (Matrilisin-2)
Transmembran Tip 1	MMP-14 (Membran Tip 1-MMP) MMP-15 (Membran Tip 2-MMP) MMP-16 (Membran Tip 3-MMP) MMP-24 (Membran Tip 5-MMP)

Transmembran Tip 2	MMP-23	(CA-MMP)
Diğer MMP'ler	MMP-12	(Makrofaj elastaz)
	MMP-19	(RASI-1)
	MMP-20	(Enamelisin)
	MMP-21	
	MMP-27	
	MMP-28	(Epilisin)

MMP ailesi içinde yer alan MMP-1, çeşitli normal hücreler tarafından sentezlenmekte ve hücre büyümesinin desteklenmesinde önemli rol oynamaktadır. Normal fizyolojik koşullar altında MMP-1 ekspresyon düzeyleri oldukça düşük olarak belirlenmiştir. Ancak otoimmün hastalıklar ve inflamasyon gibi patolojik durumlarda oldukça artmış upregüle MMP-1 düzeyleri saptanmıştır (Ay ve ark., 2021; Kader ve ark., 2007). MMP ailesinin diğer önemli bir üyesi olan MMP-2, 72 kilodaltonluk bir endopeptidazdır ve bazal membranın ana bileşenlerinden biri olarak bilinen tip IV kollajeni hidrolize etmektedir (Alkanli ve ark., 2023). MMP ailesinin diğer önemli üyesi olan MMP-3 ise çeşitli hücre yüzeyi moleküllerinin, ekstrasellüer matriks proteinlerinin, kollajen tip II, IV, IX, elastin, laminin, proteoglikanlar, fibronektin ve diğer bazı MMP'lerin degradasyonunda önemli rol oynamaktadır. Bu yüzden çeşitli MMP'lerin aktivasyonu yoluyla doku yeniden modellenmesinde etkili olabilmektedir. Fizyolojik süreçler sırasında MMP-3 makrofajlar, endotel hücreleri, stromal fibroblastlar, immün hücreleri gibi farklı hücre tipleri tarafından üretilmektedir (Ay ve ark., 2021; Kader ve ark., 2007).

Bazı MMP'lerin anjiyogenez, matriks yeniden modellenmesi, apoptoz, hücre proliferasyonu epitelyal-mezenkimal geçiş, inflamasyon gibi çeşitli süreçlerle ilişkilendirildiği bildirilmiştir (Ay ve ark., 2021; Kader ve ark., 2006). MMP'lerin bu geniş aktivite aralıklarından dolayı klinik ortamlarda tanısal veya prognostik belirteçler, terapötik hedefler olarak kullanılabilecekleri düşünülmektedir. Birçok MMP'nin tek başına ya da mevcut tanısal testler ve görüntüleme yöntemleriyle birlikte değerlendirilmesi yoluyla, potansiyel tanısal ve prognostik fayda gösterebileceği bildirilmiştir. MMP'lerin fizyolojik ve patolojik süreçlerdeki karmaşık rollerinin daha iyi anlaşılabilmesi sonucunda klinik olarak etkili olabilecek anti-MMP tedavilerinin tasarlanabileceği düşünülmektedir. Farklı MMP'lerin değişen fonksiyonlarına bağlı olarak spesifik MMP'lerin hedeflenen inhibisyonu yoluyla geniş spektrumlu anti-MMP tedavisi ile ilişkili etkinliklerin arttırılabilmesi ve olumsuz etkilerin azaltılabilmesi mümkün olabilecektir (Szarvas ve ark., 2011).

Adaptif T hücresi immün yanıtları Tip 1 yardımcı hücre yanıtı (Th1) ve Tip 2 yardımcı hücre yanıtı (Th2) olmak üzere iki grupta sınıflandırılmaktadır. Bunlardan Th2 immün reaksiyonları metabolik homeostazın korunmasında önemlidir ve atopik birtakım reaksiyonlar gelişmesinden dolayı inflamatuar belirteçlerin önemli olduğu ürotelyal kanserler ya da çeşitli ürotelyal hastalıklar gibi patolojik durumlar ortaya çıkabilmektedir. İnflamatuar süreç MMP faaliyetleri ve ekspresyonu ile ilişkilendirilmiştir. Çeşitli inflamatuar hücreler tarafından MMP aktivasyonu uyarılmaktadır. Klinik açıdan önemli olan MMP'lerin aktivitelerinde ortaya çıkan dengesizlikler sonucunda patolojik süreçler gelişmektedir. Sistemik inflamasyon çeşitli hastalıkların patogenezinde önemli bir faktör olduğundan, enzim ve inhibitör arasındaki dengenin sağlanması sonucunda MMP'lerin patolojik süreçlere karşı koruyucu bir rol oynayabileceği düşünülmektedir. (Alkanli ve ark., 2023; Ay ve ark., 2021).

İNTERSTİSYEL SİSTİT VE MATRİKS METALLOPROTEİNAZLAR

İnterstisyel sistit zayıflatıcı bir kronik pelvik ağrı durumu olarak mesane ile ilişkili ağrı, aciliyet, noktüri ve sık idrara çıkma semptomlarına dayanmaktadır. Etiyolojisi tam olarak belirlenemeyen interstisyel sistit sendromunun tanısında karıştırıcı ürolojik hastalıklar dışlanmalıdır (Abrams ve ark., 2003; McDougal ve ark., 2011). Başlangıçta mesane ile sınırlı bir durum olarak kabul edilen ve spesifik sistoskopik bulgulara dayanan bu sendrom günümüzde temel semptomları mesane ile ilişkili olan sistemik kronik ağrı sendromu olarak kabul edilmektedir (Cassão ve ark., 2019). Bu sendromun tanımlanmasında etkili olabilecek objektif bir belirteç ya da test bulunmamaktadır ve dışlanma tanısı kullanılmaktadır. Diğer kronik ağrı durumlarıyla ilişkiler tanımlandığında, bu ağrı yaşam kalitesini oldukça etkileyerek bozabilen zayıflatıcı semptom olarak bildirilmiştir (Erickson ve ark., 2001; Hanno ve ark., 2008; Nickel ve ark., 2010; van de Merwe ve ark., 2008). İnterstisyel sistit ile ilişkili birçok klinik durum tanımlanmıştır ve bu hastalıkların patofizyolojilerinde ortak yolakların etkili olabileceği düşünülmektedir. Heterojen bir sendrom olarak kabul edilen interstisyel sistit için az sayıda gerçekleştirilmiş genetik araştırmalarda hastalık biyobelirteçleri tam olarak saptanamamıştır (Akçay ve Konukoğlu, 1999; Graham ve Chai, 2006; Harrington ve ark., 1990; Keay ve Warren, 1998; Parsons ve ark., 2014; Theoharides ve ark., 2001). İnterstisyel sistit ile ilgili genetik faktörler ve bireysel fenotipik farklılıklar ağrı semptomlarına dayalı klinik şiddetin değerlendirilmesinde son derece önemlidir. İnterstisyel sistit patofizyolojisi ile ilişkili olabilecek ve ağrı duyarlılığını etkileyebilecek MMP-1, MMP-2, MMP-3 gibi matriks metalloproteinazların hastalık gelişimindeki ve progresyonundaki etkilerinin belirlenebilmesi, bu önemli faktörlerin klinik bulgular ile ilişkilendirilebilmesi, bu sendromun patogenezinin aydınlatılmasında yardımcı biyobelirteçler elde edebilmemizi sağlayabilecektir. Bu sendromda tedavi seçenekleri oldukça sınırlı olduğundan, interstisyel sistit sendromunun erken tespit edilebilmesi acil klinik zorluklar arasında yer almaktadır. Bu yüzden yeni terapötik stratejilerin geliştirilebilmesi için interstisyel sistit hastalığında patolojik süreçlerin tam olarak anlaşılabilmesine ve hastalığa nasıl müdahale edilmesi gerektiği konusunda yardımcı olabilecek moleküler düzeyde araştırmalara gereksinim duyulmaktadır. MMP-1, MMP-2, MMP-3 gibi matriks metalloproteinazlar inflamasyon sürecinin dahil olduğu çeşitli kronik hastalıkla ilişkilendirilmiştir. Bu kapsamda inflamatuar yanıtın yüksek olarak izlendiği ve inflamasyon sonrası süreçlerde artan ekstrasellüler matriksin yeniden düzenlenmesi süreçlerinin aktif olarak interstisyel sistit patofizyolojisinde yer alıyor olması sebebiyle, matriks metalloproteinazların incelenmesi ve interstisyel sistit hastalığının klinikopatolojik özellikleriyle bir arada değerlendirilmesi son derece önemlidir.

SONUÇ

İnterstisyel sistit, mesanenin koruyucu tabakasının hasar görmesiyle başlayan karmaşık bir patofizyolojiye sahiptir. Bu kronik inflamatuar süreçte, MMP'ler anahtar rol oynayan enzimlerdir. Normalde doku onarımı için gerekli olan bu enzimlerin aşırı aktivitesi, mesane dokusunda yıkım, epitel geçirgenliğinde artış ve fibrozis gibi patolojik değişikliklere yol açar. Özellikle jelatinazlar gibi bazı MMP'ler, mesane dokusunun yapısal bütünlüğünü bozarak hastalığın semptomlarını şiddetlendirir ve kronikleşmesine katkıda bulunur.

MMP'lerin bu yıkıcı etkisi, onları interstisyel sistit tedavisi için potansiyel terapötik hedefler haline getirir. Mevcut tedaviler genellikle semptom yönetimine odaklanırken, MMP'leri hedef alan stratejiler hastalığın altında yatan mekanizmayı kontrol etme potansiyeli sunar. MMP inhibitörleri, MMP aktivitesini doğrudan engelleyerek mesane dokusunun daha fazla hasar görmesini önleyebilir. Bu tür bir yaklaşım, fibrozis ve doku hasarını azaltarak semptomları hafifletebilir ve mesanenin normal işlevini geri kazanmasına yardımcı olabilir.

Ancak, MMP inhibitörlerinin kullanımı bazı zorluklar taşımaktadır. MMP'lerin normal fizyolojik süreçlerde de rol alması nedeniyle, bu enzimleri bloke etmek istenmeyen yan etkilere yol açabilir. Bu nedenle, interstisyel sistit hastalığına özgü MMP'leri veya aktivasyon yolaklarını hedefleyen seçici

inhibitörlerin geliştirilmesi kritik öneme sahiptir. Gelecekteki araştırmalar, MMP'lerin interstisyel sistit patogenezindeki tam rolünü aydınlatarak daha etkili ve güvenli terapötik ajanların tasarlanmasına olanak sağlayacaktır. Bu alandaki ilerlemeler, hastalığın yalnızca semptomlarını değil, kök nedenlerini de hedef alan yeni bir tedavi çağını başlatabilir.

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GENOTYPIC PROFILE AND CLINICAL SIGNIFICANCE OF PLASMINOGEN ACTIVATOR INHIBITOR-1 4G/5G GENE VARIATION IN PATIENTS UNDERGOING HEMODIALYSIS TREATMENT

HEMODİYALİZ TEDAVİSİ GÖREN HASTALARDA PLAZMİNOJEN AKTİVATÖR İNHİBİTÖR-1 4G/5G GEN VARYASYONUNUN GENOTİPİK PROFİLİ VE KLİNİK ÖNEMİ

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ABSTRACT

Plasminogen Activator Inhibitor-1 (PAI-1) is considered an important mediator of tissue damage and renal interstitial fibrosis which may lead to worsening of residual renal function in hemodialysis patients. Based on the observation of increased PAI-1 expression in narrow fistulas in dialysis patients, we aimed to emphasize the clinical importance of this gene variation by determining the genotypic profile of the PAI-1 4G/5G gene variation in patients receiving hemodialysis treatment. This study was conducted with 77 patients receiving hemodialysis treatment and 77 healthy controls. Those with blood clotting disorders and those diagnosed with any malignancy were excluded from our study. The genotypic profile of PAI-1 4G/5G gene variation was determined using polymerase chain reaction (PCR) method. Clinical findings of patients receiving hemodialysis treatment were obtained from the hemodialysis unit. In our study, the 4G/5G genotype of the PAI-1 4G/5G gene variation was determined significantly more common in patients receiving hemodialysis treatment (OR: 2.740, 95%CI: 1.427-5.258, p=0.0024), while the 4G/4G genotype was detected significantly more common in healthy controls (OR: 0.445, 95%CI: 0.231-0.855, p=0.015). The 4G/5G genotype of this gene variation was determined significantly higher in hemodialysis patients with diabetes mellitus, hypertension, cholesterol, heart disease, family history of dialysis, and in smokers (p=0.005). In addition, the 4G/5G genotype of the PAI-1 4G/5G gene variation was significantly more common in patients receiving hemodialysis treatment starting from the 12th month compared to those receiving treatment in the first 11 months (OR: 0.449, 95%CI: 0.208-0.966, p=0.041). In our study conducted with the Thrace population of Turkey, the 4G/5G genotype of the PAI-1 4G/5G gene variation was determined as a genetic risk factor in patients receiving hemodialysis treatment, while the 4G/4G genotype was determined as a protective factor against the disease. It is thought that PAI-1 4G/5G gene variation interacts with genetic and environmental risk factors rather than being a strong predictor on its own, and that the clinical significance of PAI-1 4G/5G gene variation in these patients can be determined more clearly by better understanding gene-gene and gene-environment interactions. It is anticipated that a clearer understanding of the clinical significance of this gene variation will enable more effective management of high-risk patients through the development of personalized therapeutic approaches.

Keywords: Hemodialysis, Plasminogen Activator Inhibitor-1, genetic variation, PCR

ÖZET

Plazminojen Aktivatör İnhibitörü-1 (PAI-1), hemodiyaliz hastalarında rezidüel böbrek fonksiyonunun kötüleşmesine yol açabilen doku hasarı ve renal interstisyel fibrozisin önemli bir mediyatörü olarak kabul edilmektedir. Diyaliz hastalarında dar fistüllerde PAI-1 ekspresyonunun arttığının gözlenmesine dayanarak, hemodiyaliz tedavisi gören hastalarda PAI-1 4G/5G gen varyasyonunun genotipik profilini belirleyerek bu gen varyasyonunun klinik önemini vurgulamayı amaçladık. Bu çalışma hemodiyaliz tedavisi gören 77 hasta ve 77 sağlıklı kontrol ile yürütüldü. Çalışmamıza kan pıhtılaşma bozukluğu olanlar ve herhangi bir malignite tanısı alanlar dahil edilmedi. PAI-1 4G/5G gen varyasyonunun genotipik profili polimeraz zincir reaksiyonu (PZR) yöntemi kullanılarak belirlendi. Hemodiyaliz tedavisi gören hastaların klinik bulguları hemodiyaliz ünitesinden elde edildi. Çalışmamızda PAI-1 4G/5G gen varyasyonunun 4G/5G genotipi hemodiyaliz tedavisi gören hastalarda anlamlı olarak daha yaygın olarak saptanırken (OR: 2.740, %95CI: 1.427-5.258, p=0.0024), 4G/4G genotipi ise sağlıklı kontrollerde anlamlı olarak daha yaygın olarak saptandı (OR: 0.445, %95CI: 0.231-0.855, p=0.015). Bu gen varyasyonunun 4G/5G genotipi, diyabetes mellitus, hipertansiyon, kolesterol, kalp hastalığı olan, ailede diyaliz öyküsü olan ve sigara içen hemodiyaliz hastalarında anlamlı derecede yüksek bulundu (p=0.005). Ayrıca PAI-1 4G/5G gen varyasyonunun 4G/5G genotipi, 12. aydan itibaren hemodiyaliz tedavisi alan hastalarda, ilk 11 ayda tedavi alanlara göre anlamlı derecede daha yaygındı (OR: 0.449, %95CI: 0.208-0.966, p=0.041). Türkiye'nin Trakya popülasyonunda yaptığımız çalışmada, hemodiyaliz tedavisi gören hastalarda PAI-1 4G/5G gen varyasyonunun 4G/5G genotipi genetik risk faktörü olarak belirlenirken, 4G/4G genotipi ise hastalığa karşı koruyucu faktör olarak belirlendi. PAI-1 4G/5G gen varyasyonunun kendi başına güçlü bir öngörücü olmaktan ziyade, genetik ve çevresel risk faktörleriyle etkileşime girdiği ve bu hastalarda PAI-1 4G/5G gen varyasyonunun klinik öneminin, gen-gen ve gen-çevre etkileşimlerinin daha iyi anlaşılmasıyla daha net bir şekilde belirlenebileceği düşünülmektedir. Bu gen varyasyonunun klinik öneminin daha iyi anlaşılmasının, kişiselleştirilmiş tedavi yaklaşımlarının geliştirilmesi yoluyla yüksek riskli hastaların daha etkili bir şekilde yönetilmesine olanak sağlayacağı öngörülmektedir.

Anahtar Kelimeler: Hemodiyaliz, Plazminojen Aktivatör İnhibitörü-1, genetik varyasyon, PZR

GİRİŞ

Böbrekler insan sağlığı için son derece önemlidir ve glomerüler filtrasyondaki bozukluklar sonucunda fonksiyonunu gerçekleştiremeyen böbreklerin nakil yoluyla değiştirilmemesi durumunda ciddi sakatlıklar ve ölüm ortaya çıkmaktadır. Diyabet, obezite, kardiyovasküler hastalıklar, derin ven trombozu gibi hastalıklar böbrek hastalıkları ile ilişkilendirilmiştir (Małgorzewicz ve ark., 2013).

Plazminojen aktivatör inhibitör-1 (PAI-1) serin proteaz inhibitörleri olarak bilinen SERPINE ailesinin önemli bir üyesi olarak doku plazminojen aktivatörünü (tPA) ve ürokinaz plazminojen aktivatörünü (uPA) inhibe etme yoluyla plazminojen / plazmin sisteminin düzenlenmesinde önemli rol oynamaktadır (Zhang ve ark., 2020). Bu yüzden PAI-1 diğer pıhtılaşma faktörleri ile birlikte progresif fibrotik bozukluklarda etkili bir faktör olarak kabul edilmektedir (Kato ve ark., 2018). Yüksek PAI-1 konsantrasyonları böbrekler gibi çeşitli organlarda doku fibrozu gelişimi ile ilişkilendirilmiştir (Sillen ve Declerck, 2021). PAI-1 makrofajlar, yağ hücreleri, trombositler, hepatositler, fibroblastlar, kardiyomiyositler gibi farklı hücre tipleri tarafından üretilmektedir ve PAI-1 üretimi çeşitli faktörler tarafından uyarılmaktadır. Fibrotik, inflamatuar ve vasküler komplikasyonları içeren hastalıklarda PAI-1 aşırı ekspresyonu gözlenmektedir (Bandinelli ve ark., 2005; Kanno, 2019; Muñoz-Valle ve ark., 2012). Birçok biyolojik süreçte önemli rol oynayan PAI-1'in hastalığa bağlı olarak aşırı eksprese edilmesi ya da yeteri kadar eksprese edilememesi beklenmedik sonuçlar doğurabilmektedir. PAI-1 eksikliği olan

hastalarda plazminin aşırı üretiminden dolayı erken pıhtı lizisi sonucunda sık gelişen kanama atakları gözlenmektedir (Małgorzewicz ve ark., 2013).

Kalıtsal PAI-1 eksikliği, çeşitli varyantların sinyal peptitindeki polimorfizmlerden ve genin 4. ekzonunda tanımlanmış fonksiyonel olmayan proteinden dolayı tam PAI-1 eksikliğine neden olabilen mutasyonlardan kaynaklanmaktadır (Małgorzewicz ve ark., 2013). PAI-1 kodlayan SERPINE1 geninin promotör bölgesinde -675 pozisyonunda PAI-1 4G/5G gen varyasyonu (rs1799889) tanımlanmıştır ve bu genetik varyasyon kardiyovasküler, otoimmün, inflamatuar, fibrotik hastalıklara yatkınlıkta önemli bir biyobelirteç olarak kabul edilmektedir (Anaya-Macias ve ark., 2020; Chen ve ark., 2021; Sotos-Prieto ve ark., 2013; Yousef ve ark., 2020). Bu fonksiyonel delesyon / insersiyon gen varyasyonu sonucunda ise PAI-1 plazma ekspresyonu artmaktadır (Małgorzewicz ve ark., 2013).

Hemodiyaliz hastalarında PAI-1 4G/5G gen varyasyonunun klinik önemi, bu genetik faktörün tromboz riskini artırmasıyla ilişkilendirilmiştir. Bu durum, özellikle hemodiyaliz tedavisi için hayati önem taşıyan damar erişim yollarında ciddi sorunlara yol açabilmektedir. PAI-1, fibrinolizin temel regülatörlerinden biri olarak bilinmektedir ve bu sistem damar tıkanıklığının önlenebilmesi için pıhtıların çözülmesinde rol oynamaktadır. Fibrinoliz süreci, tPA gibi enzimlerin plazminojeni aktif plazmine dönüştürmesiyle başlamakta ve plazmin ise pıhtıyı oluşturan fibrini parçalamaktadır. PAI-1 tPA'yı inhibe ederek bu süreci durdurmaktadır. Bu mekanizma, kanama durumunda pıhtının erkenden çözülmesini önlemek için son derece önemlidir. Ancak, PAI-1 seviyelerinin kronik olarak yüksek olması, pıhtıların çözülme yeteneğinin azalmasına ve böylece tromboz riskinin artmasına neden olmaktadır. PAI-1 geninin promotör bölgesinde tanımlanan 4G/5G polimorfizmi tarafından PAI-1 proteininin üretim seviyeleri etkilenmektedir. Bu gen varyasyonunun 4G aleli, PAI-1 geninin daha aktif formu olarak daha fazla PAI-1 üretimine yol açabilirken, 5G aleli, PAI-1 üretimini daha düşük seviyelerde tutabilmektedir. Genellikle 4G allelini taşıyan bireylerde pıhtılaşma riskinin daha yüksek olabileceği düşünülmektedir. Hemodiyaliz hastaları, hemodinamik değişiklikler, kronik inflamasyon ve diyaliz için kullanılan vasküler erişim yolları nedeniyle yüksek tromboz riski taşımaktadır. PAI-1 4G/5G gen varyasyonu bu temel riskin üzerine eklenerek klinik sonuçların daha da kötüleşmesine yol açabilmektedir. Hemodiyaliz hastalarında PAI-1 4G/5G gen varyasyonunun varlığı, bu hastaların kişisel pıhtılaşma risk profillerinin belirlenmesinde önemli bir biyobelirteç olarak düşünülmektedir (Güngör ve ark., 2011; Tabaei ve ark., 2022).

Çalışmamızda hemodiyaliz tedavisi gören hastalarda PAI-1 4G/5G gen varyasyonunun genotip dağılımlarının belirlenmesi ve bu gen varyasyonunun hemodiyaliz hastalarında klinik öneminin incelenmesi amaçlanmıştır.

MATERYAL VE METOT

Hasta ve Kontrol Gruplarının Belirlenmesi

Çalışmamız için öncelikle Girişimsel Olmayan Klinik Araştırmalar Etik Kurulu'ndan onay alınmıştır ve hemodiyaliz tedavisi gören hastalar ile sağlıklı kontrollere araştırma hakkında bilgi verilerek bilgilendirilmiş onam formları gönüllülük esasına dayanarak imzalatılmıştır. Bu çalışma hemodiyaliz tedavisi gören 77 hasta ve 77 sağlıklı kontrol ile gerçekleştirilmiştir. Çalışmamızda hasta grubu hemodiyaliz tedavisi gören hastalardan oluşmaktaydı. Sağlıklı kontrol grubu ise hemodiyaliz tedavisi görmeyen gönüllüleri içermekteydi. Hasta ve kontrol grupları için kan pıhtılaşma bozuklukları olanlar, kan hastalıkları olanlar, herhangi bir malignite tanısı almış olanlar çalışmamızda kapsam dışı bırakılmıştır.

PAI-1 Gen Varyasyonu Genotip Dağılımlarının Belirlenmesi

Çalışmamızda Trakya Üniversitesi Sağlık Araştırma ve Uygulama Merkezi Diyaliz Ünitesine başvurmuş ve hemodiyaliz tedavisi almış, rutin kontrole gelerek daha önce hemodiyaliz tanısı almış

olan hastalardan ve Trakya Üniversitesi Sağlık Araştırma ve Uygulama Merkezi Poliklinikleri ve servislerine başvurmuş ve yapılan tetkikler sonucunda hemodiyaliz saptanmamış kişilerden rutin tetkikler için alınmış olan periferik venöz kanlardan DNA örnekleri elde edilmiştir. Bu DNA örneklerinden PAI-1 4G/5G gen varyasyonunun genotip dağılımları polimeraz zincir reaksiyonu (PZR) yöntemi uygulanarak belirlenmiş ve hemodiyaliz hastalarındaki genetik yatkınlık saptanmıştır. PZR reaksiyon karışımı; kalıp DNA, tampon solüsyonu, dNTP, primerler, Taq DNA polimeraz enzimi ve uygun konsantrasyonda $MgCl_2$ içermekteydi. PAI-1 4G/5G gen varyasyonu için; 5'-CACAGAGAGAGTCTGGCCACGT-3', 5'-CCAACAGAGGACTCTTGGTCTCCACG-3' forward ve reverse primer çiftleri kullanılmıştır. PZR koşulları 94°C'de 60 saniye, 54°C'de 30 saniye, 72°C'de 40 saniye olarak 35 döngü olarak gerçekleştirilmiştir. PZR sonucunda PAI-1 4G/5G gen varyasyonu genotip dağılımları 4G/4G, 4G/5G, 5G/5G olarak üç genotip şeklinde belirlenmiştir. Ayrıca hemodiyaliz ünitesinden hastaların klinik bulguları elde edilmiştir.

İstatistiksel Analiz

Çalışmamızda istatistiksel analiz SPSS programı kullanılarak gerçekleştirilmiştir. Hemodiyaliz hastaları ve sağlıklı kontroller arasındaki demografik ve klinik parametrelerin karşılaştırılmasında bağımsız örneklem testi ve ki-kare testi kullanılmıştır. Hasta ve kontrol grupları arasında PAI-1 4G/5G gen varyasyonunun genotip dağılımları karşılaştırılması ki-kare testi, lojistik regresyon analizi kullanılarak gerçekleştirilmiş ve odds ratio değerleri hesaplanmıştır. Klinik bulgulara göre genotip dağılımlarının karşılaştırılmasında da ki-kare testi kullanılmıştır. Ayrıca hastalarda hemodiyaliz tedavi süresine göre PAI-1 4G/5G gen varyasyonu genotip dağılımları da lojistik regresyon analizi ile karşılaştırılarak odds ratio değerleri hesaplanmıştır. İstatistiksel anlamlılık düzeyi $p<0.05$ olarak kabul edilmiştir.

BULGULAR

Çalışmamızda hemodiyaliz tedavisi gören hasta grubunun yaş ortalaması 58.125 ± 14.615 olarak belirlenmişken, sağlıklı kontrol grubunun yaş ortalaması 56.078 ± 7.562 olarak saptanmıştır. Hasta ve kontrol grupları arasında yaş parametresi bakımından anlamlı bir farklılık belirlenmemiştir (OR: 2.047, %95CI: 1.738-5.832, p=0.287). Çalışmamızda hemodiyaliz tedavisi gören hastalar ve sağlıklı kontroller arasında diyabetes mellitus, hipertansiyon, kolesterol, kalp hastalığı parametreleri bakımından anlamlı bir farklılık belirlenmiştir ($p<0.05$) (Tablo 1).

Tablo 1. Hemodiyaliz tedavisi gören hastalar ve sağlıklı kontroller arasında demografik ve klinik bulguların karşılaştırılması

Klinik ve Demografik Parametreler	***Hasta Grubu (n=77)***	***Kontrol Grubu (n=77)***	***OR (%95 Confidence Interval)***	***p***
Yaş	58.125 ± 14.615	56.078 ± 7.562	2.047 (1.738-5.832)	0.287[a]
Hipertansiyon (+)	58 (%75.3)	21 (%27.3)	8.140 (3.958-16.742)	***<0.001[b*]***
Diyabetes Mellitus (+)	29 (%37.7)	7 (%9.1)	6.042 (2.448-14.911)	***<0.001[b*]***
Kolesterol (+)	26 (%33.8)	13 (%16.9)	2.510 (1.173-5.370)	***0.018[b*]***
Kalp Hastalığı (+)	26 (%33.8)	7 (%9.1)	5.098 (2.054-12.656)	***<0.001[b*]***
Sigara (+)	31 (%40.3)	26 (%33.8)	1.322 (0.686-2.548)	0.405[b]

[a]Bağımsız Örneklem Testi

[b]Lojistik Regresyon; (+): Mevcut; *: Anlamlılık (p<0,05)

Çalışmamızda hasta ve kontrol grupları arasında PAI-1 4G/5G gen varyasyonu genotip dağılımları bakımından anlamlı bir farklılık saptanmıştır (p=0.009). PAI-1 4G/5G gen varyasyonunun 4G/5G genotipi hemodiyaliz tedavisi gören hastalarda anlamlı olarak daha yaygın belirlenmiştir (OR: 2.740, %95CI: 1.427-5.258, p=0.0024). Buna karşın, bu gen varyasyonunun 4G/4G genotipi ise sağlıklı kontrollerde anlamlı olarak daha yaygın olarak saptanmıştır (OR: 0.445, %95CI: 0.231-0.855, p=0.015) (Tablo 2).

Tablo 2. Hemodiyaliz hastaları ve sağlıklı kontroller arasında PAI-1 4G/5G gen varyasyonu genotip dağılımlarının karşılaştırılması

Genotip Dağılımları		***Hasta Grubu (n=77)***	***Kontrol Grubu (n=77)***	***p***
PAI-1 4G/5G	4G/4G	25 (%32.5)	40 (%51.9)	***0.009[a]****
	4G/5G	48 (%62.3)	29 (%37.7)	
	5G/5G	4 (%5.2)	8 (%10.4)	
Genotip Dağılımları		***Hasta Grubu (n=77) ve Kontrol Grubu (n=77)***		***p***
PAI-1 4G/5G	4G/4G	OR: 0.445 (0.231-0.855)		***0.015[b]****
	4G/5G	OR: 2.740 (1.427-5.258)		***0.002[b]****
	5G/5G	OR: 0.473 (0.136-1.641)		0.238[b]

[a]Ki-kare testi; [b]Lojistik Regresyon; **OR:** Odds ratio; **4G/4G:** 4Guanin/4Guanin; **4G/5G:** 4Guanin/5Guanin;
5G/5G: 5Guanin/5Guanin; *: Anlamlılık (p<0,05)

Hemodiyaliz tedavisi gören hastalarda ve sağlıklı kontrollerde Hardy-Weinberg dağılımı incelendiğinde, hasta grubunda 4G alelinin frekansı 0.6360 olarak belirlenmişken, 5G alelinin frekansı 0.3640 olarak saptanmıştır. Hasta grubundaki alel dağılımı Hardy-Weinberg dağılımından farklılık göstermekteydi (p=0.0023). Kontrol grubunda 4G alelinin frekansı 0.7080 olarak saptanmışken, 5G alelinin frekansı ise 0.2920 olarak belirlenmiştir. Kontrol grubundaki alel dağılımı Hardy-Weinberg dağılımına uygunluk göstermekteydi (p=0.432) (Tablo 3).

Tablo 3. Hemodiyaliz hastalarında ve sağlıklı kontrollerde Hardy-Weinberg Dağılımı

Gen Varyasyonu	***Hasta Grubu (n=77)***			***Kontrol Grubu (n=77)***		
	Alel	***Olgu***	***Frekans***	***Alel***	***Olgu***	***Frekans***
PAI-1 4G/5G	**4G**	98	0.6360	**4G**	109	0.7080
	5G	56	0.3640	**5G**	45	0.2920
	Total	154	1.0000	**Total**	154	1.0000
	Hardy-Weinberg Dağılım Testi: **Pearson chi2 = 9.268** ***Pr= 0.0023[a]****			**Hardy-Weinberg Dağılım Testi:** **Pearson chi2 = 0.617** Pr=0.432[a]		

[a]Hardy-Weinberg Dağılım Testi; *: Anlamlılık (p<0,05)

Bu gen varyasyonunun 4G/5G genotipi, diyabetes mellitus, hipertansiyon, kolesterol, kalp hastalığı olan, ailede diyaliz öyküsü olan ve sigara içen hemodiyaliz hastalarında anlamlı derecede yüksek bulundu (p=0.005) (Tablo 4).

Tablo 4. Hemodiyaliz hastalarında klinik parametrelere göre PAI-1 4G/5G gen varyasyonu genotip dağılımlarının karşılaştırılması

PAI-1 4G/5G	***DM***	***HT***	***KOL***	***KH***	***ADÖ***	***SG***	***Total***	***p***
4G/4G	7	18	6	9	2	11	53	***<0.005[a]****
4G/5G	22	37	20	19	10	19	127	
5G/5G	0	3	0	0	0	1	4	
Total	29	58	26	26	12	31	184	

[a]Ki-kare testi; *: Anlamlılık (p<0,05)

DM: Diyabetes Mellitus; **HT:** Hipertansiyon; **KOL:** Kolesterol; **KH:** Kalp Hastalıkları; **SG:** Sigara; **4G/4G:** 4Guanin/4Guanin; **4G/5G:** 4Guanin/5Guanin; **5G/5G:** 5Guanin/5Guanin;

Ayrıca PAI-1 4G/5G gen varyasyonunun 4G/5G genotipi, 12. aydan itibaren hemodiyaliz tedavisi alan hastalarda, ilk 11 ayda tedavi alanlara göre anlamlı derecede daha yaygın olarak belirlenmiştir (OR: 0.449, %95CI: 0.208-0.966, p=0.041).

TARTIŞMA

Hemodiyaliz tedavisi sırasında kan numunelerinin diyalizör ve diyalizatla teması sonucunda kallikrein-kinin sistemi aktive olmakta, lökosit aktivasyonunun yanısıra sitokin üretimi ile karakterize bir inflamatuar yanıt ortaya çıkmaktadır. Kronik hemodiyaliz hastalarında artmış inflamasyon fibrinolitik sistemdeki dengesizlikler ile ilişkilendirilmiştir. İn vivo fibrinolizin başlıca fizyolojik inhibitörü olarak kabul edilen PAI-1 ekspresyonu sitokinler tarafından uyarılmaktadır. Hemodiyaliz sırasında tPA konsantrasyonları ile aktivitesi geçici olarak artmaktadır. Ayrıca kronik hemodiyaliz popülasyonunda da dolaşımdaki PAI-1 konsantrasyonlarının arttığı belirlenmiştir. Bu yüzden hemodiyaliz tedavisi gören hastalarda plazma PAI-1 düzeylerinde artışlar saptanmıştır. Kronik hemodiyaliz hastalarında ayrıca trombosit fonksiyonlarında da anormallikler gözlenmektedir. Hemodiyaliz tedavisi sırasında fibrinolitik aktivite akut olarak artmakta ve bu durum tPA artışı ile ilişkilendirilmektedir. Bazı araştırmalarda ise hemodiyaliz tedavisi sırasında PAI-1 antijeninde ve aktivitesinde anlamlı bir artış belirlenmemiştir. PAI-1 antijeni akut faz reaktanı ve fbrinoliz inhibitörü olarak bilinmektedir. Hemodiyaliz sırasında artmış tPA antijeninin PAI-1 antijeni ile kompleks oluşturması nedeniyle aktivitesinde azalma meydana geldiği düşünülmektedir. Daha önce gerçekleştirilmiş bazı çalışmalarda hemodiyaliz tedavisi gören hastalarda PAI-1 konsantrasyonları sağlıklı kontrollere kıyasla anlamlı derecede daha yüksek belirlenmiştir. Bu durumun hemodiyaliz tedavisi uygulanan hastalarda yüksek plazma sitokin düzeyleri ve endotel disfonksiyon derecesi ile ilişkili olabileceği öngörülmektedir. Farklı çalışmalarda PAI-1 aktivitesi inhibisyonunun ya da mutant PAI-1 tedavisinin matriks dönüşümünü arttırarak glomerülosklerozu azalttığı belirlenmiştir. Bu yüzden PAI-1 fibrotik böbrek hastalıkları için önemli bir terapötik hedef olarak kabul edilmektedir. Ancak net proteolitik aktivitenin PAI-1 tarafından negatif düzenlenme yoluyla uPA ve tPA tarafından aktivasyonu arasındaki dengeye bağlı olduğu düşünülmektedir. Ayrıca PAI-1 inhibitörleri tarafından plazmin aktive edilmekte ve aktive edilen plazmin sonucunda kollejenazlar, metalloproteinazlar gibi diğer proteolitik enzimlerin aktiviteleri de artmaktadır. Fonksiyonunu gerçekleştiremeyen böbreklerin neden olduğu böbrek hastalıklarında prognozun değerlendirilmesi bakımından proteoliz düzenleyicileri olarak kabul edilen bu enzimler son

derece önemlidir (Małgorzewicz ve ark., 2013). SERPINE1 geni tarafından kodlanan PAI-1 proteini öncelikle fibrinolizde önemli rol oynaması ve çeşitli otoimmün hastalıkların şiddetiyle ilişkili olması nedeniyle sistemik skleroz gibi durumlarda da etkili bir biyobelirteç olarak kabul edilmektedir (Lomelí-Nieto ve ark., 2024).

PAI-1 geninin promotör bölgesinde tanımlanmış olan PAI-1 4G/5G gen varyasyonu transkripsiyon başlangıç bölgesinin -675 pozisyonunda guanin baz sayısındaki polimorfik varyans ile karakterizedir. Bazı çalışmalarda PAI-1 4G/5G gen varyasyonunun 4G/4G homozigot genotipinin ve 4G alelinin hemodiyaliz tedavisi gören hastalarda ateroskleroz, kardiyovasküler hastalıklar, tromboz gelişimi için bağımsız bir risk faktörü olabileceği belirlenmiştir (Güngör ve ark., 2011; Lazo-Langner ve ark., 2006; Trimarchi ve ark., 2008). Arjantin popülasyonu ile gerçekleştirilmiş bir çalışmada ise hemodiyaliz tedavisi gören hastalarda PAI-1 4G/5G gen varyasyonunun 4G/5G genotipinin diğer genotiplere kıyasla PAI-1 plazma düzeylerinden bağımsız olarak anlamlı derecede daha yaygın olduğu belirlenmiştir (Trimarchi ve ark., 2008).

Bizim çalışmamızda ise PAI-1 4G/5G gen varyasyonunun 4G/5G genotipi hemodiyaliz tedavisi gören hastalarda anlamlı olarak daha yaygın belirlenmişken, bu gen varyasyonunun 4G/4G genotipi ise sağlıklı kontrollerde anlamlı olarak daha yaygın olarak saptanmıştır. Bu gen varyasyonunun 4G/5G genotipi ayrıca diyabetes mellitus, hipertansiyon, kolesterol, kalp hastalığı olan, ailede diyaliz öyküsü olan ve sigara içen hemodiyaliz hastalarında anlamlı derecede yüksek olarak belirlenmiştir. Bunun yanısıra PAI-1 4G/5G gen varyasyonunun 4G/5G genotipi, 12. aydan itibaren hemodiyaliz tedavisi alan hastalarda, ilk 11 ayda tedavi alanlara göre anlamlı derecede daha yaygın olarak saptanmıştır. Çalışmamızda yüksek PAI-1 üretimiyle ilişkili olan 4G/4G genotipinin sağlıklı kontrollerde, buna kıyasla daha düşük PAI-1 üretimiyle ilişkili olan 4G/5G genotipinin ise hemodiyaliz hastalarında daha yüksek oranda bulunması durumu, genotiplerin sadece PAI-1 üretim miktarlarını değil, aynı zamanda farklı klinik bağlamlarda nasıl bir risk profili oluşturduğunu gösteren önemli bir biyolojik ve klinik tabloyu işaret ettiğini göstermektedir. Sağlıklı kontrollerde 4G/4G genotipinin daha sık görülmesi, yüksek PAI-1 üretimi potansiyeline sahip bir genotipin popülasyonda yaygın olduğunu düşündürmektedir. PAI-1, fizyolojik olarak kan pıhtılaşmasını düzenlemek için gerekli bir protein olduğundan, kanama durumunda pıhtı oluşumunun desteklenmesi ve pıhtının erken çözülmesinin engellenmesi için yüksek PAI-1 seviyelerinin faydalı olduğu bilinmektedir. Sağlıklı bireylerde bu yüksek potansiyelin, bir hastalık durumu olmadığı sürece dengeyi bozmayacağı ve normal fizyolojik süreçlerin bir parçası olarak değerlendirilebileceği düşünülmektedir. Bu durum, genetik varyasyonun sadece risk potansiyelini taşıdığını, ancak klinik bir hastalık için kronik böbrek yetmezliği, inflamasyon, damar hasarı gibi diğer faktörlere ihtiyaç duyulduğunu düşündürmektedir. Hemodiyaliz hastalarında bu gen varyasyonunun 4G/5G genotipinin sağladığı orta düzeydeki PAI-1 artışı bile, zaten bozulmuş olan pıhtılaşma-fibrinoliz dengesini bozmaya yetebilecektir. Yani, 4G/4G'nin potansiyel olarak daha yüksek olan riskinin, hastalığın kendisi nedeniyle daha düşük seviyeli 4G/5G genotipinin klinik olarak daha belirgin hale gelmesine yol açabildiği düşünülmektedir. 4G/4G genotipi gibi çok yüksek pıhtılaşma potansiyeli taşıyan bireyler, kronik böbrek yetmezliği gibi ek risk faktörleri altında daha erken ve daha şiddetli tromboz olayları yaşayabileceklerinden, hemodiyaliz evresine ulaşamayabilirler. Öte yandan, 4G/5G genotipinin daha ılımlı bir risk taşımasından dolayı bu hastaların hemodiyaliz tedavisine kadar gelebildiği ve bu genotipin popülasyonda birikmesine yol açabildiği öngörülmektedir. PAI-1 4G/5G gen varyasyonunun klinik öneminin kişinin genel sağlık durumuna ve diğer hastalıklarla olan etkileşimine bağlı olarak değiştiği düşünülmektedir. Sağlıklı bireyde bu gen varyasyonunun 4G/4G genotipinin taşıdığı riskin, hemodiyaliz hastalarında bu gen varyasyonunun 4G/5G genotipinin oluşturduğu riskten daha az olacağı ve birincil risk faktörleri varlığında, orta düzeyde PAI-1 artışının bile ciddi klinik sonuçlara yol açabileceği öngörülmektedir. Bu yüzden, genetik faktörler olarak sadece genotiplerin

değil, aynı zamanda klinik bulguların da genotiplerle birlikte ele alınarak hemodiyaliz hastalarının değerlendirilmesinin uygun olacağı düşünülmektedir.

SONUÇ

Türkiye'nin Trakya popülasyonunda yaptığımız çalışmamızda, hemodiyaliz tedavisi gören hastalarda PAI-1 4G/5G gen varyasyonunun 4G/5G genotipi genetik risk faktörü olarak belirlenmiştir. Bu gen varyasyonunun 4G/4G genotipi ise hastalığa karşı koruyucu faktör olarak saptanmıştır. Bu gen varyasyonunun 4G/5G genotipi, diyabetes mellitus, hipertansiyon, kolesterol, kalp hastalığı olan, ailede diyaliz öyküsü olan ve sigara içen hemodiyaliz hastalarda genetik bir risk faktörü olarak belirlenmiştir. Ayrıca PAI-1 4G/5G gen varyasyonunun 4G/5G genotipi, 12. aydan itibaren hemodiyaliz tedavisi alan hastalarda, ilk 11 ayda tedavi alanlara göre anlamlı derecede daha yaygın olarak saptanmıştır. PAI-1 4G/5G gen varyasyonunun, birincil hastalık risk faktörlerinin yanısıra genetik ve çevresel risk faktörleri ile etkileşime girerek bu hastalarda bu varyasyonun klinik öneminin, gen-gen ve gen-çevre etkileşimlerinin daha iyi anlaşılmasıyla daha net bir şekilde belirlenebileceği öngörülmektedir. Bu gen varyasyonunun klinik öneminin daha iyi anlaşılmasının, kişiselleştirilmiş tedavi yaklaşımlarının geliştirilmesi yoluyla yüksek riskli hastaların daha etkili bir şekilde yönetilmesine olanak sağlayacağı düşünülmektedir. Hemodiyaliz hastalarında PAI-1 4G/5G gen varyasyonunun varlığı, bu hastaların kişisel pıhtılaşma risk profillerinin belirlenmesinde önemli bir biyobelirteç olarak değerlendirilmektedir. Genetik riskin bilinmesi, daha agresif antikoagülan tedavilerin uygulanabilmesi, damar erişim yollarının daha yakından izlenebilmesi ve tromboz riskini azaltmaya yönelik yaşam tarzı önerilerinin yapılabilmesi konusunda hekimlere yardımcı olabilecektir.

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ANTHROPOMETRIC PROFILE OF 8–9-YEAR-OLD CHILDREN IN SHKODËR, ALBANIA: GENDER DIFFERENCES AND BMI CATEGORIZATION

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ABSTRACT

Childhood obesity has become a significant global public health concern, with the World Health Organization (WHO, 2023) labeling it as one of the most serious health challenges of the 21st century. Over the past three decades, the global prevalence of overweight and obesity among children and adolescents has increased dramatically (Ng et al., 2014). The aim of this study was to assess the anthropometric characteristics of 8–9-year-old children and to analyze gender differences as well as their distribution across BMI categories. A total of 149 children (75 females and 74 males), aged 8–9 years, were recruited from three randomly selected 9-year primary schools in the urban area of Shkodra, Albania. Parental consent and school administration approvals were obtained. Descriptive statistics and the independent samples t-test were used to evaluate gender differences, and BMI was classified according to standard categories. Preliminary results showed no statistically significant differences between girls and boys in BMI, weight, or height ($p > 0.05$). However, 35% of the children were classified as overweight or obese, which raises a serious public health concern. A strong positive correlation was also found between BMI and waist circumference ($r > 0.90$). The study provides a clear overview of the physical status of children and can serve as a foundation for further intervention efforts. The high prevalence of overweight and obesity among 8–9-year-old children in Shkodra highlights the urgency of implementing public health strategies focused on early prevention. Regular monitoring, school-based interventions, and community awareness campaigns are essential to mitigate the long-term health risks associated with childhood obesity.

Keywords: childhood obesity, BMI, anthropometric measurements, Albania, school-aged children

Introduction

Childhood obesity has become a serious problem of global public health importance, with the World Health Organization (WHO, 2023) identifying it as one of the most serious health challenges of the 21st century. Over the past three decades, the global prevalence of overweight and obesity among children and adolescents has increased significantly according to (Ng et al., 2014). Data from over 200 countries show a fourfold increase in the obesity rate in children and adolescents since 1975 according to references (NCD-RisC, 2017). In Albania, the latest data from the Childhood Obesity Surveillance Initiative (COSI) 2022 shows that 30.2% of children aged 8–9 are overweight, including 14.2% categorized as obese (WHO, 2022). Also, earlier local studies, such as that of Cako et al. (2014), showed lower percentages—9.8% of boys and 5.5% of girls were obese—showing an upward trend in recent years. Increased childhood overweight and obesity is a major risk for the early onset of many diseases, including type 2 diabetes, cardiovascular disease, and metabolic syndrome (Zimmet et al., 2023; Sahoo et al., 2015). Additionally, risk factors, such as lack of physical activity, sedentary lifestyle, high

consumption of unhealthy foods, and reduced parental control over diet, are major contributors to current problems (Popkin et al., 2020; Biddle et al., 2010). Schools represent an important environment for identifying and treating overweight and obesity in children through health promotion and timely interventions (Lobstein et al., 2022). In this context, our study aims to contribute as much as possible to the identification of such cases and the taking of preventive measures. Anthropometry is the scientific field that deals with measuring and analyzing human body size, including weight, height, body size, and body mass distribution. In childhood, especially at the age of 8–9 years, these measurements are important for assessing children's physical development and health, as well as for identifying opportunities for early intervention in such cases. During this period of development, children go through different stages of growth and motor development. Anthropometric measurements, such as body mass index (BMI), waist circumference and body size, give us valuable information not only for assessing physical growth, but also for understanding their relationship with motor and sensory-perceptual abilities which are important for this age group.

Another important aspect of children's development is the link between anthropometric measurements and sensory-perceptual skills. Sensory-perceptual skills include the ability to evaluate and interpret information from the senses, such as sight, hearing, touch, and proprioceptive sensitivity. These skills are basic for children's motor development and overall physical performance. Studies show a close link between anthropometric measurements and sensory-perceptual abilities in children. For example, a study by Milanese et al. (2010) showed that anthropometric measurements, such as BMI and body size, have a significant impact on children's motor skills. This study found that children with higher BMI had a poorer performance on motor skills tests, such as jumping and running. Another study by Hurtado-Almonacid et al. (2024) analyzed the development of motor skills in children between the ages of 3 and 10 and found significant differences in motor skills based on age and gender. This study highlighted the importance of developing motor skills during this childhood period and their connection to anthropometric measurements. This study aims to assess the current anthropometric situation of 8–9 year old students in Shkodra, compare the results with national and international data, and discuss the implications for local public health strategies. Finally, the link between anthropometric measurements and sensory-perceptual abilities in children aged 8–9 years is crucial. This is to assess their physical development and to plan the interventions necessary to improve motor skills and health. Further studies are needed to better understand this link and to develop effective strategies by the relevant authorities, to support the development of children at this critical age.

Methodology

The study included a total of N=149 children (75 girls and 74 boys), aged 8–9 years, selected from three randomly selected 9-year schools in the area of the municipality of Shkodra, Albania. The schools were selected at random, to represent different socio-economic areas of the city. Approvals were obtained from parents and school administrations. The study followed the ethical standards of the Helsinki Declaration. The measurements were carried out according to the standards of the International Society for the Advancement of Kinanthropometry (ISAK) (Marfell-Jones et al., 2012). The weight was measured with a digital scale (with an accuracy of up to 0.1 kg), and the length was measured with a stadiometer (with an accuracy of up to 0.1 cm). BMI was calculated as weight in kilograms divided by the square of length in meters. The circumference of the waist was measured between the lower rib and the iliac crust. The measurements were developed by the working group who have previously been trained on this protocol.

BMI classification was made according to WHO growth references (WHO, 2007):

1. **Underweight:** BMI < 14
2. **Normal:** BMI 14–18.9

3. **Overweight:** BMI 19–21.9
4. **Obese:** BMI ≥ 22

The data was collected and analyzed with SPSS and EXCEL. Descriptive statistics (mean and standard deviation) were calculated. Independent sample t tests were used to assess gender differences. Pearson correlations were used to examine the associations between BMI and waist circumference. Graphic presentations included boxplots, histograms, cake graphics, and scatter plots. A statistically significant level was considered $p < 0.05$.

Results

From the results obtained we see that, the average BMI for the entire sample was 18.03 ± 3.24 kg/m². The average weight was 37.1 ± 11.6 kg, the average length was 139.5 ± 7.1 cm, and the average waist circumference was 64.1 ± 9.3 cm. The data show moderate variation among individuals, reflecting diversity in growth and physical development at the age of 8–9 years. The average values are in line with national and regional standards for this age group, providing a general overview of the anthropometric situation of children in Shkodra.

BMI Categories	
Underweight:	5%
Normal:	60%
Overweight:	15%
Obese:	20%

Table 1. Categorization by BMI

Most children are in the normal category, but 35% are above normal (overweight + obese) a high percentage for this age. These data show that one in five children in our sample is obese, a percentage that exceeds the global averages reported by the WHO (2023). This result reflects the growing trends of overweight and obesity in the region, especially in Southeast Europe (Radulović et al., 2021). The percentage of children with normal BMI is still high, which indicates that there is room for preventive interventions to prevent the situation from worsening. No statistically significant differences were found between boys and girls in BMI, waist circumference, or height ($p > .05$). This result is consistent with other studies in European populations, where gender differences in anthropometric indicators are often minimal at this age (Spinelli et al., 2019). The results suggest that genetic and environmental factors contribute similarly to both sexes in this period of development, reflecting similar patterns of body fat growth and spread. A strong positive correlation was found between BMI and waist circumference ($r = .92$, $p < .001$). This indicates that children with higher BMI usually also have larger waist circumference, confirming the reliability of BMI as an indicator of central adiposity and associated metabolic risks (Zimmet et al., 2023). The strong association between these two indicators highlights the importance of dual BMI and waist circumference monitoring for identifying children at high risk for metabolic disease in the future.

Variabla	**t-statistics**	**p-value**	**Interpretation**
Weight	0.74	0.46	There is no statistically significant difference
Length	0.17	0.86	There is no significant difference

BMI	0.88	0.39	The difference is not statistically significant
Perimeters	0.79	0.43	There is no significant difference

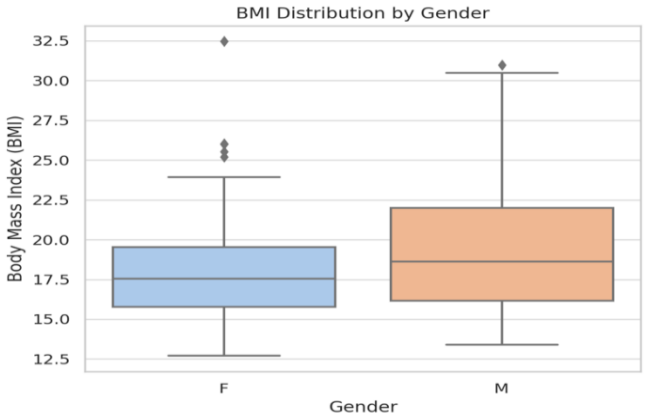
Table 2. T-test for differences by gender

There are no statistically significant differences between girls and boys in this sample for any of the anthropometric variables.

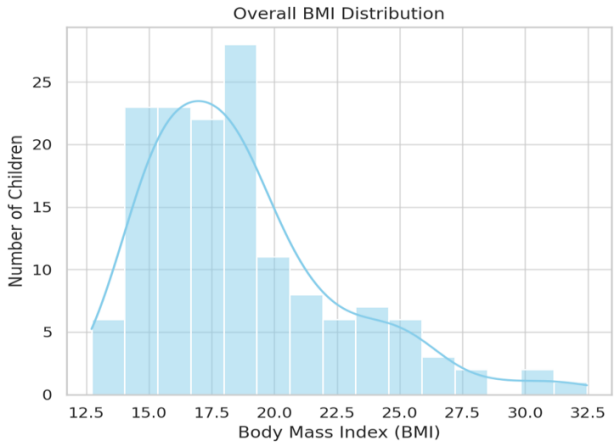
Variablat	**Coefficient r**	**Interpretation**
BMI ↔ Weight	**0.95**	Very strong connection
Perimeter ↔ Weight	**0.94**	Very strong connection
Length ↔ Perimeter	0.64	Average Links
BMI ↔ Perimeter	**0.92**	Very strong connection

Table 3. Correlations between variables

BMI is closely related to weight and waist circumference, as expected. This reinforces the use of BMI and circumference as indicators of body health.



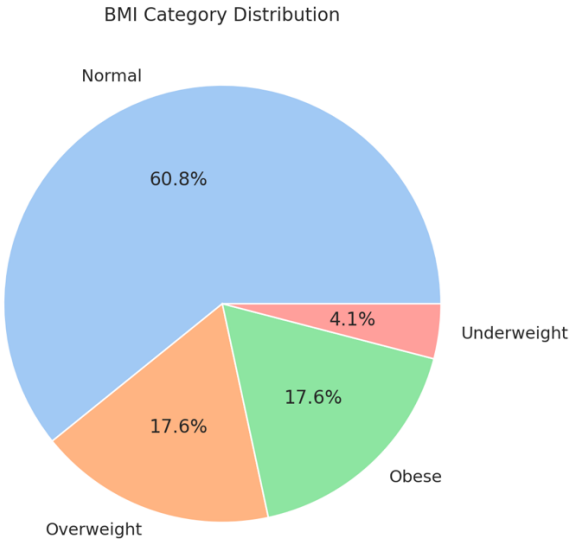
Graphics 1. BMI Distribution by Gender



Graphics 2. Overall BMI Distribution

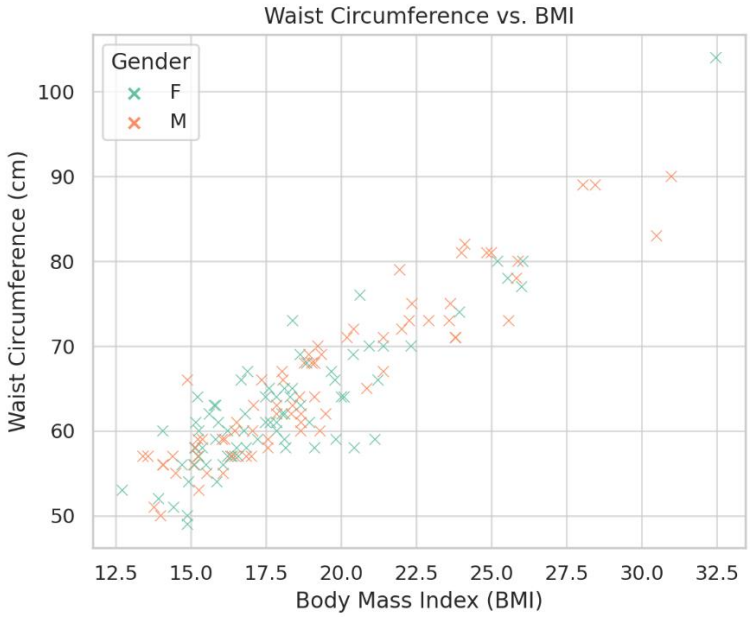
This Graphics 1, boxplot shows the distribution of Body Mass Index (BMI) values among boys and girls. The medians are very similar between genders, and the interquartile ranges largely overlap, suggesting no significant differences in BMI distribution between boys and girls. However, both genders show outliers, including some with very high BMI, indicating a risk of overweight or obesity in a subset of the sample.

The Graphics 2, histogram reveals that most children fall within the normal BMI range (approximately 14–19). However, there is a noticeable right skew, with a significant number of children having BMI values above 19, indicating overweight or obesity. The distribution suggests that although many children have normal BMI, excess weight is still a notable issue in the population.



Graphics 3. BMI Category Distribution

The chart 3, categorizes children based on their BMI into underweight, normal, overweight, and obese. A majority of the sample falls into the "Normal" category. However, approximately one-third of the children are either overweight or obese, which is concerning and highlights the need for targeted health education and intervention strategies in early childhood.



Graphics 4. Waist Circumference vs. BMI

This scatter plot shows a strong positive correlation between BMI and waist circumference for both boys and girls. As BMI increases, waist circumference tends to increase as well. This relationship reinforces that BMI is a good indicator of central adiposity (abdominal fat), which is linked to increased health risks, especially in children.

Yes, definitely In addition to BMI, waist circumference (WC) is also a very important indicator of cardiometabolic risk in children. In the literature it is noted that WC is often a more powerful marker of visceral fat distribution compared to BMI (Janssen et al., 2004; Maffeis et al., 2008). WHO and pediatric studies typically use waist circumference percentiles by age and gender. Most of the literature suggests: ≤ 75th percentile → normal 85th–95th percentile → risk of overweight ≥ 95th percentile → high risk/abdominal obesity (Katzmarzyk et al., 2004; McCarthy et al., 2001). From the data we have (149 children, WC = 54–77 cm): Normal WC (≤75th p.) → about 61% of children High WC (≥85th p.) → about 39% of children (so nearly 4 in 10 children have abdominal obesity or increased metabolic risk). This result is important because often WC is more strongly associated with the risk for metabolic syndrome, hypertension, and type 2 diabetes, compared to BMI (Brambilla et al., 2007; Maffeis et al., 2008).

Discussion

Our findings show an above-average prevalence of overweight and obesity among children in Shkodra. Compared to the COSI 2022 report, which reported that 30.2% of children aged 8–9 are overweight or obese, our study shows a slightly higher prevalence of 35%, in line with global growth trends (GBD 2025; Lobstein et al., 2022). The similarity in the prevalence rate between the sexes is consistent with the findings of the WHO European region, where gender differences in anthropometric indicators at this age are usually minimal (Spinelli et al., 2019).

The correlation between BMI and waist circumference observed in our study supports preliminary findings that abdominal fat accumulation is a strong indicator of metabolic risk (Zimmet et al., 2023). Waist circumference, as a measure of central adiposity, has been shown to provide more specific information about metabolic and cardiovascular risks than BMI alone. International studies, including those of McCarthy et al. (2001) and Kurtoglu et al. (2010), emphasize the importance of using population-adjusted percentages to correctly identify children at risk for abdominal obesity. Further,

Taylor et al. (2000) and Maffeis et al. (2001) showed that waist circumference is a more reliable predictor of central body fat and cardiovascular risk factors than waist-to-thigh ratio or conicity index. The combination of BMI with waist circumference increases the predictive power for metabolic syndrome risk, as Janssen et al. (2005) showed, and imaging studies such as MRI confirm the strong association between waist circumference and visceral and subcutaneous adipose tissue (Brambilla et al., 2006).

Several behavioral and environmental factors contribute to the increased prevalence of overweight and obesity. These include dietary changes towards energy-rich but nutrient-poor foods (Popkin et al., 2020), reduced opportunities for physical activity due to reduced physical education hours (Biddle et al., 2010), and increased sitting time and screen use (Sahoo et al., 2015). Socio-economic transition and urbanization in Albania, especially in cities like Shkodra, can exacerbate these risk factors.

Early interventions implemented through school curricula are among the most effective strategies to address this problem (Lobstein et al., 2022; WHO, 2023). These interventions should include nutrition education, increased opportunities for physical activity, and regular anthropometric monitoring to identify children at risk and provide timely preventive measures.

In conclusion, our study highlights the importance of using BMI and waist circumference for monitoring the anthropometric status of school children. The findings underscore the urgent need for public health strategies aimed at reducing overweight and obesity in children, improving physical activity, and promoting healthy eating habits, especially in urban environments experiencing rapid social and environmental change.

Conclusion

The high level of overweight and obesity among 8–9 year old children in Shkodra underlines the urgency of applying comprehensive public health strategies and pre-university education institutions, focused on early prevention. In our study cohort, 35% of children were found to be overweight or obese, exceeding the national average reported by COSI 2022 (30.2%) and reflecting global growth trends (GBD 2025; Lobstein et al., 2022). Both BMI and waist circumference were shown to be indispensable for assessing anthropometric status. Waist circumference, in particular, provides a more accurate measurement of abdominal fat and associated metabolic and cardiovascular risks, compared to overall BMI (Zimmet et al., 2023; Brambilla et al., 2006; Janssen et al., 2005). There were no statistically significant differences between boys and girls for BMI, waist circumference, or height, a result that matches previous studies in European populations (Spinelli et al., 2019). Various factors, including unhealthy eating, reduced physical activity, and increased sedentary behaviors, contribute to increased overweight and obesity. Urbanization and socio-economic changes in Shkodra can exacerbate these phenomena (Popkin et al., 2020; Biddle et al., 2010; Sahoo et al., 2015). Early, school-based interventions are essential, including nutrition education, structured physical activity, and regular anthropometric monitoring for identifying children at risk and implementing preventive measures (Lobstein et al., 2022; WHO, 2023). Parental involvement is also key to creating supportive environments that foster healthy behaviors from an early age. In conclusion, our results highlight the need for urgent and coordinated action by educators, health professionals, and policymakers to curb overweight and obesity in children. Identification, prevention and educational initiatives are necessary to reduce long-term health risks, including metabolic syndrome, and to support the healthy growth and development of children in Shkodra.

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COMPARATIVE DETECTION OF PHOTOVOLTAIC PANEL FAULTS USING U-NET AND YOLOV8 MODELS BASED ON THERMAL IMAGES

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ABSTRACT

Accurate and timely fault detection in photovoltaic (PV) panels is critical to maintaining operational reliability and energy efficiency. In this study, two deep learning-based approaches are comparatively evaluated for hotspot anomaly detection using thermal images: a classical U-Net-based segmentation model and a YOLOv8-based object detection model. Both models are trained and tested on a real-world thermal image dataset acquired from the Roboflow platform under identical preprocessing conditions. The U-Net model, supported by the segment anything model (SAM) for mask generation, demonstrated strong segmentation capabilities with an average F1-score of 0.8611 and a maximum F1-score of 0.9787, along with an average IoU of 0.7624 and a maximum IoU of 0.9582. On the other hand, the YOLOv8 model outperformed in detection efficiency, achieving a mean average precision (mAP@0.5) of 0.8643, peaking at 0.9283, and exhibiting a faster training curve. The comparative analysis highlights that while U-Net excels in fine-grained pixel-level segmentation, YOLOv8 is more suited for real-time deployment scenarios. The findings underscore the complementary strengths of the two approaches: U-Net is better suited for detailed, pixel-level segmentation tasks, while YOLOv8 offers faster and more efficient detection suitable for real-time deployment. This comparative analysis provides practical insights into model selection strategies for PV fault monitoring systems, based on application-specific requirements.

Keywords: Deep learning, photovoltaic panels, U-Net, YOLOv8, anomaly detection.

1. INTRODUCTION

Photovoltaic (PV) panels play a pivotal role in the global transition toward sustainable energy systems. As the deployment of PV systems becomes increasingly widespread, ensuring their reliable operation and optimizing energy output have gained critical importance. Accurate performance monitoring and prompt fault detection, particularly for anomalies such as hotspots, microcracks, partial shading, and connection failures, are essential to reduce energy losses and mitigate safety hazards (Gawre, 2022). Such faults may substantially reduce system efficiency and pose long-term operational risks when not properly addressed.

Traditional diagnostic techniques such as I–V curve analysis, electroluminescence imaging, and thermal camera inspection continue to be widely employed to identify faults in PV systems (Mansouri, 2021). Despite their prevalence, these approaches often entail high implementation costs, offer limited scalability, and may exhibit reduced sensitivity under actual field conditions. In particular, thermal image-based diagnostics face additional challenges, including environmental noise, complex backgrounds, and subtle temperature variations, which can hinder the precise identification of faults. These limitations underscore the pressing need for more advanced analytical methods.

Artificial intelligence-based approaches, especially those utilizing deep learning (DL), have emerged as effective alternatives within this framework. DL techniques facilitate automated, robust, and highly

accurate fault detection in PV systems, particularly when managing large-scale and complex datasets (Meng, 2022). The classical U-Net architecture, in particular, has gained widespread recognition for its ability to perform pixel-level image segmentation, enabling detailed localization of faults on PV modules. Its advantages include a relatively simple structure and strong generalization performance, which have contributed to its popularity in academic research and practical applications, as noted by Ronneberger et al. (2015). Conversely, object detection models from the YOLO family have demonstrated significant potential for real-time field implementation due to their fast inference capabilities and ease of deployment. However, these models may occasionally compromise on segmentation granularity compared to specialized architectures such as the U-Net.

1.1. Related Work

In recent years, the application of DL to PV panel fault detection has received significant attention in the literature, with both U-Net-based segmentation and YOLO-based detection approaches showing strong results. U-Net, in particular, has been used to deliver precise pixel-level segmentation of PV faults. For instance, Ab Hamid et al. (2025) categorized thermal images into three classes, PV panel, hotspot, and background, reporting an overall IoU of 0.725 and 0.258 for the hotspot class. Shen et al. (2022) enhanced the U-Net with batch normalization and RMSprop optimization, significantly improving segmentation accuracy. Rudro et al. (2024) introduced a hybrid model combining InceptionV3 and U-Net architectures, incorporating SE blocks and residual connections, and reported 94.35% test accuracy with an F1-score of 0.94.

Object detection methods such as YOLO are now commonly used for their speed and suitability for real-time analysis. Tajwar et al. (2021) applied YOLOv3 to infrared thermal images and achieved 99% accuracy for panel detection and 96% for hotspot detection. Khang et al. (2023) used YOLOv5 with drone-captured images, achieving 81% accuracy, while Meng et al. (2022) used YOLOv4 for PV anomaly detection, achieving a mAP@0.5 of 95.4%. A comparative evaluation by Khanam et al. (2025) found YOLOv8 to have a recall of 79.2% and YOLOv11 to achieve a mAP of 93.4% on the same dataset.

Recent research has increasingly focused on hybrid approaches, which combine the strengths of segmentation and detection to improve performance. Di Tommaso et al. (2022) developed a multi-stage model using YOLOv3 on thermal and visible spectrum images, reaching AP@0.5 ≈ 98% for panels and AP@0.4 ≈ 88.3% for hotspots. Xie et al. (2024) introduced the ST-YOLO algorithm, integrating C2f-SCconv modules and Triplet Attention into YOLOv8s, reporting a 15% reduction in model size, 2.9% higher precision, and 1.4% improvement in mAP@0.5. Similarly, Lei et al. (2024) combined Deeplabv3+ and YOLOv5 into a hybrid Deeplab-YOLO model, improving segmentation accuracy by 2.61% for panels and 0.7% for hotspots. A comparative overview of the key strengths and limitations of U-Net, YOLO, and hybrid models as discussed in the literature is presented in Table 1.

Table 1. Comparative features of DL approaches for PV panel fault detection

Approach	Main Strengths	Main Limitations
U-Net	Precise pixel-level segmentation	Low IoU for small hotspots; sensitive to class imbalance
YOLO (v3, v8, etc.)	Real-time performance; fast inference	Limited accuracy in detailed segmentation

Hybrid models	Balance of accuracy and speed	Dependent on the dataset, architectural complexity

Despite these advances, direct comparison between models is often hindered by differences in datasets, preprocessing methods, and evaluation metrics used across studies. To address this gap, the present study systematically compares the classical U-Net and YOLOv8 models for hotspot anomaly detection in PV panels, using a common, real-world thermal image dataset under standardized preprocessing conditions. The results provide objective and practical guidance for selecting the most appropriate DL architecture for PV fault monitoring applications in diverse field scenarios.

2. MATERIALS AND METHODS

2.1. General Workflow

In this study, two different DL approaches were comparatively evaluated for detecting faults in PV panels using thermal images: a classical U-Net-based segmentation model and a YOLOv8-based object detection model. The overall workflow of the proposed method is summarized as a block diagram in Fig. 1.

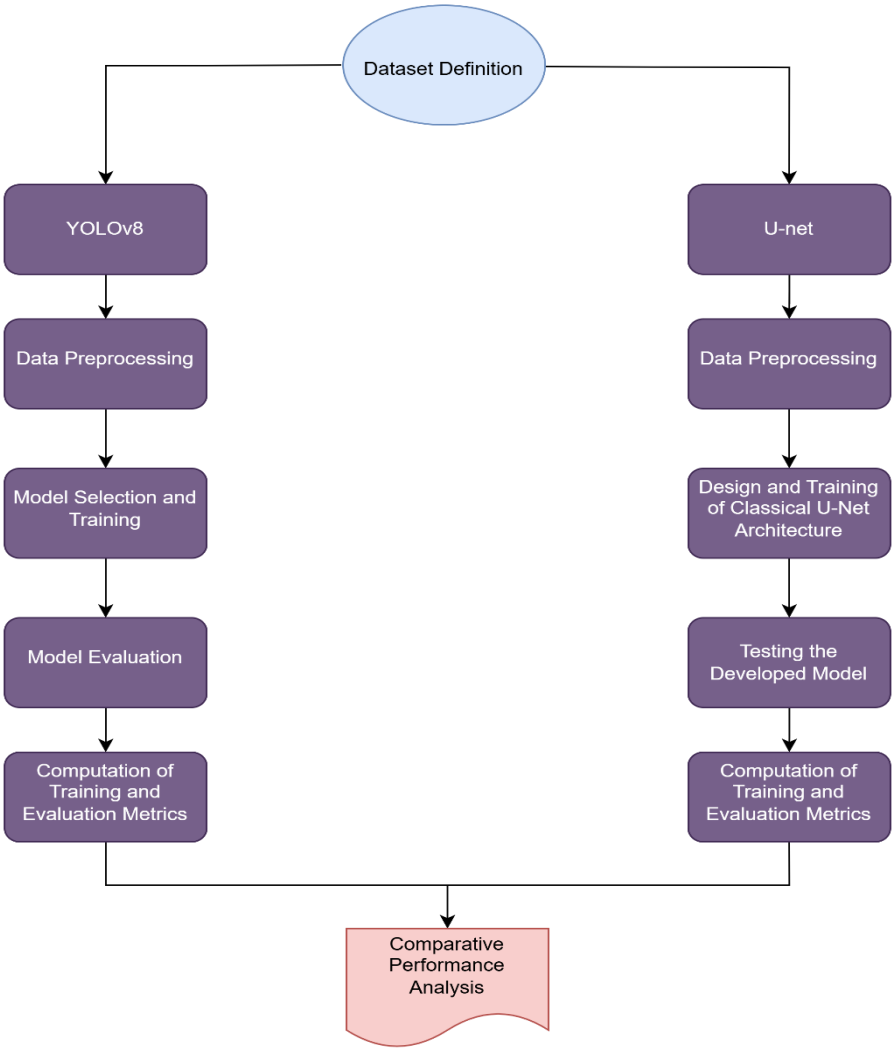


Figure 1. General workflow diagram for the classical U-Net and YOLOv8 models.

In the first stage, a dataset comprising thermal images captured by drones was prepared, and possible fault regions (e.g., hotspots, cracks, connection problems) were annotated. The photos were labeled in YOLO format and divided into training, validation, and test subsets. A standardized preprocessing procedure was applied to all images. Grayscale conversion, normalization, and data augmentation (flipping, rotation, etc.) were performed for the classical U-Net model. The YOLOv8 model was trained directly using the raw images. Both models were trained independently on the same dataset under similar conditions and evaluated on the test set. The results were compared using fundamental performance metrics, mainly IoU, Dice, precision, recall, accuracy, and mAP. This systematic workflow enabled a fair and comprehensive evaluation of segmentation and object detection approaches under real-world conditions.

2.2. Dataset

The dataset used in this study was constructed via the Roboflow platform and consists of thermal images of PV panels annotated in YOLO format (Raimundo, 2023). The images were acquired through drone-based thermal imaging of PV arrays, and each image was annotated to indicate possible fault regions, such as hotspots, cracks, or connection problems. All images are stored in .jpg format, and each annotation is provided as a .txt file containing YOLO-compatible bounding box information. To ensure robust model development and reliable evaluation, the dataset was divided into three subsets: training (769 images, ~67%), validation (289 images, ~25%), and test (88 images, ~8%). All anomaly regions are grouped under a class labeled "Class 0," representing hotspot anomalies observed in the images. The open-access dataset used in this study provides realistic images that reflect field conditions. Sample raw thermal images obtained via drone-based imaging and containing hotspot regions on PV panels are presented in Fig. 2. This dataset offers a reliable foundation for model training and evaluation in PV fault detection.

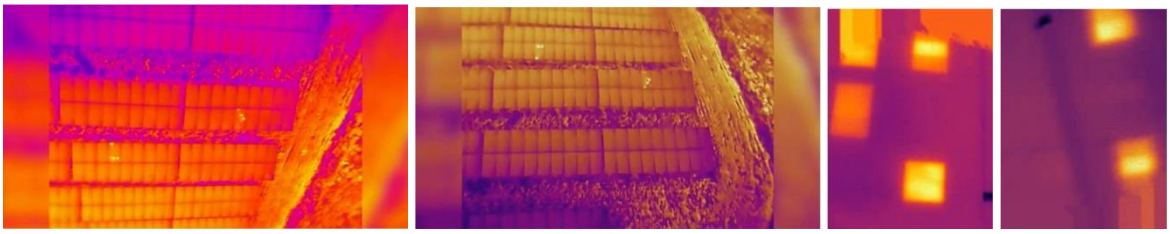


Figure 2. Sample raw thermal images from the dataset showing hotspot anomalies on PV panels acquired by drone-based imaging.

2.3. Preprocessing

Before model training, a standardized preprocessing pipeline was applied to all images. Data augmentation techniques were used to enhance model robustness and generalization capability for both the classical U-Net segmentation model and the YOLOv8 object detection model. These included horizontal and vertical flipping, rotation, and zooming operations. Additional preprocessing steps were performed for the U-Net model, such as grayscale conversion and normalization of pixel values to the range [0, 1]. In contrast, the YOLOv8 model was trained using the original RGB images without further intensity normalization or color space conversion. Furthermore, ground truth masks were automatically generated using the segment anything model (SAM) before the model was fitted for the U-Net training. This preprocessing strategy ensured that both models were exposed to diverse input variations while preserving the specific requirements of each architecture**.**

2.4. Employed Models

In this study, two different DL-based approaches were evaluated for detecting faults in photovoltaic panels using thermal images. The first approach is the YOLOv8 architecture, which provides high speed

and accuracy in object detection tasks, and the second is the classical U-Net-based model, which offers detailed pixel-level segmentation. Both models were trained on the same dataset, and the results were compared using various evaluation metrics.

2.4.1. YOLOv8-based object detection approach

In this study, the YOLOv8m architecture developed by Ultralytics was employed to detect hotspot anomalies in thermal images of PV panels. YOLO-based models are particularly favored in mobile and field applications due to their high speed and accuracy in real-time object detection tasks. The dataset utilized for model training comprised thermal images sourced from the Roboflow platform, which were annotated in YOLO format. Each fault region was labeled using bounding boxes, with corresponding class labels provided in accompanying text files. To ensure robustness across various scenarios, the dataset included various types of PV cell faults, such as isolated anomalies, clustered cell defects, and scattered hotspots. Model training was conducted in the Google Colab environment with GPU acceleration. The YOLOv8m model was configured with an input resolution of 640 × 640 pixels and trained over 100 epochs using a batch size of 8. Stochastic gradient descent was adopted as the optimization algorithm, which is in line with the default configuration of the Ultralytics YOLOv8 framework. All training outputs, including model weights, log files, and evaluation metrics, were systematically stored in a dedicated Google Drive directory, ensuring the experimental workflow's traceability and reproducibility. The YOLOv8m model accurately detected hotspot regions, especially in images with clear temperature contrasts. However, the model was observed to be limited in cases where fault regions had irregular shapes and unclear boundaries. Therefore, a classical U-Net model was also evaluated in this study for detailed pixel-level segmentation. A detailed comparison of these two approaches is presented in the following sections.

2.4.2. Classical U-Net-based segmentation model

In this study, the classical U-Net DL architecture was employed for the precise segmentation of thermal anomalies in PV panel images. U-Net is a widely adopted and high-performing model in image segmentation tasks. It features a symmetrical architecture composed of two main components: an encoder path for feature extraction and a decoder path for spatial reconstruction. The encoder compresses the input image into low-dimensional representations by extracting semantic features, while the decoder reconstructs these features back to the original resolution. Skip connections between corresponding layers in the encoder and decoder preserve spatial details and enhance segmentation accuracy.

As illustrated in Fig. 3, the model architecture begins with the encoder, which reduces the spatial resolution of the input while increasing the number of channels. Each encoder level applies two successive convolution operations with 3×3 filters to extract meaningful features. Mathematically, the convolution output at the (i, j) position in the k-th channel is defined by:

$$Y_{i,j}^{(k)} = \sum_{m=-1}^{1} \sum_{n=-1}^{1} W_{m,n}^{(k)} \cdot X_{i+m,j+n} + b^{(k)} \quad (1)$$

where $Y_{i,j}^{(k)}$, represents the output feature map at the (i, j) position in the k-th channel, $W_{m,n}^{(k)}$, are the weights of the convolution filter, $b^{(k)}$ is the bias term, and f denotes the activation function (ReLU).

Following the convolution layers, a 2×2 max pooling operation is applied to reduce the spatial dimensions, as given by:

$$Y_{i,j} = max\{X_{2i,2j}, X_{2i+1,2j}, X_{2i,2j+1}, X_{2i+1,2j+1}\} \quad (2)$$

This operation retains dominant features, decreases computational complexity, and contributes to model generalization. During encoding, the spatial resolution transitions from 320×320 to 20×20, while the number of feature channels increases from 64 to 1024, enabling hierarchical feature abstraction. In the decoder, transposed convolutions are applied to upsample the feature maps, restoring spatial dimensions. The output Y of a transposed convolution is expressed as:

$$Y = W^T \times X + b \quad (3)$$

where W^T denotes the transposed filter, X is the input, and b is the bias term. Each decoder layer receives additional spatial context via skip connections, which concatenate encoder outputs with the corresponding decoder feature maps:

$$Z = Concat(F_{up}(x), x_{enc}) \quad (4)$$

where $F_{up}(x)$ is the upsampled decoder feature map, and x_{enc} denotes the encoder output at the same hierarchical level. This mechanism combines low-level spatial and high-level semantic information. The decoder progressively reconstructs the image from 20×20 to 320×320, while the channel count is reduced from 1024 to 64. After each upsampling, two convolution layers refine the features. Finally, a 1×1 convolution is used to perform pixel-wise classification and generate the final segmentation map.

The training process was carried out in the PyCharm environment using Python version 3.10 along with the PyTorch DL library. GPU support was utilized to accelerate the computations. All outputs generated during training, including model weights, performance records, and visualizations, were systematically saved to ensure experimental reproducibility.

The model was trained for a total of 100 epochs using a batch size of 4. The learning rate was set to 0.0001, and the Adam optimizer was employed for parameter updates. A combined loss function consisting of Dice loss and Jaccard loss was used to enhance segmentation accuracy. Throughout training, the performance of the model was evaluated using several metrics such as intersection over union, Dice coefficient, precision, recall, and accuracy.

After each epoch, metric values were saved in comma-separated value format, and the model weights that achieved the best results were stored automatically. In addition, graphical representations of performance were saved as portable network graphics files, and the training progress was monitored in real time using the tqdm library.

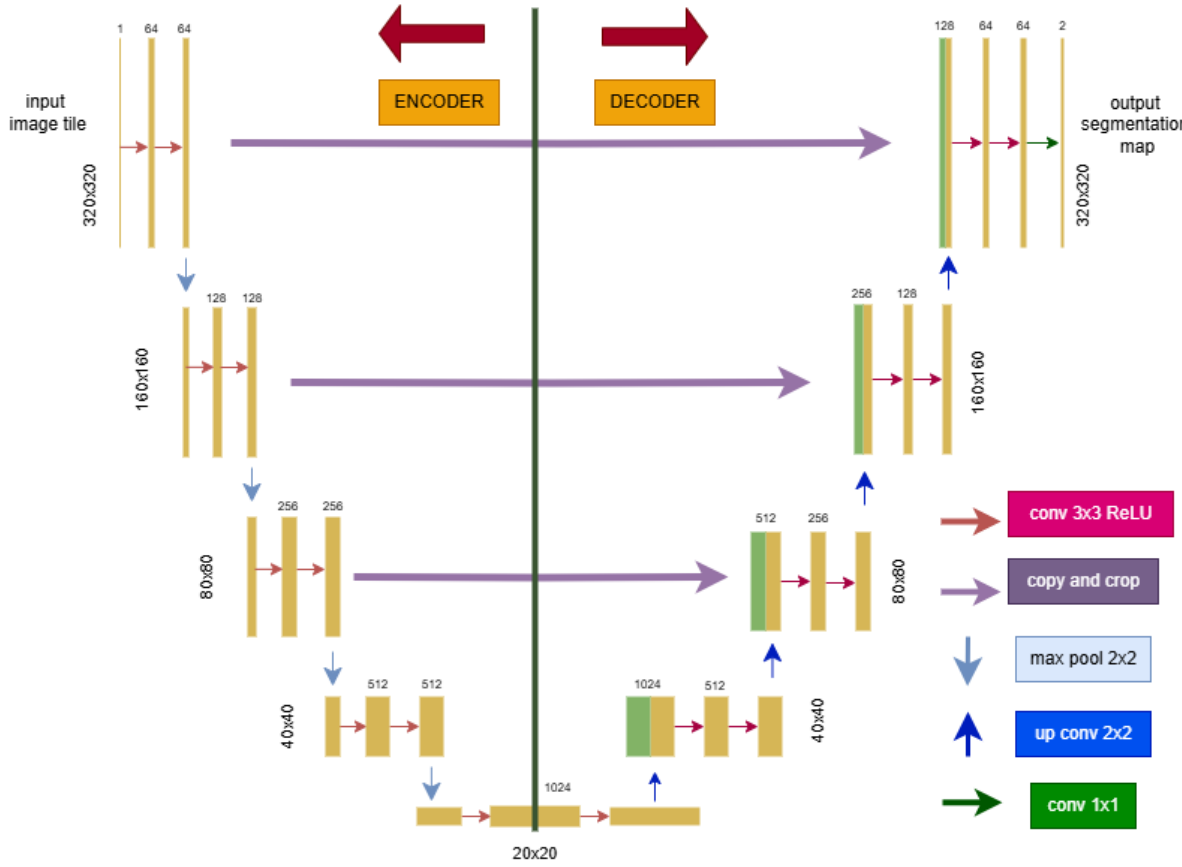


Figure 3. Classical U-Net architectural structure

2.5. Evaluation Metrics

The performance of the U-Net-based segmentation model and the YOLOv8 object detection model was evaluated using established quantitative metrics commonly applied in computer vision tasks. These metrics assess both pixel-level accuracy and bounding box localization.

For segmentation, the evaluation was performed using the metrics shown in Eqs (5)-(9):

$$IOU = \frac{TP}{TP + FP + FN} \tag{5}$$

$$Dice = \frac{2TP}{2TP + FP + FN} \tag{6}$$

$$Precision = \frac{TP}{TP + FP} \tag{7}$$

$$Recall = \frac{TP}{TP + FN} \tag{8}$$

$$Accuracy = \frac{TP + TN}{TP + FP + FN + TN} \tag{9}$$

These metrics collectively provide a comprehensive assessment of segmentation performance. Intersection over union (UIO) measures the overlap ratio between predicted and actual masks, serving as a primary evaluation metric in segmentation tasks. The Dice coefficient, closely related to the F1-score, provides a more stable overlap measure, especially under class imbalance. Precision quantifies how many of the predicted positive pixels are correct, while recall reflects how many true positive pixels are successfully identified. Finally, accuracy accounts for correctly predicted positive and negative pixels, offering an overall measure of pixel-wise classification performance. Together, these metrics enable a robust evaluation of the model's ability to distinguish between fault and non-fault regions in thermal images.

For object detection, mean average precision was the primary metric. The first version, mAP@0.5, evaluates class-wise detection at an IoU threshold of 0.5. The second version, mAP@0.5:0.95, averages precision over thresholds from 0.5 to 0.95 at 0.05 intervals, offering a stricter assessment. Precision and recall were also applied in the detection task, with true positives defined based on sufficient overlap between predicted and ground truth bounding boxes at a given IoU threshold.

3. RESULTS AND DISCUSSION

3.1 Analysis of U-Net Model

This section presents a comprehensive evaluation of the segmentation model trained using the classical U-Net architecture. The analysis covers the validation and test phases through multiple dimensions, including metric-based training curves, image-level performance, and statistical summaries derived from the test set.

The model's behavior during training and validation was evaluated using the IoU, F1 score, and loss curves, as illustrated in Fig. 4. The validation IoU curve in Fig. 4(a) starts around 0.1, surpasses 0.5 after epoch 30, and stabilizes between 0.65 and 0.7 beyond epoch 90, indicating steady improvement in segmenting the target regions. Likewise, the validation F1 score in Fig. 4(b) increases consistently and reaches a plateau between 0.75 and 0.78, reflecting balanced precision and recall. Fig. 4(c) shows that training loss decreases monotonically and remains low after convergence. Periodic increases in validation loss suggest that sample diversity occasionally challenges the model, possibly leading to slight overfitting. Nonetheless, the model demonstrates a generally stable and robust learning behavior.

The test performance of the model was assessed using both per-image segmentation metric distributions, presented in Figs. 5 and 6, and the summary statistics provided in Table 2. This evaluation offers a detailed understanding of the model's generalization capability across different samples in the test set.

Fig. 5 presents the distributions of Dice, IoU, and Accuracy scores across individual test images. As shown in Fig. 5(a), most Dice scores exceed 0.85, indicating strong agreement between predicted masks and ground truth. A few images, however, display Dice and IoU scores near zero, as seen in Figs 5(a) and 5(b). These low values are not indicative of failure but are expected due to the presence of anomaly-free images in the dataset. In such cases, no segmentation is required or predicted, leading to zero overlap by definition. Accuracy values, shown in Fig. 5(c), are generally above 0.99, reflecting a high proportion of correctly classified pixels, particularly in background regions. Since the dataset predominantly contains negative pixels, high accuracy is expected. When considered alongside the low Dice and IoU scores for anomaly-free samples, these results confirm the model's ability to identify defective and defect-free regions correctly.

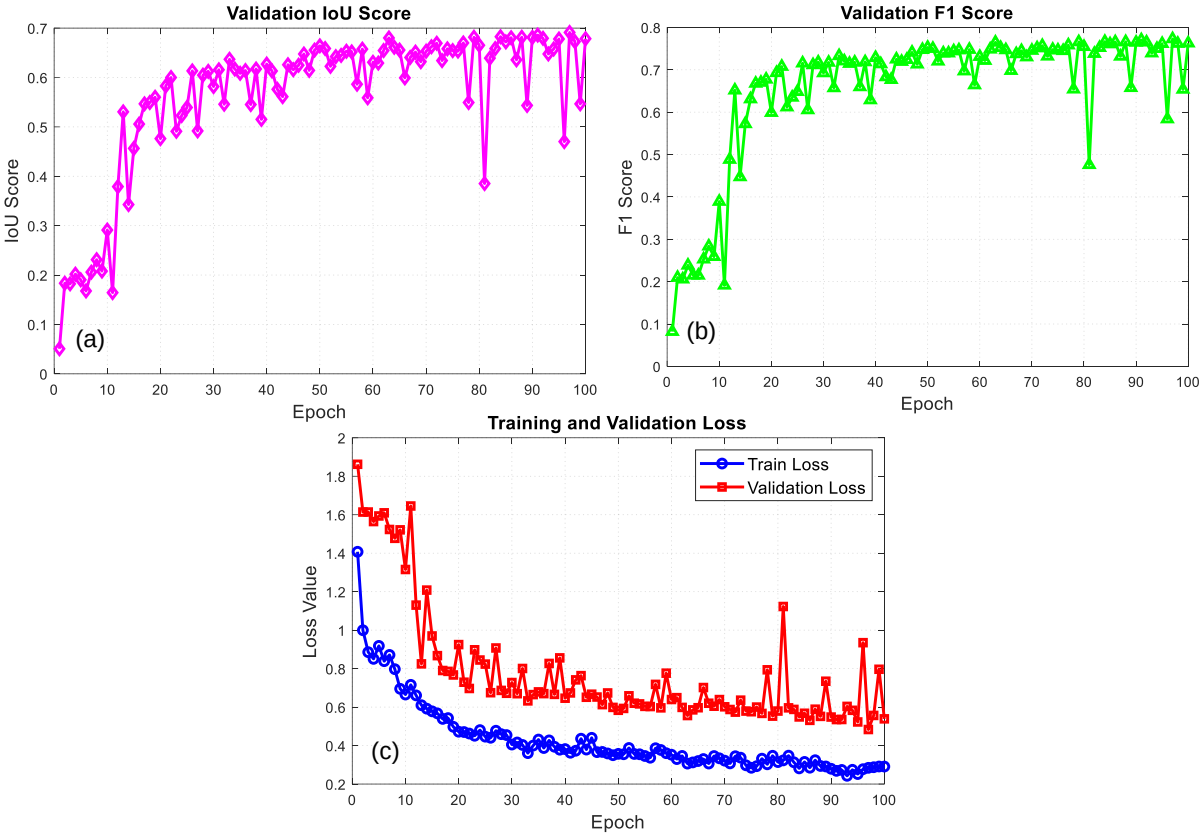


Figure 4. Validation metrics and loss curves for the classical U-Net model: (a) Validation IoU score, (b) Validation F1 score, (c) Training and validation loss values.

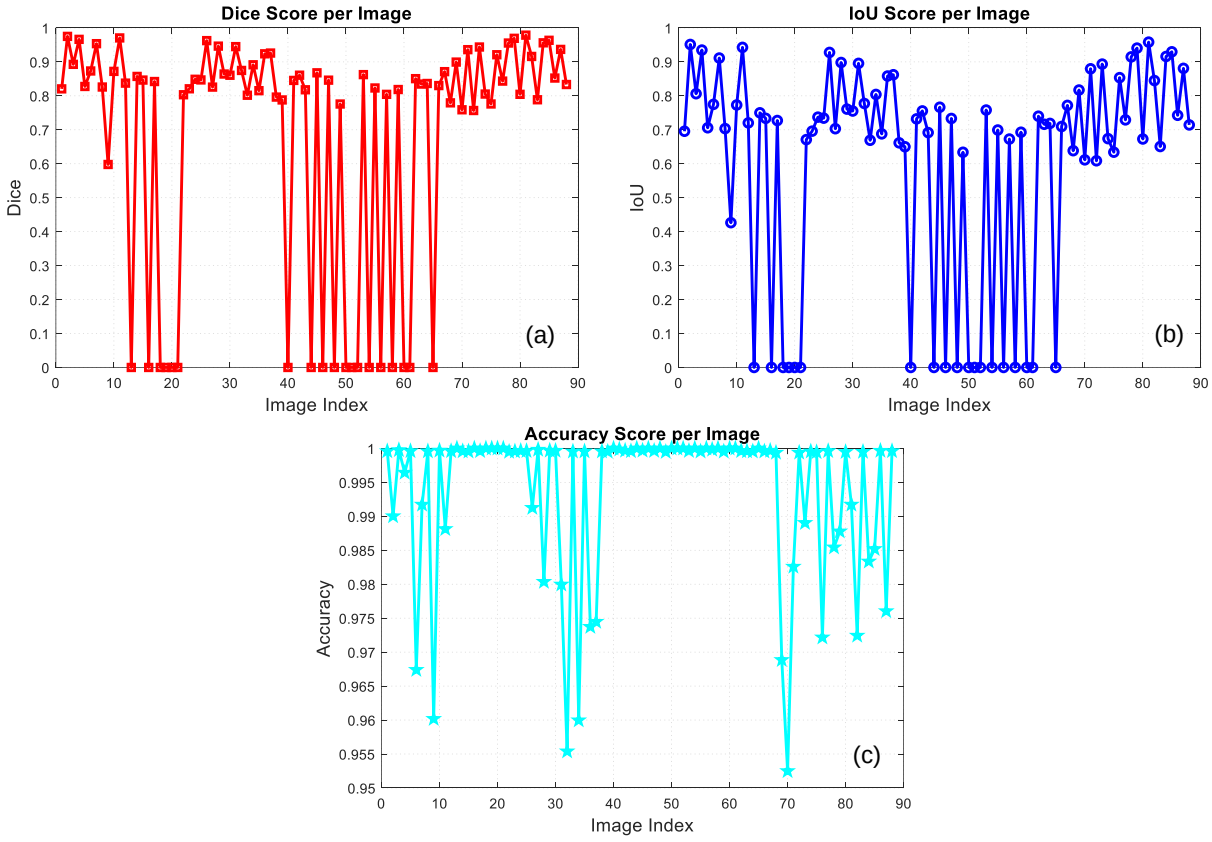


Figure 5. Per-image segmentation performance: (a) Dice, (b) IoU, and (c) Accuracy metrics.

Table 2. Test dataset performance metrics for the classical U-Net architecture

Metric	Average Value	Max Value
Precision	0.9107	0.9997
Recall	0.8227	0.9823
F1 Score (Dice)	0.8611	0.9787
IoU	0.7624	0.9582
Accuracy	0.9919	0.9999

3.2. Analysis of the YOLOv8

Table 3 presents the key performance metrics obtained from the test set for the YOLOv8 object detection model. The model achieved an average precision of 0.8117 and an average recall of 0.8258, indicating a balanced detection capability in terms of both selectivity and sensitivity. The average F1 score, computed as the harmonic mean of precision and recall, was 0.8168, demonstrating the model's ability to maintain consistent detection accuracy across different sample conditions. The mean average precision at an IoU threshold of 0.5 was 0.8643, reflecting a high level of detection accuracy in moderately challenging scenarios. In contrast, the mAP evaluated over a range of IoU thresholds from 0.5 to 0.95 yielded a value of 0.4301, indicating more conservative performance under stricter matching conditions. The model reached a maximum mAP@0.5 of 0.9283, showing its potential to achieve highly accurate detection on favorable samples.

Table 3. Object detection performance metrics of the YOLOv8 architecture on the test dataset

Metric	Average Value	Max Value
Precision	0.8117	0.8773
Recall	0.8258	0.8977
F1 Score (Dice)	0.8168	0.8812
mAP@0.5	0.8643	0.9283
mAP@0.5:0.95	0.4301	0.4936

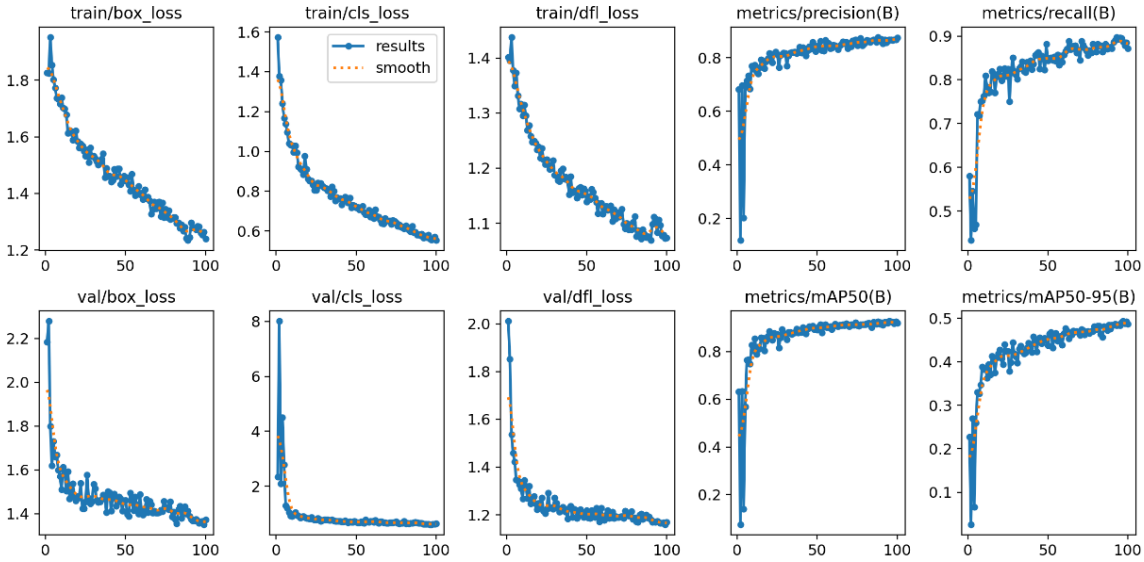
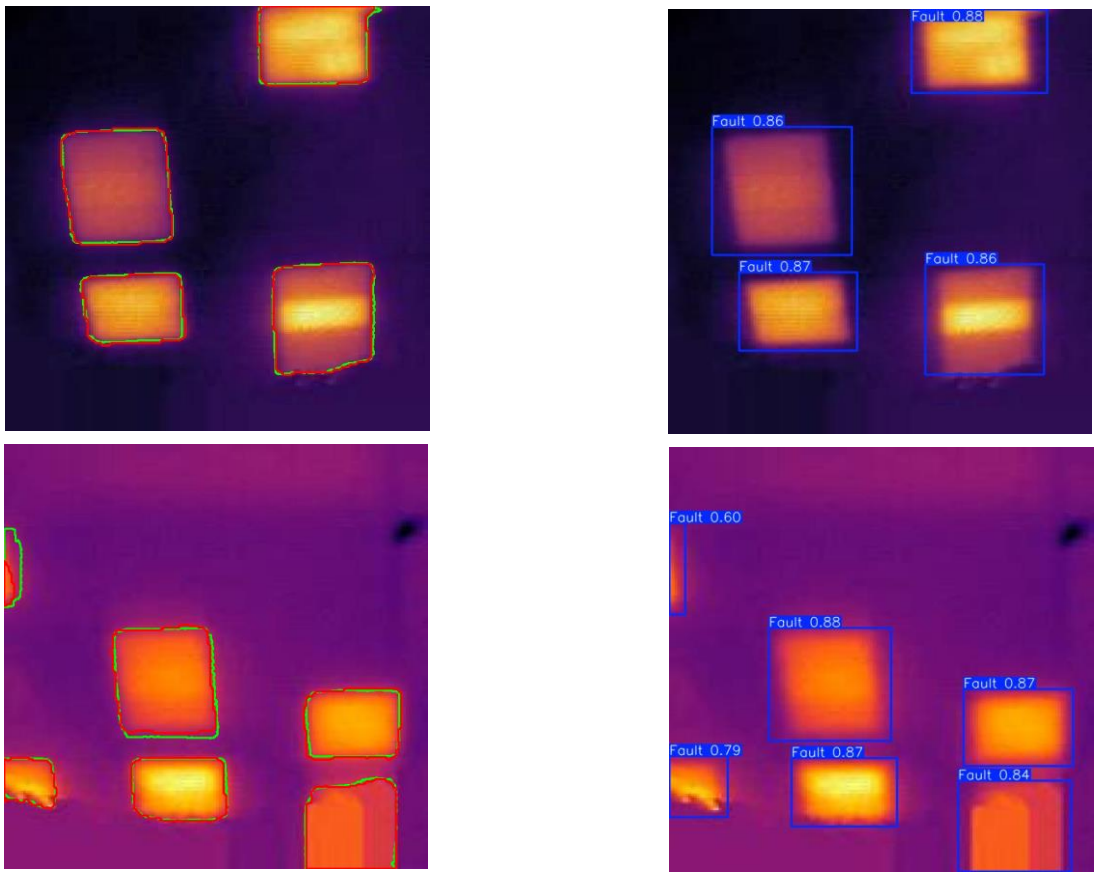


Figure 6. Epoch-based changes in loss functions and success metrics during the training of the YOLOv8 model.

Fig. 6 illustrates the learning behavior of the YOLOv8 model over 100 training epochs, including changes in loss components and performance metrics. The steady decline in box loss, classification loss, and distribution focal loss for training and validation indicates effective convergence in learning object localization and class separation. A sharp drop in the validation classification loss highlights rapid semantic learning during early training. The consistent decrease in validation box and distribution losses confirms that the model accurately learns object positions in the feature space. Precision and recall metrics gradually increase across epochs, showing improved detection capability and a reduction in false negatives. The upward trend in mAP values demonstrates that the model generalizes well across different IoU thresholds and target complexities. Overall, the results confirm that YOLOv8 achieves balanced and reliable performance in classification and localization tasks.

3.3. Comparative Evaluation of Model Performance

In addition to quantitative findings, **Fig. 7** presents detection results for selected test images. The predicted segmentation masks from the U-Net model and the bounding boxes from the YOLOv8 model are shown alongside the ground truth. The U-Net model demonstrates smoother and more accurate boundaries, particularly for small or irregular hotspot regions, whereas YOLOv8 successfully localizes the anomalies but may lack precision in capturing their exact shapes. These visual comparisons support the numerical results and clarify each model's strengths and limitations under real-world conditions.



(a) (b)

Figure 7. Model outputs on sample test images: (a) U-Net segmentation results; (b) YOLOv8 detection results.

4. CONCLUSION

This study compared the U-Net and YOLOv8 models for hotspot anomaly detection in thermal images of photovoltaic panels. U-Net achieved higher pixel-level accuracy, with a Dice score of 0.8611 and an IoU of 0.7624, demonstrating strong performance in detecting small and irregular defects. Its detailed segmentation ability makes it suitable for precision-focused applications. YOLOv8 offered faster inference and reliable localization, reaching a mAP@0.5 of 0.8643 and a precision of 0.8117. Although its boundary accuracy was lower, its speed and flexibility support real-time use in field systems. Visual and numerical findings suggest that U-Net excels in segmentation quality, while YOLOv8 is advantageous for rapid detection. A hybrid approach combining the strengths of both models, along with techniques such as transfer learning and attention mechanisms, is recommended for future studies.

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INTELLIGENT FIRE SAFETY IN INDOOR ENVIRONMENTS: TECHNOLOGIES FOR FIRE PREVENTION, DETECTION AND SUPPRESSION

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ABSTRACT

This paper presents an overview of recent advancements in technologies for indoor fire prevention, detection and suppression, with a focus on sensor-based systems, vision-based techniques, and robotic solutions. Wireless sensor networks demonstrate significant advantages over traditional wired solutions, enabling early detection, real-time localization, and reliable alarm delivery while simplifying installation and maintenance. Multisensor approaches, integrating flame, gas, and temperature detection, have shown high accuracy for Class-A fires, with innovations such as acoustic-based and NB-IoT-enabled smoke detectors enhancing range and efficiency. Vision-based methods have evolved from hand-crafted features to deep learning architectures, including CNNs, optical flow, and hybrid fusion, improving robustness in challenging environments. In suppression, IoT-enabled smart sprinklers and robotic firefighting robots offer autonomous, responsive, and safe operation in hazardous conditions. Furthermore, FireSense, a proactive and autonomous AIoT system for real-time fire hazard detection is designed to meet the technological and safety requirements of Industry 5.0, currently in the development stage by our team, is also presented. The proposed system introduces a novel multimodal deep learning framework that integrates visual data from RGB cameras with environmental data acquired from distributed gas, temperature, humidity, and pressure sensors. A transformer-based architecture is employed to perform multimodal fusion and temporal analysis, enabling early and reliable detection of anomalous patterns associated with incipient fire events. Collectively, these technologies represent an integrated, intelligent approach to next-generation indoor fire safety.

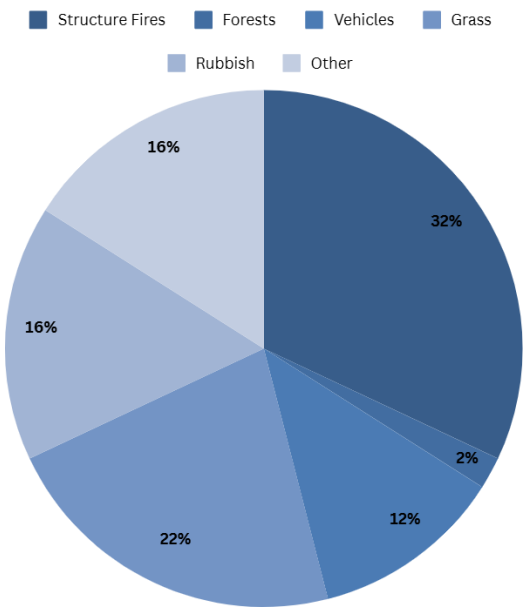
Keywords: fire detection systems, fire extinguishing, indoor fire, machine learning, smoke detection.

INTRODUCTION

Alongside wildfires, structural fires contribute to numerous fatalities and significant material damage (World Fire Statistics, CTIF, 2025). Structural fires mainly occur in residential, industrial, commercial, or community-based buildings. The propagation rates of these fires fluctuate based on the materials utilized in construction, affecting the intensity of flame and radiant heat produced (Song et al., 2017). Various combustible materials such as wooden furniture, textiles, cooking gas, oil, and noncombustible substances such as metal furniture, ceramic appliances and water may interact with structural fires, potentially generating substantial flame, radiant heat, hot surfaces, heated liquids, and toxic gases (Findik, 2022). Industrial fires provide considerable hazards due to their capacity to emit toxic substances into the environment, resulting in contamination of air, water, and soil (Planas et al., 2023). Moreover, these fires can cause enduring ecological harm and adversely affect public health (Pivello et al., 2021). The economic losses and infrastructural damage resulting from industrial fires can be considerable, complicating recovery efforts and emphasizing the necessity for effective fire prevention and response techniques. Process Hazard Analysis (PHA) comprises a structured and methodical evaluation of potential hazards associated with an industrial process, aimed at examining the possible

causes and repercussions of fires, explosions, toxic or flammable chemical releases, and significant hazardous chemical spills (Cameron et al., 2017). In 2021, over four million fires in total resulting in 20,755 casualties occurred throughout 48 countries with a population of 3.3 billion, were reported by World Fire Statistics, CTIF. Furthermore, over one million were structural fires (32.2%), resulting in 18,845 civilian fatalities (90.8%) and exceeding $36 billion in property damage.

When selecting a firefighting system, it is essential to consider the type of fire being extinguished as a critical factor. Figure 1 illustrates the categorization of fires by type. The implementation of wireless sensor networks offer significant improvements over traditional wired systems. These modern sensor-based approaches enable not only early fire detection but also real-time localization and reliable alarm delivery, while overcoming challenges related to complex wiring and maintenance. Systems integrating flame, gas, and temperature sensors have demonstrated effective detection of Class-A fires and reliable data transfer using open-source hardware and software frameworks. In addition, acoustic-based systems exploit the unique physical properties of flame specifically sound absorption and velocity shifts to detect fires with high accuracy, even at a room scale. Furthermore, standalone NB-IoT-based smoke detection systems offer wide coverage and low energy consumption, marking a major advancement in smart home fire safety.



Vision-based fire detection systems represent the transition from traditional hand-crafted feature extraction methods to advanced deep learning architectures. Convolutional Neural Networks (CNNs), optical flow analysis, and hybrid feature fusion techniques have significantly improved the robustness and precision of smoke and flame recognition, even in challenging indoor environments. Notable contributions include novel models that leverage color space transformations, motion analysis, and attention mechanisms to optimize detection accuracy and reduce false positives. Such system is also FireSense, a proactive and autonomous AIoT System for real-time fire hazard detection based on multimodal deep neural network in Industry 5.0. The proposed system introduces a novel multimodal deep learning framework that integrates visual data from RGB cameras with environmental data acquired from distributed gas, temperature, humidity, and pressure sensors. A transformer-based

architecture is employed to perform multimodal fusion and temporal analysis, enabling early and reliable detection of anomalous patterns associated with incipient fire events.

This paper also presents indoor fire suppression technologies such as sprinklers and robots. Modern indoor fire extinguishing technologies include IoT-enabled smart sprinkler systems that autonomously detect and suppress fires using multisensor data and robotic firefighting units capable of remote operation in hazardous environments, thereby enhancing safety, accuracy, and responsiveness.

The rest of the paper comprehensively analyzes improvements in early structural fire prevention and detection, and discusses the latest technologies employed for extinguishing of indoor fires. The research aims to leverage technology to identify methods for mitigating the severe impacts of structural fires and safeguarding the ecosystem, people and, properties from fire hazards.

TECHNOLOGIES FOR INDOOR FIRE PREVENTION AND EARLY DETECTION

Sensor based technologies

Installing wire-based systems takes a huge amount of time and effort. Additionally, these systems hardly ever have any fire localization capabilities. Islam et al. (2015) show how a fire detection and localization system was designed and put into use leveraging open source hardware and software components and ZigBee wireless networking technologies. ZigBee offers mesh networking, genuine multi-hoping, data encryption, and dependable wireless stability (Liu et al., 2007). However, consumer-level ZigBee-based fire detection systems are not yet available. ZigBee has a lot of benefits, including the sensor nodes which do not need a cable junction to the central processing unit because they are wireless. Encryption available on wireless devices, guaranteeing secure data. If one sensor node is damaged, the system is not affected. The installation of numerous sensor nodes does not result in a tangled connection. A facility for indoor localization makes it possible to find the fire and track its progress. ZigBee based systems are dependable and capable of accumulating a large number of nodes. Furthermore, better wireless stability makes it more effective than conventional fire detection systems on the market at minimizing fire damage (Allied Market Research, 2024). To develop and scale the system at a low cost, it employs open source Arduino hardware and software. Besides many options available for setting up a wireless sensor network, ISM band wireless devices are chosen in order to keep project costs low. ISM Band uses a variety of wireless technologies such as Infra-Red, RF-433MHz, Bluetooth, Wi-Fi, ZigBee. The system gathers every piece of information it can about Class-A fires. A clear picture of the fire event is provided by the system's flame, gas, and temperature sensors. The ZigBee network coordinator receives the sensor data, and an Arduino transmits it to the Wi-Fi network. Actual time HTML pages are used to display sensor values and localization, while a database server is used to continually store sensor data.

Smoke detectors are widely employed in a variety of situations as essential devices for smoke and fire detection. However, wired systems installation is expensive in the building process, as well as challenging to maintain. Currently, there have been only two kinds of smoke alarm systems: The conventional smoke induction systems which require engineering wiring characterized by manual inspection, high difficulty in building renovation, high construction challenges, lack of support for telephone/SMS warnings, and lack of awareness of equipment status. A standalone WiFi/ZigBee-based wireless smoke sensor systems are based on newer technology. One advantage of this technology is that it is wireless and does not need wiring. Although there is no need for wiring, the system's architecture based on the building characteristics could be complex.

The concept of a smart smoke induction system employing NB-IoT technology has been implemented by Wang et al. (2019). Compared to the WiFi/ZigBee-based systems, NB-IoT technology provides excellent dependability, wide coverage, and low power consumption. The system primarily consists of the following components: a user terminal, an existing base station (operator network), a wireless NB-loT smoke, increase of humidity and temperature, and a warning terminal. A SIM card is housed inside

the smoke sensor which contains an NB-loT chip, and the data is transmitted straight through the antenna. The user will be informed immediately if any unusual data is found while the platform is analysing the data. The firefighters' ability to respond promptly to a disaster relies heavily on the platform's integration with the fire control system.

The narrow detecting range of current indoor fire detection systems their vulnerability to disruptions, or their significant calculation and distribution costs are significant problems (Maric et al., 2022). Wang et al. (2023) proposed HearFire, an acoustic-based fire detection system that is affordable and user-friendly. A combined speaker and microphone set called are used to detect fire from a distance by sending out unheard waves of sound. Due to the special physical characteristics of flame, HearFire takes advantage of the absorption of sound and velocity fluctuations to detect the fire. By comparing the connection among the transmitted signal length and sensing distance, it successfully accomplishes sensing at room level. To increase sensing range and optimize a number of practical elements that affect the efficiency of the system, the transmission frame is cautiously chosen. Using various experimental variations, HireFire provides an ultimate seven-meter detection range and provides early fire detection in indoor conditions with a maximum of 99.2% accuracy.

Image based systems

Considering a video consists of consecutive images, identification of smoke on images is a critical issue for visual smoke detection. The two main types of visual smoke detection are classical and deep learning-based techniques. The classic approaches to smoke recognition primarily concentrate on smoke features extraction. The classical approaches evaluate if the quantity of features extracted as smoke exceeds a threshold in order to detect smoke in a picture. Latest studies show cutting-edge performance using deep learning for computer vision applications including object identification and image categorization. As opposed to classical methods, deep learning techniques might learn complex properties out of big datasets and avoid hand-crafted design aspects. A two-stage approach is recommended for video smoke detection indoors is proposed by Nguyen et al. (2020). The absence of data makes training the model harder. By extending the training set with artificial smoke images, the problem is being fixed. First step is to use optical flow to find areas of interest by detecting mobility between adjacent frames (Chunyu et al., 2010). After that, a model based on deep learning must be used to detect smoke in the discovered locations. Optical flow algorithms can be categorized as gradient techniques, phase methods, area-based corresponding methods, and feature-based techniques. Infrequent optical flow is not practicable in this situation since smoke has a wide variety of forms, densities, and smoothness. Therefore, dense optical flow is used to pinpoint the region of interest in order to solve the issue.

The precision of fire detection is increased by Pritam and Dewan (2017) since they suggested LUV colour space and hybrid transformation method, although it is not resistant to fire detection in complicated situations. When extracting brightness from chrominance, Celik and Demirel (2019) employed the color space known as YCbCr model, which they found to be more effective than the color space defined by RGB. The motion shift characteristics of flame flickering were employed by Lee and Han (2007) to identify very early fire aspects. Chen et al. (2021) constructed an improved YCbCr model to perform early fire categorization and provided an enhanced region-expanding method to accomplish precise fire segmentation. They additionally suggested a fire detection approach incorporating fire segmentation and multi-feature synthesis. In order to better identify changing uneven flame aspects in videos, Foggia et al. (2015) developed an additional information mixture using shape, colour alter, and movement analysis for tracking potential fires. An autonomously flame recognition technique based on the Dirichlet procedure Gaussian mixed model was proposed by Li et al. (2018) and can produce more precise flame identification outcomes.

Another set of detection techniques depend on recently developed deep learning techniques. For instance, Hong et al. (2022) handle the issue of wildfire recognition in remotely sensed pictures using a unique CNN developed with multiscale convolution and residue tolerance. In order to increase the accuracy of flame recognition for appearance and fuzzy edges, Li et al. (2021) suggested to effectively pick potential flame regions with changing and colour characteristics. Seydi et al. (2022) proposed a deep learning architecture for the integration of optical and thermal modality for the identification of burning biomass and ongoing fires. A more advanced pyramidal network was suggested by An et al. (2022) to enhance the MobileNet SSD model's capacity for small object flame identification. YOLOv5 and EfficientDet, two separate learners, were combined by Xu et al. (2021) to finish the fire recognition procedure and decrease the number of false positives. In order to keep track of nascent fires in forests, Zhan et al. (2021= suggested a parallel spatial domain attention system and a compact transformer featuring a pyramidal network using YOLOX as an example. A VFD recognition network utilizing variable convolution has been suggested by An et al. (2022), which lowers its classification error rate.

FireSense

FireSense is a proactive and autonomous AIoT system for real-time fire hazard detection designed to meet the technological and safety requirements of Industry 5.0, currently in the development stage by our team (Figure 2.). Unlike conventional fire detection systems that rely on threshold-based rules or single-modality sensing, FireSense operates as a hybrid intelligent edge solution that can processes data locally which ensured rapid response, increases privacy, and lowers communication delays. The system is consisted of two main components: (i) a low-power embedded smart camera unit capable of on-device inference and encrypted video transmission, and (ii) a network of compact sensor nodes measuring volatile organic compounds (VOCs), CO_2, and other combustion-related parameters. Video recordings surrounding the time of detection are securely logged using blockchain technology to ensure integrity and non-repudiation of incident data. Currently we are testing the proof of concept, and the first results show the advantages of our approach over state-of-the-art solutions, particularly in terms of detection accuracy, latency, and robustness against false positives in industrial scenarios. Furthermore, the use of transformer mechanisms enables the model to capture complex correlations across sensor modalities, while also improving generalisation to diverse industrial environments. Last but not the least, the modular nature of the FireSense platform enables scalability and integration into existing infrastructures. FireSense represents a significant step forward in intelligent fire hazard detection, offering a generalisable, multimodal, and secure AIoT framework for protecting critical assets and human life in next-generation industrial settings.



Fire Sensing Robots

With the aid of developing visual technologies, an indoor fire detection robot may end up being the finest option for spotting abnormalities in a complicated circumstance. Robots that can detect inside fires can help firefighters understand the indoor scenario and reduce disasters. Compact, quick-moving robots can gather extensive contextual data and become less reliant on complicated sensor systems by using video fire detection (VFD) (Li et al., 2023), which can replace detection devices such as smoke and flame sensors which are based on optical, ultraviolet, and infrared detectors. Wang et al, (2022) suggests a faster and more accurate framework for quick video flame recognition that successfully increases the ability to extract features from erratic flames. Their greatest contribution is a flame progression trend-indicating visualized Heat Release Rate (vHRR) model that is connectable to the flame target recognition network; extended layer aggregation block (ELAB), that extracts finer characteristics without harming the network, offers improved layer aggregation links, minimizes the amount of variables while guaranteeing precision by extracting rich information regarding features by cross-connecting with phantom convolutions, the phantom convolution space pyramidal combining cross-stage partial block (GhostSPPCSP) module, which is utilized at the junction among the core and the neck, increases its recognition precision and a multiple-branch topology that boosts the network's efficiency while being trained. To switch to a one-way structure throughout inference, lower memory consumption, and accelerate inference, use new structure parameters.

In our work (Balen et al., 2023) we examined the challenges and importance of early fire detection in residential and industrial structures and the advancement of indoor firefighting robots. We developed the FireBot, an autonomous robot for fire prevention, detection and extinguishing utilizes technology such as LiDAR, depth cameras, infrared sensors, ultrasonic sensors, and RGB cameras integrated with deep neural networks to facilitate fire detection and prevention, autonomous navigation, and obstacle avoidance. Furthermore, we developed a customized fire dataset consisting of used to benchmark the performance of three deep neural networks. Furthermore, we also used infrared thermal (IRT) cameras

for identifying thermal anomalies prior to the appearance of visible fire indicators. Our second work (Filipovic et al., 2023) focuses on a mobile robot-based warehouse firefighting system referred to as the PR-FER model. Our proposed model is consisted of two different categories of robots: patrol robots equipped with RGB and thermal imaging cameras for fire detection and assistant robots equipped with fire extinguishers. Furthermore, our software system is consisted of several modules such as the Path Planning Module, Image Processing Module, Communication Module, and Planning and Decision-Making Module. Our system employs a SLAM algorithm to create an obstacle map that integrates a unified global coordinate system used by each robot. This functionality enables the system to ascertain its relative distance and position concerning other robots, obstacles, and charging stations.

TECHNOLOGIES FOR INDOOR FIRE SUPPRESSION

Sprinklers

A fire sprinkler system is an active fire protection method, consisting of a water supply system providing adequate pressure and flowrate to a water distribution piping system, to which fire sprinklers are connected. Their main field of usage is in factories, warehouses and large commercial buildings. Based on the coverage area, hazard application, or response type needs a fire sprinkler system can be adopted to any scenario. However, sometimes due to the false alarms or activating sprinkler systems on high areas can cause huge amount of damage due to the water flood, specially older systems without intelligent fire detection and suppression capabilities. Such system incorporating automatic water sprinklers, driven by temperature, gas, and flame sensors, has been proposed by Alqourabah et al. 2021. The system quickly collects data on flames, heat and smoke, analyses them and quickly activates an automatic sprinkler to extinguish the fire. An ultrasonic sensor measures the water level in the tank and uses IoT device and network to provide the necessary information. Sensors are arranged in different places in the room to ensure fast data reading.

Robots

Firefighting robots can successfully replace fire fighters while performing activities close to the flame source and in hazardous locations, including observation and suppression of fires. In order to prevent injuries, the operators managing firefighting robots can control them for long distances. Fires at underground storage and freight centres, large-span plants, petrochemical fuel depots, and refineries may all be extinguished using a diesel-operated indoor firefighting robot with an IP67 rating (Guoxing ,2024). In addition, it can be employed for rescue missions in perilous circumstances, as well as identifying targets, assault, and protection during massive hazardous gas and smoke mishaps and life-threatening fires. It provides the ability for connecting three high-pressure hoses with a 95-meter-range and 150 l/s multipurpose water gun. It is capable of rotating in place and manoeuvring through wall openings and narrow doorways.

CONCLUSION

In conclusion, advances in fire detection, prevention and suppression technologies are having a transformational impact on improving fire safety and reducing the devastating consequences caused by fires. The incorporation of sensor technologies, such as ZigBee-based fire detection systems and wireless smoke detectors, facilitates swift and precise fire detection. This results in minimized property damage and enhanced safety for both firefighters and civilians. The utilization of image-based systems, which involve deep learning techniques and visual smoke detection, has notably elevated the accuracy and dependability of fire detection. These systems allow for early identification of flames and smoke patterns, enabling prompt intervention and the prevention of fire spread. Additionally, the adoption of

fire detection systems such as FireSense introduces groundbreaking approaches to extinguishing indoor fires. These systems leverage advanced visual technologies to detect and monitor fire behavior, providing real-time data to firefighters. The integration of advanced technologies based on AI enhances situational awareness and improves the efficiency of firefighting operations, leading to a positive impact on reducing firefighter mortality, civilian casualties, and material damage. Through early detection, effective extinguishing, and rapid response, these technologies contribute significantly to enhancing fire safety. Continuous advances in technologies for preventing and extinguishing interior fires contribute significantly to the protection of life and property and to the creation of a safer environment for all.

ACKNOWLEDGMENT

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DETERMINATION OF DYNAMIC CHARACTERISTICS OF A CRANKSHAFT THROUGH MODAL AND ROTORDYNAMICS ANALYSIS

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ABSTRACT

In this study, the dynamic characteristics of a crankshaft designed for a four-cylinder internal combustion engine were investigated. The parametric design of the crankshaft was performed in SolidWorks, and its 3D model was created. Through this parametric design, the influence of varying widths of the connecting rod journals and main journals on the crankshaft's dynamic characteristics was examined. Initially, modal analysis was conducted on the different parametrically designed crankshafts in ANSYS Workbench under free boundary conditions. For each case, the natural frequencies and mode shapes were obtained. This approach allowed for the investigation of how journal widths alter the dynamic properties of the crankshaft. Subsequently, with the definition of the crankshaft's bearings, rotordynamics analyses were performed. Campbell diagrams were generated, and critical speeds were calculated for each parameter variation. This detailed investigation explored how changes in the widths of the crankshaft's main journal bearings and connecting rod journal bearings affected the critical speeds of the crankshaft. The results obtained demonstrated that crankshafts, operating under significant dynamic loads, are directly influenced by alterations in their journal bearings. This suggests that such analyses can be utilized for dynamic design and optimization purposes. Therefore, it can be concluded that designing crankshafts to avoid resonance conditions is feasible.

Keywords: Crankshaft, rotordynamics, modal analysis, natural frequency, mode shape

INTRODUCTION

When designing crankshafts for internal combustion engines, the technical specifications and operating conditions of the vehicle play a decisive role. Crankshafts are specifically engineered by engine manufacturers to meet predefined targets such as engine power, torque, fuel economy, and durability. One of the most critical elements of this design is the crankshaft's length. Fundamental engine dimensions, such as the cylinder bore and stroke, directly influence the crankshaft's design and, consequently, its overall length. The length of the crankshaft can vary significantly, depending on the engine's dimensions, the center-to-center distance between cylinders, bearing widths, and the overall design architecture. For small-displacement (1.0L - 1.6L) four-cylinder gasoline engines, the crankshaft length typically ranges from 350 mm to 500 mm. For medium-displacement (1.8L - 2.5L) four-cylinder engines, this length may fall within the 450 mm to 600 mm range. Conversely, for engines with larger cylinder volumes, this value can increase further.

Another parameter considered in crankshaft design is the journal width. The journals on a crankshaft are designed in two different ways: as rod journals and main journals. The rod journals are used to support the connecting rods, while the main journals support the crankshaft within the engine block. Several factors influence the determination of journal widths, including the engine design, power output, displacement, and the manufacturer's engineering preferences. Larger displacement and more powerful engines typically require wider and larger-diameter journals, as they must handle higher loads and torque. The journal width provides the necessary surface area for the bearings to have sufficient load-

carrying capacity. This width is optimized based on the pressure exerted on the bearings (load/area). The bearing width-to-diameter ratio is a critical parameter that affects the bearing's load-carrying capacity and the formation of the oil film. While this ratio can generally range from 0.125 to 1.5, the optimal value is often considered to be between 0.8 and 1. Wider journals can promote a more stable oil film and better heat dissipation. However, excessive width can increase friction and the overall space occupied within the engine. The journal width and diameter directly influence the torsional and bending stiffness of the crankshaft. This, in turn, affects the natural frequencies and critical speeds, which are crucial in dynamic analyses (modal and rotordynamics). Designers must optimize journal dimensions to achieve the desired stiffness and dynamic properties. Journal dimensions are also determined by considering manufacturing tolerances and assembly processes. The distance between cylinders determines the overall length of the engine, and consequently, the journal widths have a decisive effect on the total engine length. The journal diameter and width are often determined as a ratio of the cylinder bore diameter. Let D be the cylinder bore diameter, l_m and d_m be the main bearing journal width and diameter, and l_c and d_c be the crankpin (or connecting rod) journal width and diameter. In the design process, the following empirical ratios are typically used: $d_m=(0.70-0.90)D$, $l_m=(0.45-0.84)d_m$, $d_c=(0.60-0.70)D$ and $l_c=(0.50-0.60)d_c$.

The static and dynamic behavior of crankshafts under operational conditions has been studied by numerous researchers, and their dimensioning and optimization are of great importance to design engineers. Garg and Baghla [9] performed a static analysis of a cast iron crankshaft from a single-cylinder engine. They utilized the results of this analysis in their optimization work. They investigated the stress distribution in the critical regions of the crankshaft and made geometric modifications without exceeding the stress levels of the original crankshaft. Azzawi et al. [1] conducted simulation studies on the crank-connecting rod mechanism of an internal combustion engine. In this context, they analyzed the thermal and mechanical stresses the mechanism is subjected to during engine operation. Additionally, they investigated the stress behavior under random vibrations within a frequency range of 100-500 Hz. In another study, Zhou et al. [2] performed numerical stress and dynamic analyses of a crankshaft from a four-cylinder diesel engine. They examined the fatigue strength of the crankshaft under alternating loads and determined the natural frequencies and mode shapes for the first six modes of free vibration. Kumar and Suresh [3] numerically investigated the fatigue behavior of three different crankshaft models they designed. Using fatigue sensitivity graphs, they observed how the fatigue behavior of the models changed in critical locations depending on the applied load. Roszak [4] conducted a numerical modal analysis to investigate the changes in the natural frequencies of a Deutz V12M540 engine crankshaft with varying numbers of counterweights. In Ref. [5], a numerical static and dynamic analysis was performed on the crankshaft of an NL9340 high-power diesel engine. The study examined the equivalent stress and deformation behavior and used modal analysis to determine the natural frequencies corresponding to the first 14 modes. Jie and Jingdong [6] conducted a numerical modal analysis of a crankshaft, identifying the natural frequencies and mode shapes for the first 20 vibration modes. In another study, Ying et al. [7] investigated the nonlinear dynamic characteristics of a motor's crankshaft assembly. They emphasized the importance of considering nonlinear factors, such as non-constant inertia, for the reliability and service life of the engine, particularly in cases where traditional linear models are insufficient. Bist and Bhatt [8] performed numerical analyses to identify the most suitable material for improving the structural durability and performance of a single-cylinder crankshaft. For this purpose, they tested four different materials: gray cast iron, structural steel, titanium alloy, and aluminum alloy.

In this study, the dynamic characteristics of a crankshaft for a four-cylinder internal combustion engine were investigated. Using SolidWorks, a parametric 3D model of the crankshaft was developed to investigate the influence of varying connecting rod and main journal widths on its dynamic behavior.

The analysis began with a modal analysis in ANSYS Workbench under free-free boundary conditions for each parametrically modified design. This step allowed for the determination of the natural frequencies and corresponding mode shapes, revealing how changes in journal widths affect the crankshaft's intrinsic dynamic properties. Subsequently, a rotordynamics analysis was performed by incorporating the crankshaft bearings. This advanced analysis involved generating Campbell diagrams and calculating critical speeds for each parameter variation. The results conclusively demonstrated that the significant dynamic loads experienced by the crankshaft are directly influenced by alterations in the journal bearing widths. The findings confirm that such analyses are invaluable for dynamic design and optimization, making it possible to design crankshafts that effectively avoid resonance conditions.

MATERIALS AND METHOD

The lengths of the journal bearings on the crankshaft affect its dynamic properties. In the design of crankshafts, it is of vital importance for the healthy operation of the system to analyze and investigate the effects of these dimensions on the dynamic characteristics of the crankshaft, along with many mechanical and strength calculations. In this study, the changes in the dynamic properties of the crankshaft with varying journal bearing lengths were investigated. For this purpose, a parametric solid model of a four-cylinder crankshaft was first created. In this parametric model, the widths of the journal bearings vary. An image of the designed crankshaft is given in Figure 1 below.

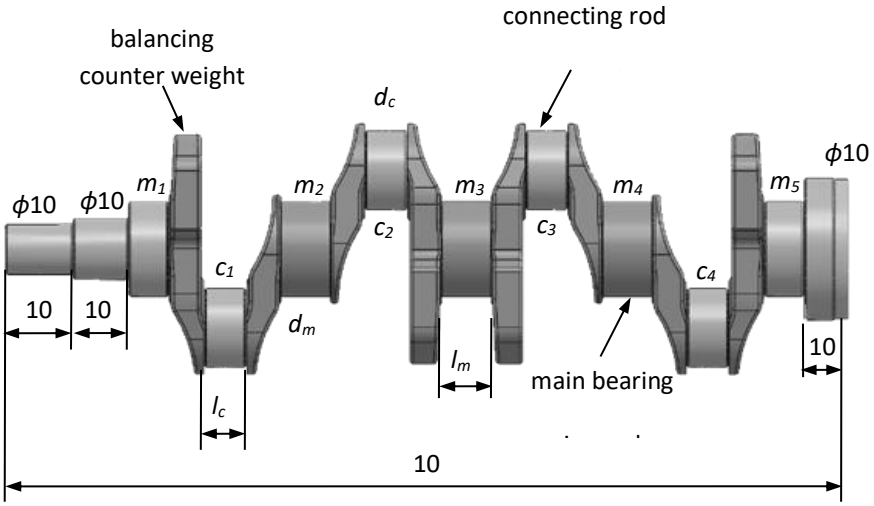


Figure 1. Designed crankshaft and its physical dimensions

The natural frequencies of the crankshaft were investigated for different lengths of the crankpin journals and main journals, as seen in Figure 1. The change in the length of the journals also affects the total length of the crankshaft. The physical properties of the parametrically designed crankshaft are given in Table 1.

Table 1. Physical parameters of the crankshaft

Parameter	Value
l_m (mm)	20, 21,…, 30

l_c (mm)	20, 21,…, 30
L (mm)	430-500
d_m (mm)	55
d_c (mm)	45

The mechanical properties of the designed crankshaft are given with Table 2.

Table 2. Mechanical properties of the crankshaft

Properties	Values
Material	AISI 1045
Elastic modulus (GPa)	205
Shear modulus (GPa)	80
Poisson ratio	0.29
Mass density (kg/m^3)	7850

Solid modeling studies were conducted using Solidworks. Subsequently, numerical modal analyses were performed for each model created. The modal analyses were carried out using ANSYS Workbench. The modal analyses of the models were performed under free vibration boundary conditions, and the first ten vibration frequencies, excluding the rigid body modes, were examined. Knowing these frequencies of the crankshaft is of vital importance to avoid a resonance condition in the system. Harmonics in the engine system, especially at engine operating speeds and their multiples, can cause resonance in some cases.

Afterward, rotordynamics analyses of the crankshafts were performed using ANSYS Workbench. The crankpin journals were left free, and the crankshaft was assumed to be supported at its two ends by external bearings to a fixed chassis, and the boundary conditions were determined accordingly. Campbell diagrams were obtained for each model, and critical speeds were determined.

RESULTS AND DISCUSSIONS

In this section, the analysis results for each generated crankshaft are presented in tables and graphs. Table 3 shows the natural frequency values obtained for the first ten free vibration modes of the crankshafts modeled with journal bearing lengths created in 1 mm increments from 20 mm to 30 mm.

Table 3. Natural frequencies of the crankshaft for different journal lengths

Natural Frequencies (Hz)

Mode	Journal Length (mm)										
	20.0	21.0	22.0	23.0	24.0	25.0	26.0	27.0	28.0	29.0	30.0
1	312.0	309.7	308.1	306.3	304.3	302.4	300.4	298.4	296.7	294.8	293.3
2	421.3	418.1	415.7	412.8	409.9	407.3	403.8	401.0	398.2	395.7	393.5
3	698.1	697.1	696.7	695.4	694.1	693,0	692.8	690.9	689.5	687.9	686.2
4	727.9	724.5	722.1	719.0	716.4	713.0	710.4	706.8	704.6	702.2	700.9
5	861.3	859.0	857.3	854.9	852.7	850.4	847.8	845.4	843.1	840.6	838.8
6	1006.9	1002.5	999.7	996.2	992.7	989.4	985.7	982.2	979.3	975.9	973.1
7	1211.6	1205.6	1200.9	1194.6	1188.8	1183.5	1176.1	1170.3	1164.6	1158.9	1154.7
8	1326.9	1323.1	1319.8	1315.9	1312.4	1308.7	1305.0	1301.3	1297.6	1294.0	1290.7
9	1676.4	1673.4	1670.9	1667.1	1663.8	1660.8	1657.9	1654.7	1651.5	1648.7	1645.8
10	2058.5	2050.5	2043.6	2035.1	2027.7	2020.3	2011.2	2003.5	1995.1	1987.8	1980.5

An analysis of Table 3 reveals that for all modes, the natural frequencies decrease as the journal bearing length increases. It is observed that these decreases show a near-linear trend, differing for each mode. This phenomenon is more clearly illustrated in Figure 2 below.

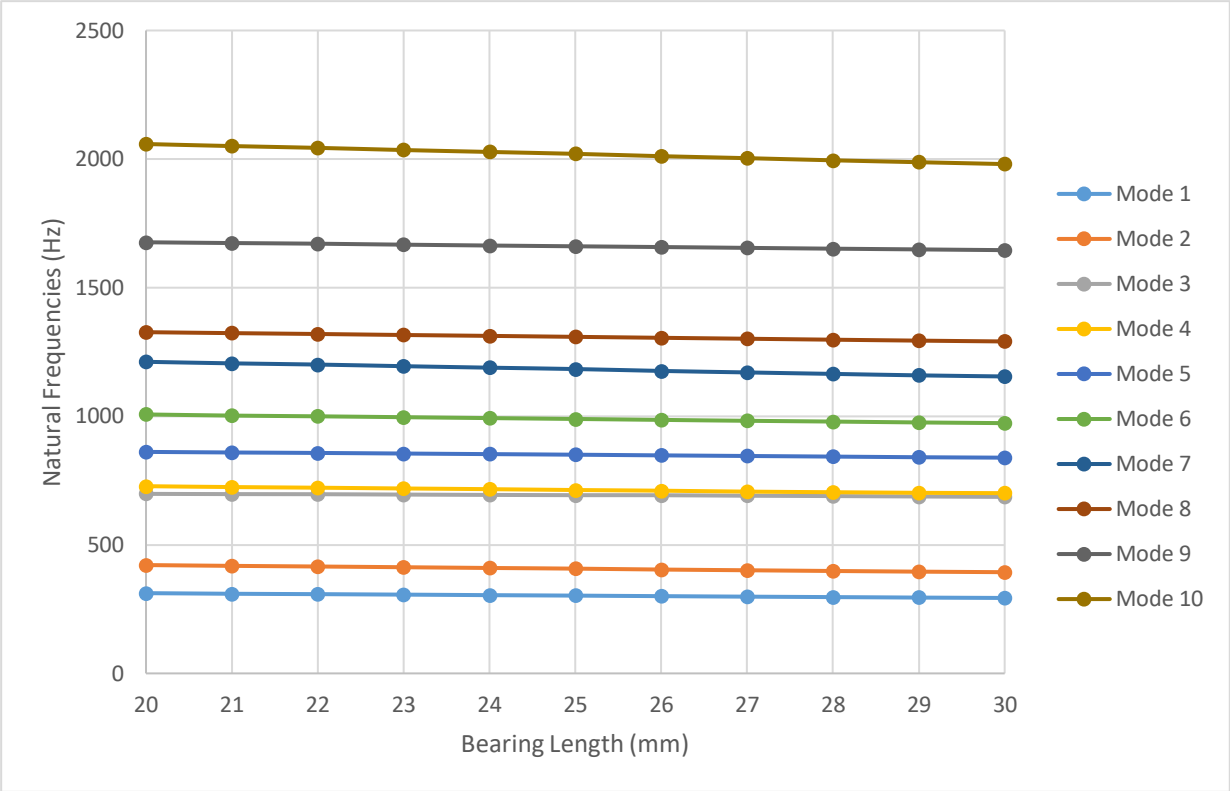


Figure 2. Natural frequencies for different bearing lengths

The points in Figure 2 represent the natural frequency values obtained for each model for the first ten free vibration modes. It is observed that for increasing journal bearing lengths, there is a decrease in natural frequencies that can be considered linear for each mode, although the trend of this decrease differs across the modes. As the journal bearing length increases, the mass of the crankshaft also slightly increases due to the constant diameters. Furthermore, the total length of the crankshaft slightly increases with longer journal bearing lengths, which in turn reduces the shaft's stiffness. Consequently, as can be interpreted from basic vibration theory (Equation 1), a decrease in the system's natural frequencies is observed.

$$(\omega = \sqrt{\frac{k}{m}}) \tag{1}$$

In Equation 1, ω, k, and m represent the natural frequency (r/s), stiffness (N/m), and mass (kg), respectively. It is clear that an increase in mass or a decrease in stiffness has a reducing effect on the natural frequency values.

The vibration mode shapes corresponding to each calculated natural frequency value for free vibrations were also analyzed. The obtained mode shapes include both bending and torsional vibrations, and nine of the analyzed mode shapes are given sequentially in Figure 3.

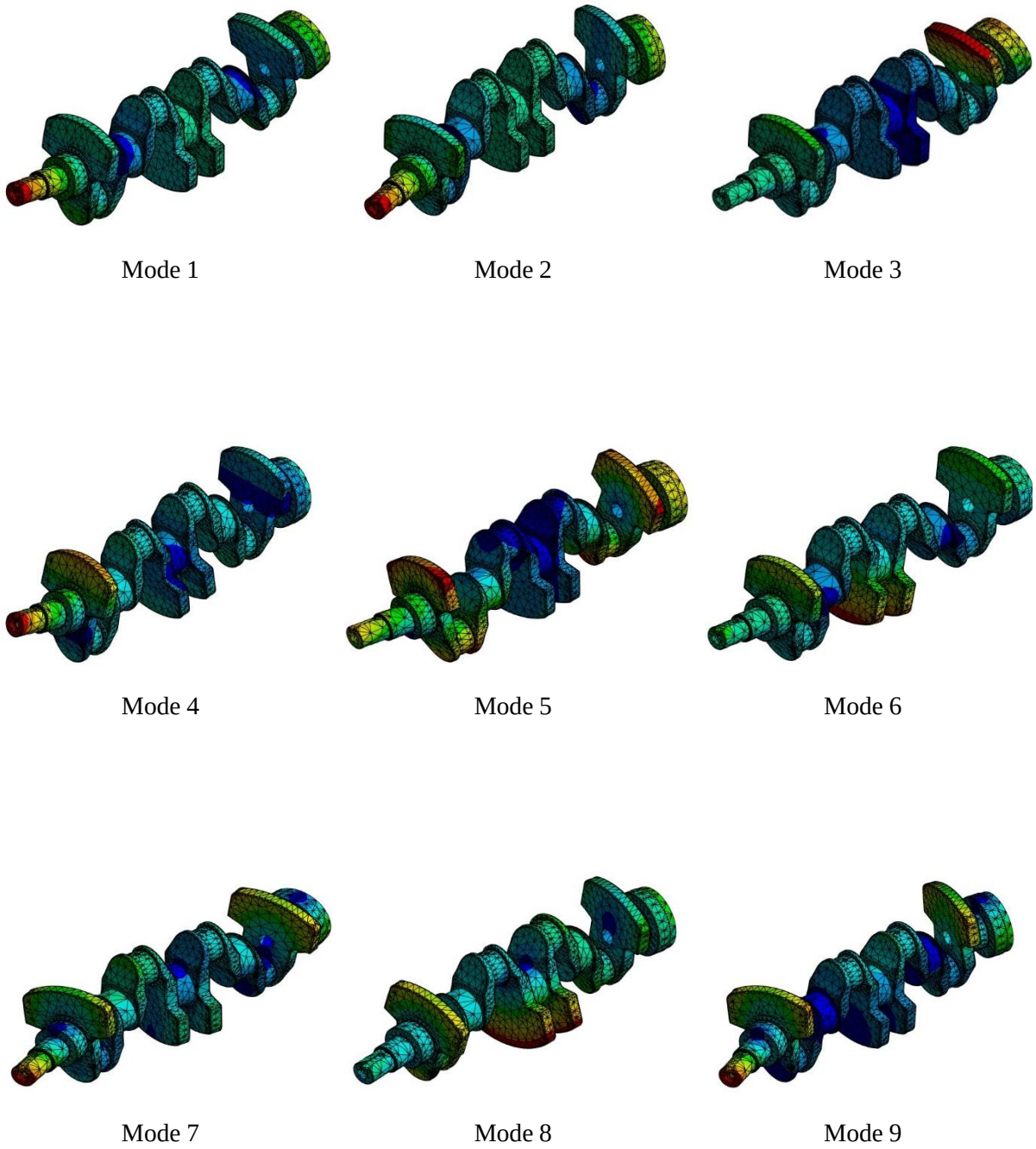


Figure 3. Vibration mode shapes of the crankshaft.

Next, rotordynamic analyses were performed to determine the critical speeds of the crankshaft during operation. For this purpose, the operating range of 0-25,000 rpm was examined. The critical speeds were determined and shown with Campbell Diagrams by identifying the intersection points of the damped natural frequencies of the crankshaft with the operating speeds and their harmonics (1x, 2x, 3x, 4x, and 5x). Below, Figure 4 shows the Campbell Diagram for the crankshaft with a 24 mm journal bearing length.

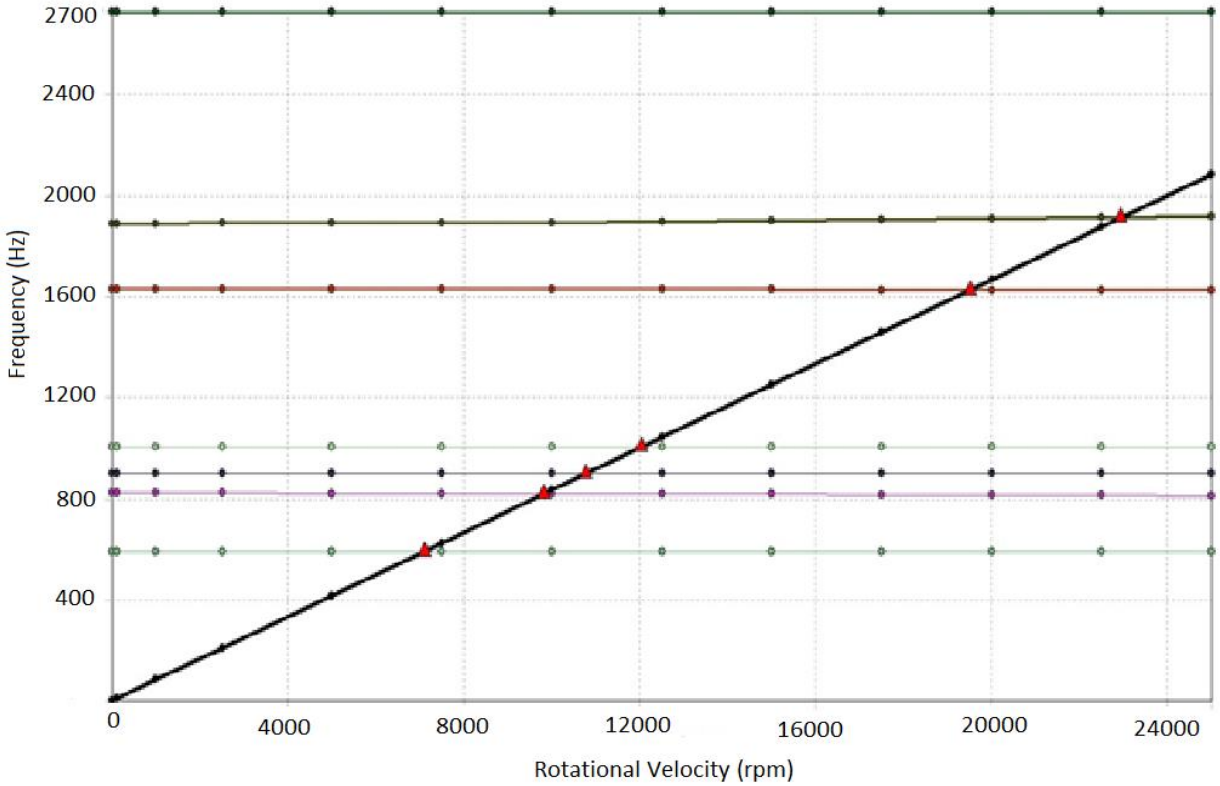


Figure 4. Campbell Diagram (Critical Speed Map) of 24 mm bearing length

In the Campbell Diagram shown in Figure 4, the vertical axis represents the damped natural frequencies (Hz) as a function of speed, and the horizontal axis shows the rotational speed of the crankshaft (rpm). The diagonal lines indicate the harmonic effects, which are multiples of the rotational speed (e.g., the 5x line represents a harmonic effect at 5 times the rotor's rotational speed). The points where these diagonal lines intersect the natural frequency curves are the critical speed points (six red triangles on the graph). Critical speeds are of great importance in rotor design, and they must be avoided to ensure the healthy operation of the rotor. In rotor design, it is essential to keep critical speeds away from the rotor's operating range. This can be achieved through model updates or structural modifications. Alternatively, if critical speeds fall within the operating range, the rotor can be designed to pass through them as quickly as possible to prevent damage to the system.

The calculated critical speed values for all considered journal bearing lengths are given in Table 4.

Table 4. Natural frequencies of the crankshaft for different journal lengths

Critical Speeds (rpm)											
Mode	Journal Length (mm)										
	20.0	21.0	22.0	23.0	24.0	25.0	26.0	27.0	28.0	29.0	30.0
1	7095	7022	6953	6882	6814	6746	6678	6612	6546	6484	6421
2	9826	9768	9728	9679	9632	9587	9533	9486	9445	9396	9356

3	10775	10678	10594	10500	10417	10327	10239	10155	10067	9988	9905
4	12036	12008	11984	11955	11929	11903	11875	11848	11821	11796	11772
5	19504	19343	19203	19038	18888	18738	18544	18387	18226	18071	17940
6	22932	22848	22772	22683	22617	22523	22460	22369	22291	22224	22154

An examination of the critical speeds in Table 4 shows that as the journal bearing lengths increase, the critical speed values tend to decrease in a nearly linear fashion. While the decrease in some critical speeds is significant, others show a relatively smaller decrease. This change in critical speed values is more clearly visible in Figure 5 below.

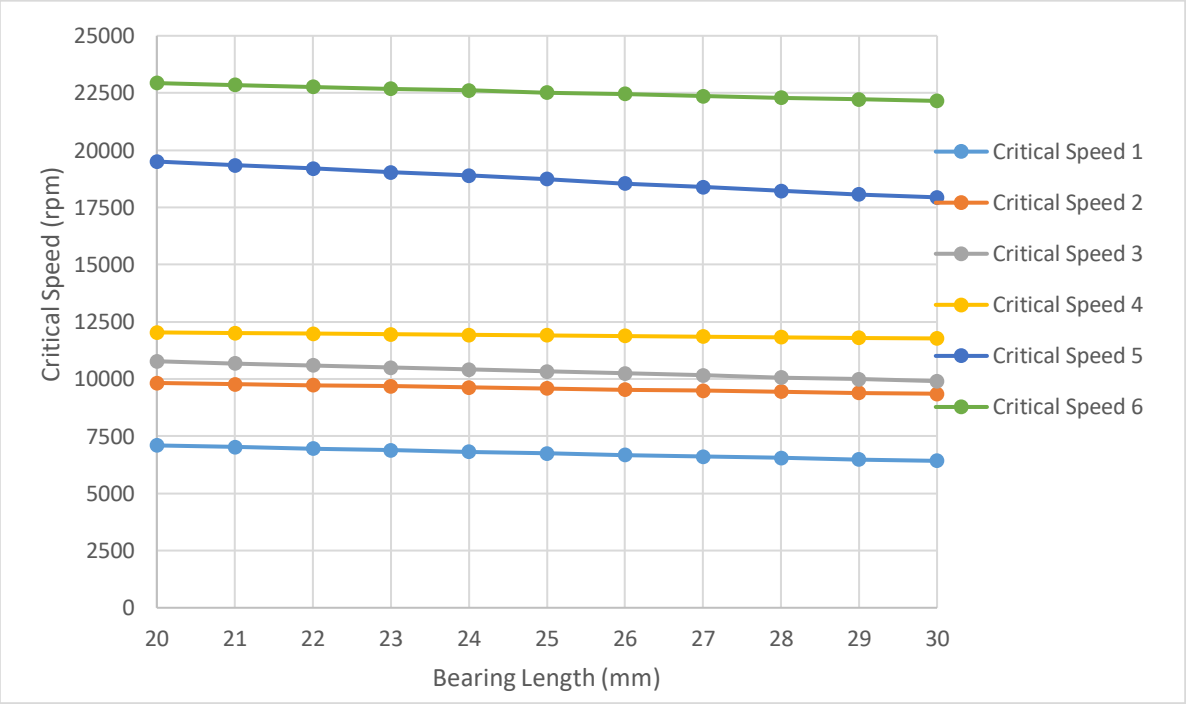


Figure 5. Critical speeds for different bearing lengths

Figure 5 clearly shows how the first 6 critical speeds change with varying crankshaft journal bearing lengths. Each point in the figure represents a critical speed. While the change in some critical speeds is very small (Critical Speed 2 - red line), the change in others is relatively larger (Critical Speed 5 - dark blue line).

CONCLUSION

In this study, the dynamic analyses of a four-cylinder internal combustion engine's crankshaft were conducted. The changes in natural frequencies and critical speeds of the crankshaft for different journal

bearing lengths were investigated through modal analysis and rotordynamics analysis. The lengths of the crankshaft journal bearings were varied from 20 mm to 30 mm in increments of 1 mm. Separate dynamic analyses were performed for each model.

It was determined that both the natural frequency values and the critical speeds decrease with increasing journal bearing lengths. The changes in natural frequencies and critical speeds were observed to follow a nearly linear trend. The decrease in natural frequencies was interpreted as being caused by the increase in the crankshaft's mass and the decrease in its stiffness as the journal bearing length increases.

The findings show how important it is to perform dynamic analyses to determine the natural frequencies and critical speeds in crankshaft design, in addition to mechanical and strength calculations. Furthermore, it can be said that parametric physical designs of the crankshaft can lead to optimal design calculations for the production of dynamically safer and more efficient crankshafts.

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INTEGRATION OF ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING FOR MOLECULAR IMPRINTING STUDIES IN CELL CULTURE

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ABSTRACT

In recent years, advances in Artificial Intelligence (AI) and Machine Learning (ML) and the integration of AI and ML have significantly accelerated advances in molecular imprinting and cell culture techniques. These computational tools have facilitated complex data analysis. In molecular imprinting, AI/ML is enabling the design of more efficient molecularly imprinted polymers (MIPs) in determining suitable functional monomers, cross-linkers, and synthesis conditions. Algorithms that analyze large data sets can significantly optimize the structural properties, binding affinities, and selectivity of MIPs, significantly reducing trial-and-error experiments. Using techniques such as Quantitative Structure-Property Relationship (QSPR) modeling and deep learning, it is possible to predict template-polymer interactions and final polymer properties. In cell culture, AI/ML provides effective results in optimizing process parameters, predicting cell behavior, automating image analysis and quality control. ML models can be used to improve media formulations, predict cell growth kinetics, differentiation pathways, and responses to stimuli. Convolutional Neural Networks (CNNs) enable the identification of cell morphology, viability and phenotype from microscopy images and rapid, automatic and high-throughput analysis of images. AI is effective in predicting possible contaminations and abnormalities in cell culture. These developments increase the efficiency and predictive power of molecular imprinting and cell culture techniques. In addition, it is possible to realize more sophisticated applications with diagnostics, advanced therapeutics and cutting-edge biotechnological developments, including personalized medicine approaches and advanced biomanufacturing. This study summarizes the important roles that AI and ML play in advancing molecular imprinting and cell culture techniques and focuses on the developments in recent years.

Keywords: Artificial Intelligence, Machine Learning, Convolutional Neural Networks, Molecular Imprinting, Cell Culture.

INTRODUCTION

Molecularly imprinted polymers (MIPs) are a novel recognition technique designed to create synthetic polymers that can selectively bind to specific target molecules (Armutcu et al. 2019; Armutcu et al. 2021). They mimic natural antibodies and enzymes (Yarman et al. 2017). MIPs possess superior properties, including high stability, cost-effectiveness, reusability, selectivity, durability and versatility, even in challenging chemical environments such as organic solvents, extreme pH, and high temperatures (Karasu et al. 2024). MIPs are appealing alternatives for a diverse array of applications, such as catalysis, separation, sensing and biotechnology due to these advantages (Çorman and Akgöl 2012).

MOLECULAR IMPRESSED POLYMERS AND ARTIFICIAL INTELLIGENCE INTEGRATION

The integration of artificial intelligence (AI) and machine learning (ML) offers great potential in biomedical applications and sensing technologies by significantly improving the design, optimization, sensor performance, and analysis of collected data in MIPs (Du et al. 2023). In addition to software and big data analysis, AI has significant potential for material design, decision-making, and data

classification (Karasu et al. 2024). As computing power increases, ML techniques have proliferated to enable data-driven modeling for a range of engineering applications. The purpose of this integration is to establish high-throughput experimental platforms for the development of new materials and to enhance the efficiency of synthesis and measurements (Lu et al. 2024).

AREAS OF APPLICATION

Biosensors and Continuous Health Monitoring

Improvements in MIP-based sensor technologies are meeting the need for quick, accurate, and easy-to-use diagnostic tools that can be used in places other than labs, like homes, clinics, and remote areas (Kaya et al. 2023).

Wearable and Implantable Biosensors

Combining MIPs with cutting-edge materials, production processes, and digital health technologies has made it possible to create wearable and implantable sensors that allow for ongoing health monitoring. These sensors provide useful information for disease management, fitness tracking, and medical diagnosis (Karasu et al. 2024).

Cortisol Detection

Touch-based, non-invasive MIP-electrochemical sensors can rapidly and selectively detect cortisol in fingertip sweat (Caldara et al. 2023). By employing AI-assisted iterative synthesis parameters, the sensitivity of the sensor for cortisol detection was enhanced by 1.5 times (Dykstra et al. 2022).

Glucose Monitoring

MIPs have become a promising avenue for continuous glucose monitoring systems by providing selectivity and stability to electrochemical glucose sensors (Dong et al. 2021; Caldara et al. 2023). In addition to warning users of possible hyperglycemic or hypoglycemic episodes, machine learning is used to estimate glucose levels (Zhang et al. 2023).

Lactate and Urea Monitoring

Ag nanowire-integrated MIPs have been employed in wearable electrochemical biosensors to non-invasively monitor lactate levels in human sweat (Zhang et al. 2020). Flexible sensors based on a composite of MIPs and nanotubes have also been successfully used to monitor urea in sweat (Liu et al. 2018).

Alpha-amylase, C-reactive protein (CRP) and SARS-CoV-2

MIP-based biosensors have been implemented to rapidly and selectively identify α-amylase, a stress biomarker (Rebelo et al. 2021); immune-like membranes for the quick CRP detection (Hong et al. 2013); and a variety of disease biomarkers, including the SARS-CoV-2 virus (Raziq et al. 2021).

Multi-Analyte Detection

The integration of MIP-based sensors with microfluidic chips enables the simultaneous detection of multiple analytes in a single analysis and miniaturizes point-of-care (PoC) devices (Ribeiro et al. 2017).

Drug Development and Release

Ophthalmic Drug Release

Smart contact lenses fabricated with a combination of MIPs and an inverse opal structure enable controlled release of the glaucoma drug timolol and self-reporting analysis of drug release through visible color change (Karasu et al. 2024).

Drug Screening and Response Prediction

Artificial intelligence algorithms have ushered in a new era in predicting drug responses and identifying therapeutic targets by integrating the use of organoids in drug screening (Du et al. 2023). Deep learning-based systems such as Deep-SeSMo have assessed cellular aging and screened anti-aging drugs by analyzing changes in cellular morphology (Kusumoto et al. 2021; Kusumoto et al. 2022).

Antimicrobial Drug Detection

Artificial intelligence and smartphone-based molecularly imprinted electrochemiluminescence (MIECL) sensors have been used for high-sensitivity detection of environmental pollutants such as ciprofloxacin (CFX) (Wu et al. 2018).

MACHINE LEARNING ALGORITHMS AND APPLICATIONS

An essential tool for handling and deciphering sensor data is machine learning (Kouchehbaghi et al. 2024).

Data Analysis and Pattern Recognition

Fundamental Analysis Techniques

Techniques such as Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) are widely used in the field of chemistry (Karasu et al. 2024) and biosensors to process optical signals, perform cluster separation, and analyze different types of analytes (Hamedpour et al. 2019; Pandit et al. 2019; Wong et al. 2020; Slipchenko et al. 2022; Ward et al. 2023).

Artificial Neural Networks (ANN)

It is based on the working principles of the human brain and has been widely used to obtain meaningful outputs from sensor arrays and analytes (Gómez-Ramos and Venegas-Martínez 2013). It has been used in the analysis of amino acid mixtures in electrochemical sensors, in improving the selectivity of nonenzymatic electrochemical biosensors, and in wearable sensors (Faura et al. 2016; Zhou et al. 2022).

Random Forest (RF)

This ensemble method, which is used for regression and classification, has proven successful in a number of applications, including the safety of food and water (Nafouanti et al. 2021; Liu et al. 2022), infectious disease detection (Doulani et al. 2023), and DNA binding monitoring (Mondal et al. 2023).

Image Processing Algorithms

Object detection algorithms such as YOLOv8 and RT-DETR were used for real-time analysis of unstained microscopic cell culture images and cell identification. They were particularly successful in distinguishing between leukemic cell lines with high morphological similarity, such as K562, HL-60, and Kasumi-1 (Hildebrand et al. 2025).

Gaussian Process (GP)

It is an integrated data-driven framework used to optimize the synthesis and sensor performance of electropolymerized MIPs (e-MIPs) (Dykstra et al. 2022).

Support Vector Machines (SVM)

This algorithm for supervised learning has been employed in the prediction of pathogens and pathogenic infections in fluorescent, bioluminescent, and electrochemical signals, as well as in image processing. It is capable of performing both regression and classification. (Smolander et al. 2009; Taubner et al. 2023; Wang et al. 2023; Pennacchio et al. 2024).

K-Nearest Neighbors (KNN)

It is a simple yet effective supervised learning algorithm (Review of Literature on Improving the KNN Algorithm 2023), useful for chemists because it works with small features. It has provided accurate predictions in molecular imprinting (Yarahmadi et al. 2023) and wearable sensors (Zeng et al. 2020).

K-Means Clustering (K-means)

It is a technique for unsupervised learning that groups data samples that are similar (Oti et al. 2021). It has been widely used for the detection of DNA (Moon et al. 2020), diseases (Amin et al. 2015), and small organic molecules (Kim et al. 2020).

Naive Bayes (NB)

Based on Bayes' theorem, it is a probabilistic classifier (Wickramasinghe and Kalutarage 2021). It has been shown in studies like fluorescent array-based protein detection (Pandit et al. 2019) and SERS-based cancer detection (Moisoiu et al. 2022).

Decision Tree (DT)

It is a supervised learning algorithm used for classification or regression and is a common tool for medical diagnosis (Costa and Pedreira 2023).

Adaptive Boost (AdaBoost)

It is a boosting technique for regression and classification (Wang 2012). It has been used successfully in materials science, particularly in areas such as blood pressure monitoring in graphene-based tattoos (Kireev et al. 2022) and characterizing the extraversion potential of cancer cells (Oliver et al. 2019).

ML in MIP Connectivity Simulations

Multitask regression and graph convolution models were identified as the most promising algorithms for estimating MIP binding affinities. These models produced the most accurate representations of the experimental data (Lowdon et al. 2021).

Directed Acyclic Graph (DAG) Model

It works by converting molecular structures into nodes (atoms) and edges (bonds). However, its predictive capabilities have been found to be limited in test data (Lusci et al. 2013).

ChemCeption Model

It performs pixel-based image comparison by converting molecular SMILES into 2D images. This approach has proven inadequate for extracting complex binding affinity data (Lowdon et al. 2021).

Graph Convolution Weave Model

It combines primitive operations between atoms and related layers into a single module. It has been noted to be problematic for smaller datasets and to be prone to higher error (Tan et al. 2021).

Material Design and Optimization

ML techniques facilitate the development and optimization of high-dimensional design space of electropolymerized MIPs (e-MIPs) (Dykstra et al. 2022). Through data analysis and modeling, AI can figure out how chemical processes will affect the environment, speed up reactions, and use less energy. Integrating AI with green solvent design is a promising approach (Wen et al. 2023). ML was used to predict critical parameters in the nanoimprinting process of CuZr metallic glasses (Sayed et al. 2023).

ORGANOIDS AND THEIR ASSOCIATION WITH ARTIFICIAL INTELLIGENCE

Organoids are 3D in vitro models of organs, tissues, and cells and are used as innovative tools in personalized medicine, cancer research, and drug development (Hu et al. 2023; Ma et al. 2024). ML

algorithms play a key role in verifying similarities between in vivo organs and in vitro organoid models by resolving patterns in complex organoid datasets (Shi et al. 2024).

Organoid Image Analysis

Deep learning (DL)-based tools are being developed for analyzing microscopy images, one of the most challenging aspects of organoid research. These tools can automatically quantify changes in organoids (Shi et al. 2024).

Convolutional Neural Networks (CNNs)

It can automatically detect and classify morphological features and phenotypic changes from high-resolution organoid images (Kegeles et al. 2020).

Special Software

Open-source tools such as OrganoID, OrgaExtractor, 3DeeCellTracker, OrganoSeg, OrgaQuant, MOrgAna, and D-CryptO have been developed to detect, segment, and track the location, size, shape, number, and development of organoids (Gunel et al. 2024).

Organoid Intelligence (OI)

It's a novel approach that aims to mimic learning, memory, and cognition in laboratory settings by incorporating brain organoids with scientific and bioengineering innovations (Smirnova et al. 2023). It aims to open new doors for OI, biocomputing, and synthetic intelligence (Morales Pantoja et al. 2023).

CONCLUSION

This work highlights the transformative potential of artificial intelligence (AI) and machine learning (ML) in various scientific and engineering fields, such as the design of molecularly imprinted polymers (MIPs) and their optimization of sensor performance and their applications in wearable biosensors. Specifically, AI has improved material synthesis by increasing the sensitivity of electropolymerized MIPs (e-MIPs) by 1.5-fold for cortisol detection. Furthermore, deep learning models such as YOLOv8-s have reliably distinguished subtle morphological changes among leukemic cell lines such as K562 in unstained microscopic cell culture images in real time with over 97% accuracy, which is critical for drug testing and personalized medicine. In the field of bioprocess optimization, artificial neural networks (ANNs) have enabled significant increases in monoclonal antibody (mAb) titers of up to 48% by optimizing CHO cell culture processes. In image analysis of organoids, deep learning-based tools have also been effective in quantifying complex datasets by reducing manual errors and enabling automation. Overall, while this integration increases diagnostic capabilities, efficiency, and personalized care, challenges remain, such as limited datasets and the “black box” nature of the models.

Beyond the study, key recommendations for the integration of AI and biological systems include the creation of larger, more diverse, and higher-quality datasets to increase the reliability and generalizability of models. For MIP binding simulations, it would be particularly beneficial to "horizontally expand" datasets by collecting additional physical or quantum properties of existing molecules. Furthermore, research to increase the transparency and interpretability of deep learning models will strengthen trust in biomedical applications. The integration of AI models into automation and real-time feedback loops will enable adaptive and efficient experimental designs by automatically adjusting experimental conditions. In personalized medicine, AI-assisted morphological analysis can be used for individualized treatment selection and dosage adjustment. Finally, validating bioprocessing conditions optimized at the laboratory scale in larger bioreactor systems is critical for industrial applicability.

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TÜRKİYE YÜZYILI MAARİF MODELİNİN FEN EĞİTİMİNDE DİSİPLİNLER ARASI ETKİLEŞİM VE BECERİ GELİŞİMİNE ETKİSİ

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ÖZET

Fen eğitiminde geleneksel disiplin sınırlarını aşan, bilimi etik, sosyal ve teknolojik bağlamıyla bütünleştiren bütüncül yaklaşımlar giderek önem kazanmaktadır. Bu çalışma, 2024 yılında Türkiye'de uygulamaya konulan ve "bütüncül eğitim" felsefesini merkeze alan yeni Fen Bilimleri Programı'nın, bu iddialı vizyonu öğretmenlerin perspektifinden nasıl yansıttığını ve hangi potansiyelleri barındırdığını incelemektedir. Nitel durum çalışması deseniyle yürütülen araştırmaya, programı ilk yılında deneyimleyen 12 fen bilimleri öğretmeni katılmıştır. Yarı yapılandırılmış görüşmelerden elde edilen verilerin tematik analizi, öğretmenlerin programın teorik çerçevesini ve yenilikçi felsefesini güçlü bir şekilde benimsediğini ortaya koymaktadır. Özellikle, "Köklerden Geleceğe" temasıyla iç içe geçen değerler eğitimi, öğretmenler tarafından fen eğitimine ahlaki ve kültürel bir derinlik katan en önemli yenilik olarak görülmüştür. Bulgular, programın disiplinler arası etkileşimi (sosyal, ahlaki, teknolojik) ve 21. yüzyıl becerilerini (kariyer bilinci, girişimcilik, sürdürülebilirlik) geliştirme potansiyelinin öğretmenlerce takdir edildiğini göstermektedir. Ayrıca öğretmenler, yeni programı kendi mesleki gelişimlerini teşvik eden ve onları daha bütüncül bir öğretim anlayışına yönelten bir araç olarak değerlendirmişlerdir. Çalışma, uygulama zorluklarına rağmen, yeni programın felsefi temelinin öğretmenler tarafından bir umut ve fen eğitimini yeniden tanımlama potansiyeli taşıyan anlamlı bir adım olarak görüldüğünü ortaya koymaktadır.

Anahtar Kelimeler: Fen Eğitimi, Bütüncül Eğitim, Değerler Eğitimi, Öğretmen Görüşleri, Türkiye Yüzyılı Maarif Modeli, Disiplinler arası Yaklaşım

GİRİŞ

21. yüzyılda fen eğitimi, bireylere yalnızca bilimsel olguları ve teorileri aktaran bir disiplin olmanın ötesine geçerek, onları etik kararlar alabilen, sosyal sorumluluk sahibi ve karmaşık sosyo-bilimsel konuları analiz edebilen vatandaşlar olarak yetiştirme misyonunu üstlenmiştir (Zeidler ve Sadler, 2008). Bu dönüşüm, bilginin parçalara ayrıldığı geleneksel disiplinel yapıyı sorgulamakta ve bunun yerine bilimi, teknolojiyi, toplumu ve değerleri bir araya getiren bütüncül ve disiplinler arası eğitim paradigmalarını ön plana çıkarmaktadır. Bütüncül eğitim felsefesi, öğrencinin yalnızca bilişsel gelişimine değil, aynı zamanda duyuşsal, sosyal, ahlaki ve estetik boyutlarına da odaklanarak, zihin, beden ve ruh arasında bir denge kurmayı hedefler (Miller, 2007). Bu bağlamda fen eğitimi, sadece "ne biliyoruz?" sorusuna değil, aynı zamanda "bildiklerimizle nasıl yaşamalıyız?" ve "kim olmalıyız?" gibi varoluşsal sorulara da yanıt arayan, değer yüklü bir alan olarak yeniden tanımlanmaktadır.

Bu yaklaşım, öğretim programlarının, öğrencilerin bilimsel okuryazarlık becerilerini geliştirirken aynı zamanda kariyer bilinci, girişimcilik ruhu, sürdürülebilirlik anlayışı ve kültürel miras farkındalığı gibi yetkinlikleri de kazanmalarını gerektirir. Dolayısıyla, modern bir fen programından beklenen, bilimsel içeriği evrensel insani değerler ve yerel kültürel bağlam ile anlamlı bir şekilde bütünleştirmesidir.

Türkiye'deki eğitim reformları da bu küresel eğilimlere paralel olarak, özellikle son yıllarda daha bütüncül ve değer odaklı bir vizyon benimseme arayışındadır. Bu arayışın en somut ve kapsamlı ürünü, 2024 yılında uygulamaya konulan "Türkiye Yüzyılı Maarif Modeli" (TYMM) ve bu modelin bir parçası olan yeni Fen Bilimleri Dersi Öğretim Programı'dır. Yeni program, teorik çerçevesinde "bütüncül eğitim" felsefesini merkeze alarak, fen eğitimini ahlaki, sosyal ve teknolojik boyutlarıyla entegre etme iddiasını taşımaktadır. Programın "Köklerden Geleceğe" gibi özgün bir temayla değerler eğitimine yaptığı güçlü vurgu, disiplinler arası etkileşimi teşvik etmesi ve öğrencilerin çok yönlü beceri gelişimini hedeflemesi, onu önceki programlardan felsefi olarak ayıran en temel özelliklerdir (MEB, 2024).

Eğitim reformu literatürü, genellikle reformların uygulama sürecindeki zorluklara ve başarısızlıklara odaklanma eğilimindedir (Coburn, 2004). Ancak bir reformun, özellikle başlangıç aşamasında, uygulayıcıları olan öğretmenler tarafından felsefi ve pedagojik düzeyde nasıl karşılandığı, hangi yönlerinin bir "umut" ve "potansiyel" olarak görüldüğü ve mesleki gelişimlerini nasıl tetiklediği gibi konular görece daha az incelenmiştir. Yeni bir programın sadece yarattığı sorunlar değil, aynı zamanda barındırdığı potansiyel ve öğretmenlerde uyandırdığı olumlu beklentiler de reformun geleceği ve sürdürülebilirliği açısından kritik öneme sahiptir. Bu çalışma, reformlara yönelik "problem odaklı" bakışın ötesine geçerek, yeni fen programının en yenilikçi ve iddialı yönlerinin öğretmenler tarafından nasıl algılandığını ve anlamlandırıldığını ortaya çıkarmayı hedeflemektedir.

Araştırmanın Amacı ve Araştırma Soruları

Bu araştırmanın temel amacı, 2024 Fen Bilimleri Dersi Öğretim Programı'nın benimsediği bütüncül, değer odaklı ve disiplinler arası yaklaşımın, programı ilk yılında uygulayan fen bilimleri öğretmenleri tarafından nasıl algılandığını, bu yeni felsefenin hangi potansiyelleri barındırdığını ve öğretmenlerin mesleki gelişimlerine etkisini derinlemesine analiz etmektir. Bu genel amaç doğrultusunda aşağıdaki araştırma sorularına yanıt aranmıştır:

i. Fen bilimleri öğretmenleri, yeni programın değerler eğitimini ("Köklerden Geleceğe" teması) ve disiplinler arası yaklaşımları fen bilimi öğretimine entegre etme biçimini nasıl algılamakta ve değerlendirmektedir?

ii. Öğretmenlerin gözünden yeni program, öğrencilerin fen okuryazarlığının ötesinde kariyer bilinci, girişimcilik ve sürdürülebilirlik gibi temel yaşam becerilerini geliştirme konusunda ne gibi potansiyeller sunmaktadır?

iii. Fen bilimleri öğretmenleri, yeni programın felsefi ve pedagojik yeniliklerinin kendi mesleki gelişimlerini ve öğretim pratiklerini nasıl etkilediğini düşünmektedir?

Bu sorulara verilecek yanıtların, yeni programın en güçlü ve gelecek vadeden yönlerini ortaya koyarak, bu yönlerin güçlendirilmesi ve reformun ruhunun korunarak yaygınlaştırılması için politika yapıcılara ve program geliştiricilere önemli bir perspektif sunması beklenmektedir.

YÖNTEM

Bu bölümde araştırmanın bilimsel titizliğini ve bulgularının geçerliğini temellendiren metodolojik çerçeve sunulmaktadır. Bu doğrultuda araştırmanın deseni, katılımcıların seçimi, veri toplama araç ve süreçleri, verilerin analizi ve araştırmanın inandırıcılığını sağlamak üzere izlenen stratejiler detaylandırılmıştır.

Araştırma Deseni

Bu araştırma, fen bilimleri öğretmenlerinin yeni öğretim programının felsefi ve pedagojik yeniliklerine ilişkin deneyimlerini, bu yeniliklere yükledikleri anlamları ve bunlara dair perspektiflerini kendi doğal bağlamı içinde, derinlemesine ve bütüncül bir bakış açısıyla anlamayı hedeflemektedir. Bu amaç doğrultusunda, nitel araştırma yaklaşımlarından durum çalışması deseni benimsenmiştir. Durum

çalışması, güncel bir olguyu kendi gerçek yaşam bağlamı içinde, olgu ve bağlam arasındaki sınırların net olmadığı durumlarda inceleyen uygulamalı bir araştırma yöntemidir (Yin, 2018). Bu araştırmadaki "durum", 2024 Türkiye Yüzyılı Maarif Modeli Fen Bilimleri Öğretim Programı'nın bütüncül, değer odaklı ve disiplinler arası felsefesinin, programı ilk yılında uygulayan öğretmenler tarafından deneyimlenmesi ve anlamlandırılması sürecidir. Bu desen, programın teorik düzeydeki iddialı vizyonunun, sahadaki uygulayıcılar tarafından nasıl karşılandığını, hangi yönlerinin potansiyel bir güç olarak görüldüğünü zengin betimlemelerle ortaya koymak için en uygun metodolojik zemini sunmaktadır.

Katılımcılar

Araştırmanın katılımcıları, nitel araştırmanın doğasına uygun olarak, araştırma problemine ilişkin zengin ve derinlemesine bilgi sağlayabilecek "bilgi-zengini durumlar" arasından amaçlı örnekleme stratejisiyle belirlenmiştir (Patton, 2015). Bu kapsamda, ölçüt örnekleme tekniği kullanılarak, aşağıdaki önceden tanımlanmış kriterleri karşılayan öğretmenler çalışmaya dahil edilmiştir: (1) Fen Bilimleri branşında aktif olarak görev yapıyor olmak, (2) Kayseri il merkezindeki bir devlet ortaokulunda çalışıyor olmak ve (3) 2024-2025 eğitim-öğretim yılında yeni öğretim programını bizzat uyguluyor olmak.

Bu ölçütler doğrultusunda, katılımın tamamen gönüllülük esasına dayandığı vurgulanarak, farklı mesleki deneyim düzeylerine sahip 8'i erkek ve 4'ü kadın olmak üzere toplam 12 fen bilimleri öğretmeni ile çalışılmıştır. Katılımcıların gizliliğini temin etmek amacıyla kendilerine Ö1, Ö2, ..., Ö12 şeklinde kod adları atanmıştır.

Veri Toplama Aracı ve Süreci

Araştırmanın verileri, öğretmenlerin programın felsefi ve pedagojik boyutlarına ilişkin karmaşık ve derinlemesine görüşlerini ortaya çıkarmak için en uygun teknik olan yarı yapılandırılmış görüşme yoluyla toplanmıştır. Bu teknik, önceden hazırlanmış bir görüşme protokolü ile görüşmenin doğal akışına izin veren esnekliği bir arada sunarak zengin veri elde etmeyi mümkün kılar.

Veri toplama aracı olarak, araştırmanın özel amaçlarına (değerler eğitimi, disiplinler arası yaklaşım, beceri gelişimi vb.) odaklanan 20 açık uçlu sorudan oluşan bir Görüşme Formu kullanılmıştır. Formun geçerliği, alanında uzman bir öğretim üyesinin uzman görüşü alınarak ve çalışma grubuna benzer özellikler taşıyan iki öğretmenle pilot uygulama yapılarak sağlanmıştır.

Görüşmeler, Eylül 2024-Mart 2025 tarihleri arasında, katılımcıların görev yaptıkları okullarda, önceden planlanmış ve sessiz bir ortamda yüz yüze gerçekleştirilmiştir. Her bir görüşme, katılımcıların izniyle ses kaydına alınmış ve ortalama 30-40 dakika sürmüştür.

Verilerin Analizi

Ses kayıtlarının yazıya dökülmesiyle elde edilen transkriptler, tematik analiz yöntemi kullanılarak çözümlenmiştir. Bu çalışmada, verilerden temaların türetildiği tümevarımsal bir yaklaşım benimsenmiştir. Analiz süreci, Braun ve Clarke'ın (2006) tanımladığı aşamalar takip edilerek yürütülmüştür: (1) Veriye aşina olma, (2) İlk kodların oluşturulması, (3) Kodlardan temaların oluşturulması, (4) Temaların gözden geçirilmesi, (5) Temaların tanımlanması ve (6) Raporun yazılması. Veri analizinin güvenirliğini artırmak amacıyla, kodlama sürecinin bir bölümü iki araştırmacı tarafından bağımsız olarak yapılmış ve kodlayıcılar arası tutarlılık sağlanana kadar müzakereler yürütülmüştür.

Araştırmanın İnandırıcılığı ve Etik İlkeler

Bu çalışmanın bilimsel titizliği, Lincoln ve Guba'nın (1985) inandırıcılık kriterleri temel alınarak sağlanmıştır. İnanılırlığı artırmak için uzman incelemesi ve katılımcı teyidi stratejileri; aktarılabilirliği

sağlamak için zengin ve ayrıntılı betimleme; tutarlılık ve teyit edilebilirliği güvence altına almak için ise şeffaf bir denetim izi kullanılmıştır.

Araştırma sürecinde etik ilkelere en üst düzeyde riayet edilmiştir. Erciyes Üniversitesi Sosyal ve Beşerî Bilimler Etik Kurulu'ndan (Tarih: 30/07/2024, Karar No: 336) gerekli onay alınmış, tüm katılımcılardan bilgilendirilmiş yazılı onam alınmış ve katılımcı gizliliği kod adları kullanılarak korunmuştur.

BULGULAR

Yarı yapılandırılmış görüşmelerden elde edilen verilerin tematik analizi, fen bilimleri öğretmenlerinin 2024 Fen Bilimleri Öğretim Programı'nın getirdiği felsefi ve pedagojik yenilikleri büyük ölçüde benimsediğini ve bu yeniliklerde önemli bir potansiyel gördüğünü ortaya koymuştur. Bulgular, öğretmenlerin programın sadece içeriğini değil, aynı zamanda ruhunu ve vizyonunu da takdir ettiğini gösteren üç ana tema etrafında toplanmıştır: (1) Bütüncül ve Değer Odaklı Felsefenin Benimsenmesi, (2) Disiplinler Arası Etkileşim ve Yetkinlik Gelişimi ve (3) Mesleki Gelişim İçin Bir Katalizör Olarak Program.

Tema 1: Bütüncül ve Değer Odaklı Felsefenin Benimsenmesi

Araştırmanın en güçlü bulgularından biri, öğretmenlerin programın "bütüncül eğitim" felsefesini ve değerler eğitimine yaptığı güçlü vurguyu takdirle karşılamasıdır. Öğretmenler, bu yaklaşımın fen eğitimine ahlaki, kültürel ve insani bir derinlik kattığını düşünmektedir. Bu tema altındaki temel bulgular Tablo 1'de özetlenmiştir.

Tablo 1. Programın Felsefesine ve Bütüncül Yapısına İlişkin Olumlu Algılar

Kategori	Kod	Katılımcılar	Frekans (f)
Bütüncül ve Değer Odaklı Yaklaşım	Değerler ve Ahlak Eğitimiyle Uyum Sağlama	Ö1, Ö3, Ö4, Ö7, Ö8, Ö10, Ö11, Ö12	8
	Erdem ve Etik Eğitimiyle Uyum Sağlama	Ö2, Ö3, Ö5, Ö7, Ö8, Ö10, Ö11, Ö12	8
	Köklerden Geleceğe Düşüncesinin Benimsenmesi	Ö1, Ö5, Ö8, Ö10, Ö11, Ö12	6
	Bütüncül Yaklaşıma Uyumun Benimsenmesi	Ö1, Ö10, Ö11, Ö12	4

Öğretmenler, özellikle programın "Köklerden Geleceğe" sloganıyla sembolize edilen, milli ve manevi değerleri bilimsel bilgiyle bütünleştirme çabasını çok anlamlı bulduklarını ifade etmişlerdir. Ö1, bu felsefenin programın en etkileyici yönü olduğunu şu sözlerle dile getirmiştir:

“Program değişikliğindeki en önemli ve beni en çok etkileyen tanım ise ‘Köklerden Geleceğe’ olan düşüncedir. O kadar güzel bir tanımlama olmuş ki, gerçekten köklerimiz bir ve birlikte gövdemizi, ağacımızı, yaprağımızı oluşturmamız kaçınılmaz ve bunu hep birlikte başaracağız.” (Ö1)

Benzer şekilde, programın sadece bilişsel hedeflere odaklanmayıp, değerler ve ahlak eğitimini de merkeze alması, öğretmenler tarafından takdirle karşılanmıştır. Ö3, bu durumu "programın temeli ahlaki değerlerin üzerine oturmuştur" şeklinde ifade ederek, bu yaklaşımın öğrencilerin karakter gelişimine yapacağı katkıyı vurgulamıştır.

Tema 2: Disiplinler Arası Etkileşim ve Yetkinlik Gelişimi

Öğretmenler, yeni programın öğrencilerin sadece fen kavramlarını öğrenmesini değil, aynı zamanda bu bilgiyi kullanarak çeşitli yaşam becerileri geliştirmesini hedeflemesini önemli bir potansiyel olarak görmektedir. Programın disiplinler arası yapısı ve beceri odaklı hedefleri, öğretmenler tarafından sıkça vurgulanmıştır (Tablo 2).

Tablo 2. Programın Beceri Gelişimi ve Disiplinler Arası Etkileşime Katkısına Yönelik Görüşler

Kategori	Kod	Katılımcılar	Frekans (f)
Temel Beceri Hedefleri	Fen Okuryazarı Becerisi Geliştirme	Ö1, Ö2, Ö3, Ö4, Ö5, Ö6, Ö7, Ö8, Ö9, Ö10, Ö11, Ö12	12
	Kariyer Bilinci Geliştirme	Ö1, Ö2, Ö3, Ö4, Ö5, Ö6, Ö7, Ö8, Ö10, Ö11, Ö12	11
	Girişimcilik Becerisi Geliştirme	Ö1, Ö2, Ö3, Ö4, Ö5, Ö7, Ö8, Ö10, Ö11, Ö12	10
Disiplinler Arası Etkileşim	Bilimsel ve Teknolojik Etkileşimin Artırılması	Ö1, Ö2, Ö3, Ö4, Ö7, Ö8, Ö9, Ö10, Ö11, Ö12	10
	Ahlaki ve Sosyal Etkileşimin Artırılması	Ö1, Ö3, Ö4, Ö7, Ö8, Ö10, Ö11, Ö12	8
	Proje ve Araştırma Çalışmalarının Teşvik Edilmesi (TÜBİTAK)	Ö1, Ö2, Ö3, Ö4, Ö5, Ö6, Ö7, Ö8, Ö9, Ö10, Ö11, Ö12	12

Katılımcıların tamamı (f=12), programın temel amacının "Fen Okuryazarı Becerisi Geliştirmek" olduğunu ve bunu başarma potansiyeli taşıdığını belirtmiştir. Bunun ötesinde, kariyer bilinci (f=11) ve girişimcilik (f=10) gibi 21. yüzyıl becerilerinin program hedeflerine entegre edilmesi, öğretmenler tarafından olumlu karşılanmıştır. Ö11, bu durumu şöyle açıklamıştır:

"Şimdiye kadar gözlemlediğime göre hem kariyer bilinci oluşturulması hem girişimcilik becerileri ve sürdürülebilir bilinci oluşturması öğretim programındaki değişikliklerindeki amaçlardan en güzel noktalara temas etmektedir. Ayrıca öğrenciler mesleki araştırma yapmayı ve Fen eğitimindeki alanların kendilerine nasıl katkılar sağlayacaklarını... araştırma yaparak öğrenme becerisi kazanmışlardır." (Ö11)

Ayrıca öğretmenler, programın TÜBİTAK ve TEKNOFEST gibi ulusal projelere katılımı teşvik etmesinin, öğrencilerin teorik bilgiyi pratiğe dökmesi ve inovasyon kaynaklı çalışmalar yapması için önemli bir fırsat sunduğunu belirtmişlerdir.

Tema 3: Mesleki Gelişim İçin Bir Katalizör Olarak Program

Araştırmanın dikkat çekici bulgularından biri de öğretmenlerin yeni programı sadece öğrencilere yönelik bir reform olarak değil, aynı zamanda kendi mesleki gelişimlerini de tetikleyen bir unsur olarak görmeleridir. Programın yenilikçi yapısı, öğretmenleri de değişime ve sürekli öğrenmeye teşvik etmiştir. Bu tema altındaki temel bulgular Tablo 3'te özetlenmiştir.

Tablo 3. Yeni Programın Öğretmenlerin Mesleki Gelişimine Etkisi

Kategori	Kod	Katılımcılar	Frekans (f)
Profesyonel Gelişim	Sürekli Kendini Geliştirme	Ö1, Ö3, Ö4, Ö5, Ö8, Ö10, Ö11, Ö12	8
	Sürekli Araştırma İnceleme	Ö1, Ö3, Ö4, Ö7, Ö10, Ö12	6
	Değişime Uyum Sağlama	Ö2, Ö5, Ö7, Ö8, Ö10, Ö11	6
Yeni Yetkinlikler	Teknoloji Kullanımını Artırma	Ö1, Ö5, Ö10, Ö11	4
	Dijital Okuryazarlığı Artırma	Ö2, Ö7, Ö10, Ö11	4

Katılımcıların önemli bir kısmı (f=8), yeni programla birlikte kendilerini sürekli geliştirme ihtiyacı hissettiklerini ifade etmiştir. Programın getirdiği yenilikler, öğretmenleri yeni konuları araştırmaya, yeni teknolojileri öğrenmeye ve daha inovatif düşünmeye yöneltmiştir. Ö1, bu etkiyi şöyle ifade etmiştir:

"Mesleki gelişimimi olumlu yönde etkiledi. Sürekli kendini geliştirme, sürekli araştırma, inceleme yapma gibi amaçlar zaten vardı ama üzerlerine de eklenmiş oldu. Tabi ki teknoloji kullanımının artması da bizi inovatif düşünmeye yol açtırdı." (Ö1)

Benzer şekilde Ö10, formatör öğretmen olarak edindiği rolün, kendisini sürekli güncel kalmaya ve öğrendiklerini meslektaşlarıyla paylaşmaya ittiğini, bunun da mesleki gelişimini olumlu etkilediğini belirtmiştir. Bu bulgular, programın sadece bir müfredat metni olmanın ötesinde, öğretmenler için de bir mesleki gelişim katalizörü olarak işlev görme potansiyeli taşıdığını göstermektedir.

TARTIŞMA, SONUÇ VE ÖNERİLER

Bu bölümde, araştırmadan elde edilen temel bulgular özetlenmekte, bu bulgular fen eğitiminde bütüncül ve değer odaklı yaklaşımlar üzerine kurulu ilgili literatür ışığında tartışılarak yorumlanmakta ve son olarak öneriler sunulmaktadır.

Bu araştırmanın en temel bulgusu, 2024 Fen Bilimleri Öğretim Programı'nın, onu ilk yılında uygulayan öğretmenler tarafından sadece bir içerik güncellemesi olarak değil, fen eğitiminin felsefesine ve ruhuna yönelik anlamlı ve potansiyel vadeden bir dönüşüm olarak algılandığıdır. Uygulamadaki pratik zorluklara rağmen, öğretmenlerin programın teorik çerçevesine ve bütüncül vizyonuna yönelik bu güçlü olumlu bakış açısı, reformun en önemli sermayesidir.

Öğretmenlerin, programın değerler eğitimini ve disiplinler arası yapısını bu denli takdir etmesi, fen eğitiminin artık sadece bilimsel kavramların öğretildiği izole bir alan olarak görülmediğinin sahadaki en net göstergesidir. Bu durum, sosyo-bilimsel konular üzerine kurulu öğretim modellerinin önemini vurgulayan literatürle tam bir uyum içindedir. Bu modellere göre fen eğitimi, öğrencilerin etik muhakeme, argümantasyon ve karar verme becerilerini geliştirecek şekilde ahlaki ve sosyal ikilemleri de içermelidir (Zeidler ve Sadler, 2008). Öğretmenlerin, programın "ahlaki temellerini" ve "Köklerden Geleceğe" yaklaşımını benimsemesi, yeni programın bu çağdaş pedagojik vizyonu başarıyla yansıttığını göstermektedir. Bu bulgu, önceki programlara yönelik yapılan ve değer/tutum boyutlarının eksik kaldığını belirten eleştirilere (Özcan ve Kaptan, 2019) yeni programın bir yanıt niteliği taşıdığı şeklinde yorumlanabilir.

Programın, fen okuryazarlığının yanı sıra kariyer bilinci ve girişimcilik gibi 21. yüzyıl becerilerini de hedeflemesi, öğretmenler tarafından önemli bir potansiyel olarak görülmüştür. Bu, fen eğitiminin sadece

akademik bir disiplin değil, aynı zamanda öğrencileri geleceğin dünyasına hazırlayan pratik ve işlevsel bir alan olarak konumlandırıldığını göstermektedir. Programın TÜBİTAK ve TEKNOFEST gibi proje tabanlı uygulamaları teşvik etmesi, öğrencilerin otantik öğrenme (authentic learning) deneyimleri yaşayarak, okulda öğrendikleri bilgileri gerçek dünya problemlerine uygulama fırsatı bulmalarını sağlar (Herrington ve Oliver, 2000). Bu tür deneyimler, öğrencilerin hem mesleki ilgilerini keşfetmelerine hem de problem çözme, yaratıcılık gibi üst düzey becerilerini geliştirmelerine olanak tanır.

Son olarak, öğretmenlerin yeni programı kendi mesleki gelişimleri için bir katalizör olarak görmeleri, reformların sadece öğrenciyi değil, öğretmeni de dönüştürme potansiyelini ortaya koymaktadır. Programın yenilikçi yapısı, öğretmenleri konfor alanlarının dışına çıkmaya, yeni bilgiler araştırmaya ve daha dinamik bir mesleki tutum sergilemeye teşvik etmektedir. Bu durum, eğitimde değişimin sürdürülebilirliğinin, öğretmenlerin de birer "yaşam boyu öğrenen" olmalarına ne kadar bağlı olduğunu gösteren önemli bir bulgudur.

Sonuç

Bu çalışma, 2024 Fen Bilimleri Öğretim Programı'nın, sahadaki uygulayıcıları olan öğretmenler tarafından, fen eğitimini geleneksel sınırlarının ötesine taşıyan, bilimi değerler, kültür ve yaşam becerileriyle bütünleştiren ilerici ve umut vadeden bir reform olarak algılandığını ortaya koymuştur. Öğretmenler, programın felsefi derinliğini, bütüncül yapısını ve beceri odaklı hedeflerini takdir etmekte ve bu vizyonun hem öğrenci gelişimi hem de kendi mesleki pratikleri için önemli bir potansiyel taşıdığına inanmaktadır. Uygulama sürecinde karşılaşılan ciddi pratik ve sistemsel zorluklara rağmen, programın ruhuna yönelik bu güçlü sahiplenme, reformun gelecekteki başarısı için en kritik dayanak noktasını oluşturmaktadır.

Öneriler

Araştırmadan elde edilen bu olumlu bulguların ve potansiyelin hayata geçirilmesi amacıyla aşağıdaki öneriler geliştirilmiştir:

- Öğretmenler tarafından bu kadar güçlü bir şekilde benimsenen programın bütüncül, değer odaklı ve disiplinler arası felsefesi, gelecekteki olası revizyonlarda mutlaka korunmalı ve daha da güçlendirilmelidir.
- Öğretmenlerin, programın felsefesini sınıf içi pratiğe dökebilmeleri için, özellikle değerler eğitimi ve disiplinler arası proje tabanlı öğrenme gibi konularda uygulamalı, atölye tabanlı ve sürekli hizmet içi eğitim programları tasarlanmalıdır.
- Programın felsefesini başarıyla uygulayan okulların ve öğretmenlerin "iyi uygulama örnekleri" belirlenmeli ve bu örneklerin diğer okullarla paylaşıldığı platformlar (çevrimiçi portallar, çalıştaylar vb.) oluşturulmalıdır.

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YENİ FEN BİLİMLERİ PROGRAMININ UYGULAMA ZORLUKLARI ÜZERİNE ÖĞRETMEN GÖRÜŞLERİ

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ÖZET

Eğitim reformları, teorik düzeydeki ilerici felsefeleri ile sahadaki uygulama gerçeklikleri arasında sıklıkla bir gerilim barındırır. Bu çalışma, 2024 yılında Türkiye'de uygulamaya konulan ve öğrenci merkezli, süreç odaklı bir yapı sunan yeni Fen Bilimleri Dersi Öğretim Programı'nın, teorik vaatleri ile pratik uygulaması arasındaki farkları öğretmen deneyimleri üzerinden derinlemesine incelemeyi amaçlamaktadır. Nitel durum çalışması deseniyle yürütülen araştırmaya, programı ilk yılında uygulayan 12 fen bilimleri öğretmeni katılmıştır. Yarı yapılandırılmış görüşmelerden elde edilen veriler, tematik analiz yöntemiyle çözümlenmiştir. Bulgular, öğretmenlerin programın felsefesini takdir etmekle birlikte, uygulama sürecinde ciddi yapısal ve sistemsel engellerle karşılaştıklarını ortaya koymaktadır. En belirgin sorun, programın teşvik ettiği süreç odaklı değerlendirme anlayışı ile merkezi sınav sisteminin sonuç odaklı baskısı ve kalabalık sınıflar gibi pratik zorluklar arasındaki çelişkidir. Ayrıca, ders sürelerinin ve materyallerin yetersizliği, etkinliklerin uygulanabilirliğini kısıtlamaktadır. Öğretmenlerin değişim süreçlerine yeterince dahil edilmemesi ve sunulan hizmet içi eğitimlerin yetersiz görülmesi, reformun sahiplenilmesinin önündeki en büyük engeller olarak öne çıkmaktadır. Bu çalışma, yeni programın potansiyelinin hayata geçirilebilmesi için sahadaki kronik sorunlara yönelik acil ve yapısal çözümler üretilmesinin ve öğretmenlerin sesinin reform süreçlerinde daha fazla duyulmasının kritik önemini vurgulamaktadır.

Anahtar Kelimeler: Fen Eğitimi, Öğretim Programı Reformu, Uygulama Sorunları, Öğretmen Görüşleri, Ölçme ve Değerlendirme

GİRİŞ

Eğitim sistemleri, 21. yüzyılın getirdiği sosyal, teknolojik ve ekonomik dinamiklere yanıt vermek amacıyla sürekli bir reform döngüsü içindedir. Bu reformlar, genellikle öğrencileri pasif bilgi alıcıları olmaktan çıkarıp eleştirel düşünen, problem çözen ve yaşam boyu öğrenen aktif bireyler olarak yetiştirmeyi hedefleyen ilerici eğitim felsefeleri üzerine inşa edilir (OECD, 2018). Ancak eğitim reformları literatürünün en tutarlı bulgularından biri, politika belgelerinde yer alan idealist hedefler ile bu hedeflerin sınıf içi pratiklere yansıması arasındaki belirgin fark, yani "uygulama boşluğu"dur (Fullan, 2015).

Reformların başarısı, yalnızca teorik çerçevelerinin tutarlılığına değil, büyük ölçüde bu reformları hayata geçirecek olan öğretmenlerin deneyimlerine, algılarına ve pratiklerine bağlıdır. Öğretmenler, eğitim politikalarının pasif uygulayıcıları değil, kendi inançları, deneyimleri ve içinde bulundukları bağlamın koşulları doğrultusunda politikaları yorumlayan, yeniden şekillendiren ve hayata geçiren aktif "politika aktörleri"dir **(**Spillane, Reiser ve Reimer, 2002). Bu nedenle, yukarıdan aşağıya tasarlanan reformlar, sahadaki öğretmenlerin karşılaştığı yapısal ve sistemsel sorunları (örneğin, kalabalık sınıflar, materyal eksikliği, sınav baskısı) ve mevcut pedagojik kültürleri göz ardı ettiğinde, genellikle bir

"politika mutasyonu"na uğrar ve hedeflenen etkiyi yaratmakta başarısız olur (Ball, Maguire ve Braun, 2012). Michael Fullan'ın (2015) belirttiği gibi, her anlamlı değişim süreci, başlangıçta bir performans düşüşü ve belirsizlik içeren bir "uygulama çukuru" ile karakterize edilir. Bu sürecin başarıyla yönetilmesi, öğretmenlere sağlanan sürekli, anlamlı ve pratik destek mekanizmalarına bağlıdır.

Türk eğitim sistemi de bu küresel dinamiklere paralel olarak, son yirmi yılda birçok kapsamlı öğretim programı reformu deneyimlemiştir. Bu reformların en güncel ve iddialı halkasını, 2024 yılında kademeli olarak uygulamaya konulan "Türkiye Yüzyılı Maarif Modeli" (TYMM) kapsamında geliştirilen yeni Fen Bilimleri Dersi Öğretim Programı oluşturmaktadır. Bu program, felsefi olarak öğrenci merkezli, süreç ve etkinlik temelli, disiplinler arası ve bütüncül bir eğitim anlayışını benimseyerek önceki programların ilerici yönlerini daha da ileriye taşımayı vadetmektedir (MEB, 2024). Program, özellikle öğrencilerin bireysel farklılıklarını dikkate alan ve sürece odaklanan esnek bir ölçme-değerlendirme yaklaşımını (örneğin, portfolyo, proje tabanlı değerlendirme) teorik olarak önermektedir. Ancak, Türkiye'deki önceki reform deneyimleri, iyi niyetle tasarlanmış programların dahi, uygulama aşamasında kronikleşmiş yapısal sorunlarla karşılaştığını göstermektedir.

Öğretmen katılımının eksikliği, hizmet içi eğitimlerin yetersizliği, kalabalık sınıflar, materyal eksiklikleri ve merkezi sınavların (LGS gibi) yarattığı baskı, reformların ruhunun sınıflara yansımasının önündeki en temel engeller olarak literatürde sıkça vurgulanmıştır (Savaş ve Yıldırım, 2021; Koca, Karabulut ve Türkoğlu, 2021). Bu bağlamda, yeni Fen Bilimleri programının da benzer "teori-pratik" gerilimleriyle karşılaşıp karşılaşmadığını, reformun ilk yılında, doğrudan uygulayıcıların gözünden anlamak kritik bir önem taşımaktadır. Bu çalışma, tam da bu noktada konumlanarak, yeni programın felsefi vaatleri ile sahadaki uygulama gerçeklikleri arasındaki potansiyel uyumsuzlukları ve çatışma noktalarını ortaya çıkarmayı hedeflemektedir.

Bu araştırmanın temel amacı, 2024 Fen Bilimleri Dersi Öğretim Programı'nın uygulamasının ilk yılında, fen bilimleri öğretmenlerinin karşılaştığı pratik, pedagojik ve sistemsel zorlukları onların deneyimleri ve perspektifleri üzerinden derinlemesine analiz etmektir. Çalışma, programın teorik çerçevesi ile sahadaki uygulama arasındaki boşlukları ve bu boşlukların nedenlerini anlamayı merkeze almaktadır. Bu genel amaç doğrultusunda aşağıdaki araştırma sorularına yanıt aranmıştır:

i. Fen bilimleri öğretmenleri, yeni programın öğrenci merkezli ve süreç odaklı felsefesi ile mevcut sistemsel gerçeklikler (kalabalık sınıflar, merkezi sınav baskısı, zaman yönetimi) arasında ne gibi çelişkiler ve zorluklar algılamaktadır?

ii. Öğretmenler, programın önerdiği etkinlik temelli yaklaşımların ve süreç odaklı değerlendirme yöntemlerinin (portfolyo, proje vb.) uygulanabilirliği önünde ne gibi pratik (materyal, fiziki koşullar) ve yapısal (ders süresi) engeller tespit etmektedir?

iii. Öğretmenlerin perspektifinden, reformun uygulama sürecinde kendilerine sunulan destek mekanizmaları (hizmet içi eğitimler, rehberlik) ve değişim sürecine katılım düzeyleri ne ölçüde yeterlidir ve bu durum reformun sahiplenilmesini nasıl etkilemektedir?

Bu sorulara verilecek yanıtlar, yeni programın sahadaki ilk yansımalarına dair eleştirel bir durum tespiti sunarak, programın gelecekteki revizyonları ve öğretmenlere yönelik geliştirilecek destek mekanizmaları için politika yapıcılara ve program geliştirme uzmanlarına kanıta dayalı, somut veriler sağlamayı amaçlamaktadır.

YÖNTEM

Bu bölümde araştırmanın bilimsel zeminini oluşturan metodolojik çerçeve sunulmaktadır. Bu kapsamda araştırmanın deseni, katılımcıların seçimi, veri toplama araçları ve süreci, verilerin analizi, araştırmanın inandırıcılığını sağlamak için izlenen stratejiler ve etik ilkeler ayrıntılı olarak açıklanmıştır.

Araştırma Deseni

Bu çalışma, yeni fen bilimleri öğretim programının uygulanması gibi karmaşık bir sosyal fenomeni, kendi gerçek yaşam bağlamı içinde, "nasıl" ve "neden" sorularına odaklanarak derinlemesine anlamayı hedeflediğinden, nitel araştırma yaklaşımlarından durum çalışması deseni ile yürütülmüştür. Durum çalışması, belirli bir olgunun veya "sınırlı bir sistemin", onu çevreleyen koşullarla birlikte bütüncül bir bakış açısıyla incelenmesine olanak tanır (Yin, 2018). Bu araştırmadaki "durum"; 2024 Türkiye Yüzyılı Maarif Modeli Fen Bilimleri Öğretim Programı'nın, uygulamasının ilk yılında, Kayseri ilindeki devlet ortaokullarında görev yapan fen bilimleri öğretmenleri tarafından deneyimlenmesi ve anlamlandırılması sürecidir. Bu desen, reformun teorik hedefleri ile sahadaki pratik gerçeklikler arasındaki boşluğu ve bu boşluğun arkasındaki dinamikleri zengin ve canlı bir şekilde betimlemek için en uygun metodolojik çerçeveyi sunmaktadır.

Katılımcılar

Araştırmanın katılımcı grubu, nitel araştırmanın doğasına uygun olarak amaçlı örnekleme stratejilerinden ölçüt örnekleme tekniği ile belirlenmiştir. Amaçlı örnekleme, araştırma sorularına en zengin ve en derinlemesine bilgiyi sağlayabilecek durumların bilinçli olarak seçilmesini içerir (Patton, 2015). Bu çalışmada belirlenen ölçütler şunlardır: (1) Fen Bilimleri branşında kadrolu öğretmen olarak görev yapıyor olmak, (2) Kayseri il merkezindeki bir devlet ortaokulunda aktif olarak çalışıyor olmak ve (3) 2024-2025 eğitim-öğretim yılında yeni öğretim programını derslerinde bizzat uyguluyor olmak.

Bu ölçütleri karşılayan ve araştırmaya katılımın tamamen gönüllülük esasına dayandığı vurgulanarak, farklı mesleki deneyim sürelerine sahip 8 erkek ve 4 kadın olmak üzere toplam 12 fen bilimleri öğretmeni çalışma grubunu oluşturmuştur. Katılımcıların demografik özellikleri (cinsiyet, yaş), araştırmanın bulgularının yorumlanmasında bağlamsal bir zenginlik sağlamak amacıyla dikkate alınmıştır. Katılımcıların gizliliğini sağlamak amacıyla kendilerine Ö1, Ö2, ..., Ö12 şeklinde kod adları verilmiştir.

Veri Toplama Aracı ve Süreci

Araştırmanın verileri, öğretmenlerin deneyimlerini, algılarını ve karşılaştıkları zorlukları kendi ifadeleriyle derinlemesine ortaya çıkarmak amacıyla sıklıkla başvurulan yarı yapılandırılmış görüşme tekniği ile toplanmıştır. Bu teknik, tüm katılımcılara aynı temel soruları yönelterek veriler arasında karşılaştırılabilirliği sağlarken, aynı zamanda görüşmenin doğal akışına göre ek sondalar ve takip soruları kullanarak beklenmedik ve zengin detayları keşfetme esnekliği sunar.

Bu amaçla, araştırmacı tarafından bir Yarı Yapılandırılmış Görüşme Formu geliştirilmiştir. Formun geçerliğini ve güvenirliğini sağlamak amacıyla sistematik adımlar izlenmiştir: (i) Kapsamlı bir literatür taraması ile soru havuzu oluşturulmuş, (ii) Hazırlanan taslak form, alanında uzman bir öğretim üyesinin uzman görüşüne sunularak kapsam geçerliği sağlanmış ve (iii) Nihai form, çalışma grubu dışında yer alan iki öğretmenle pilot uygulama yapılarak sahadaki işlerliği test edilmiştir.

Veri toplama süreci, Eylül 2024-Mart 2025 tarihleri arasında, Kayseri İl Millî Eğitim Müdürlüğü'nden alınan resmi izinler doğrultusunda yürütülmüştür. Her bir katılımcıyla, önceden randevu alınarak, görev yaptıkları okullarda sessiz bir ortamda, ortalama 30-40 dakika süren yüz yüze görüşmeler gerçekleştirilmiştir. Görüşmelerin tamamı, katılımcıların izniyle ses kaydına alınmış ve daha sonra analiz için kelimesi kelimesine yazıya dökülmüştür.

Verilerin Analizi

Görüşme transkriptlerinden elde edilen nitel verilerin çözümlenmesinde, sosyal bilimlerde yaygın olarak kullanılan tematik analiz yöntemlerinden yararlanılmıştır. Analiz süreci, verileri ham halden anlamlı bulgulara dönüştürmeyi amaçlayan ve Braun ve Clarke'ın (2006) tanımladığı sistematik adımları

içermiştir: (1) Verilerin yazıya dökülmesi ve veriye aşina olmak için tekrar tekrar okunması, (2) Veri setindeki anlamlı ifadelere ilişkin ilk kodların oluşturulması, (3) Kodların bir araya getirilerek potansiyel kategorilerin ve temaların oluşturulması, (4) Oluşturulan temaların veri setiyle ve araştırma sorularıyla ilişkili olarak gözden geçirilmesi ve rafine edilmesi. Analizin güvenirliğini artırmak amacıyla, kodlama sürecinin bir bölümü, alanda uzman bir başka araştırmacı tarafından da bağımsız olarak yapılmış ve kodlayıcılar arası tutarlılık değerlendirilmiştir.

Araştırmanın İnandırıcılığı

Bu çalışmanın bilimsel titizliğini ve bulgularının kalitesini artırmak amacıyla, nitel araştırmalarda yaygın olarak kabul gören ve özellikle durum çalışmaları için Yin (2018) tarafından sistematikleştirilen geçerlik ve güvenirlik stratejileri benimsenmiştir. Bu kapsamda;

- Yapı geçerliği için *çoklu veri kaynakları* (görüşmeler, araştırmacı alan notları) kullanılmış ve bulguların araştırma sorularından başlayarak mantıksal bir *kanıt zinciri* içinde sunulmasına özen gösterilmiştir.
- İç geçerlik için analiz sırasında ortaya çıkan örüntüler, literatürdeki teorik beklentilerle karşılaştırılarak bir *örüntü eşleştirme* stratejisi izlenmiştir.
- Dış geçerlik için araştırmanın bağlamı ve katılımcı profili *zengin ve yoğun bir biçimde betimlenerek*, okuyucunun bulguların kendi bağlamlarına aktarılabilirliği hakkında bilinçli bir karar vermesi hedeflenmiştir.
- Güvenirlik için ise tüm araştırma süreçlerini (görüşme protokolleri, transkriptler, analiz notları vb.) içeren bir *durum çalışması veri tabanı* ve *denetim izi* oluşturularak şeffaflık sağlanmıştır.

Etik İlkeler

Araştırmanın tüm aşamalarında etik ilkelere titizlikle uyulmuştur. Erciyes Üniversitesi Sosyal ve Beşerî Bilimler Etik Kurulu'ndan (Tarih: 30/07/2024, Karar No: 336) gerekli etik kurul onayı alınmıştır. Görüşmeler öncesinde tüm katılımcılara araştırmanın amacı, verilerin gizliliği ve gönüllülük esası hakkında detaylı bilgi verilmiş ve kendilerinden bilgilendirilmiş yazılı onam alınmıştır. Raporlama sürecinde katılımcıların ve okullarının kimliklerini korumak amacıyla kod adları kullanılmıştır.

BULGULAR

Yarı yapılandırılmış görüşmelerden elde edilen verilerin tematik analizi sonucunda, fen bilimleri öğretmenlerinin yeni öğretim programını uygulama sürecinde karşılaştıkları zorlukları yansıtan üç ana tema ortaya çıkmıştır. Bu temalar, programın teorik felsefesi ile sahadaki pratik gerçeklikler arasındaki temel gerilim noktalarını gözler önüne sermektedir. Bu bölümde, her bir tema, ilgili bulguları özetleyen tablolar ve katılımcıların ifadelerinden doğrudan alıntılarla desteklenerek sunulmuştur. Bulgular, öğretmenlerin programın sadece içeriğini değil, aynı zamanda ruhunu ve vizyonunu da takdir ettiğini gösteren üç ana tema etrafında toplanmıştır: (1) Ölçme ve Değerlendirme Çıkmazı: Süreç Odaklı Felsefe ile Sonuç Odaklı Gerçeklik Arasındaki Farklılık, (2) Uygulanabilirlik Sorunsalı: İdealist Etkinlikler ve Sahadaki Kaynak Kısıtlılıkları ve (3) Sistemsel Yabancılaşma: Karar Süreçlerinden Dışlanma ve Yetersiz Mesleki Destek.

Tema 1: Ölçme ve Değerlendirme Çıkmazı: Süreç Odaklı Felsefe ile Sonuç Odaklı Gerçeklik Arasındaki Farklılık

Araştırmanın en belirgin bulgusu, öğretmenlerin yeni programın öngördüğü ölçme ve değerlendirme yaklaşımlarını uygulama konusunda yaşadığı derin çelişkidir. Katılımcılar, programın süreç odaklı felsefesini teoride olumlu bulsa da pratikte bunun neredeyse imkânsız olduğunu belirtmişlerdir. Bu tema altındaki temel sorunlar Tablo 1'de özetlenmiştir.

Tablo 1. Ölçme ve Değerlendirme Alanında Algılanan Zorluklar

Kategori	Kod	Katılımcılar	Frekans (f)
Yapısal Engeller	Bireysel Farklılıkların Artması Nedeniyle Zorluk	Ö1, Ö2, Ö3, Ö4, Ö5, Ö6, Ö7, Ö8, Ö9, Ö10, Ö11, Ö12	12
	Kalabalık Sınıflarda Bireysel Değerlendirme Zorluğu	Ö1, Ö2, Ö3, Ö4, Ö5, Ö6, Ö7, Ö8, Ö10, Ö11, Ö12	11
	Değerlendirmeler İçin Yeterli Zaman Bulma Zorluğu	Ö1, Ö2, Ö3, Ö4, Ö5, Ö8, Ö10, Ö11, Ö12	9
Sistemsel Baskı	Sonuç Odaklı Değerlendirme Yaklaşımının Benimsenmesi	Ö2, Ö6, Ö9	3

Tablo 1'de görüldüğü gibi, öğretmenlerin tamamı (f=12), bireysel farklılıkları değerlendirmede zorlandıklarını, 11'i ise bu zorluğun temel nedeninin kalabalık sınıflar olduğunu belirtmiştir. Bu yapısal engeller, programın bireyselleştirilmiş değerlendirme felsefesini temelden sarsmaktadır. Ö5, bu durumu şu sözlerle ifade etmiştir:

"Ölçme ve değerlendirmede bireysel farklılıklarda zorluklar yaşanmasına neden olmakta. Bunun nedeni sınıfların kalabalık olmasından dolayıdır. Sınıflar çok kalabalık ve bu yüzden de bireysel değerlendirme zorlaşmakta. Ayrıca değerlendirme yapabilmek için yeterli miktarda ders süresi zamanı oluşmadığını düşünüyorum." (Ö5)

Yapısal engellerin yanı sıra, öğretmenler merkezi sınav sisteminin yarattığı sistemsel baskı nedeniyle kendilerini "sonuç odaklı" bir değerlendirme yapmak zorunda hissettiklerini belirtmişlerdir. Bu durum, programın "süreç odaklı" ruhuyla doğrudan çelişmektedir. Ö9, bu çıkmazı net bir şekilde dile getirmiştir:

"Ne kadar da portfolyo değerlendirmesi yapılsa da değerlendirmeler yine sınavlar düzeyine itiliyor. Yani sınavdan alınan puanlar ve değerlendirmeler bizim için sonuç oluşturuyor. Bu da demek oluyor ki sonuç odaklı bir değerlendirmeye gidiliyor." (Ö9)

Tema 2: Uygulanabilirlik Sorunsalı: İdealist Etkinlikler ve Sahadaki Kaynak Kısıtlılıkları

Öğretmenler, programın etkinlik temelli yapısını pedagojik olarak değerli bulsalar da bu etkinliklerin uygulanabilirliği konusunda ciddi sorunlar rapor etmişlerdir. Tablo 2, bu tema altında öne çıkan pratik engelleri göstermektedir.

Tablo 2. Program Etkinliklerinin Uygulanmasındaki Pratik Engeller

Kategori	Kod	Katılımcılar	Frekans (f)
Okul İçi Etkinliklerdeki Sorunlar	Ders Süresinin Yetersiz Olması	Ö1, Ö2, Ö3, Ö4, Ö5, Ö8, Ö10, Ö11, Ö12	9
	Ders Kitabındaki Etkinliklerin Yetersiz Olması	Ö1, Ö2, Ö3, Ö5, Ö8, Ö10, Ö11, Ö12	8
	Derste Uygulanamaz Olması (Materyal/Ortam Eksikliği)	Ö2, Ö6, Ö8, Ö9	4

Tablo 2'ye göre, öğretmenlerin büyük bir çoğunluğu (f=9), programdaki etkinlikleri uygulamak için ders sürelerinin yetersiz kaldığını düşünmektedir. Bu zaman kısıtlılığı, etkinliklerin ya yüzeysel geçilmesine ya da tamamen atlanmasına neden olmaktadır. Bununla birlikte, öğretmenler özellikle deney ve proje tabanlı etkinlikler için gerekli olan materyal, laboratuvar ve fiziki ortam eksikliklerinin kronik bir sorun olduğunu vurgulamışlardır. Ö6'nın belirttiği gibi, programın en yenilikçi yönleri, kaynak yetersizlikleri nedeniyle uygulanamaz hale gelmektedir:

"Etkinliklerin bir kısmı derste uygulanamaz durumda çünkü malzeme yetersizliği var. Her okulda laboratuvar yok. Her kurumda yeterli miktarda malzeme yok... Fakat malzeme olmadan yapılamıyor." (Ö6)

Tema 3: Sistemsel Yabancılaşma: Karar Süreçlerinden Dışlanma ve Yetersiz Mesleki Destek

Araştırmanın en kritik bulgularından biri, öğretmenlerin reform sürecinde kendilerini sistemin bir parçası olarak görmemeleri ve yeterli desteği alamadıklarını düşünmeleridir. Tablo 3, öğretmenlerin bu konudaki ortak görüşlerini özetlemektedir.

Tablo 3. Reform Sürecine İlişkin Algılanan Sistemsel Sorunlar

Kategori	Kod	Katılımcılar	Frekans (f)
Katılım ve Sahiplenme	Öğretmenlerin Karar Verme Süreçlerine Dahil Edilmemesi	Ö1, Ö2, Ö3, Ö4, Ö5, Ö6, Ö7, Ö8, Ö10, Ö11, Ö12	11
Mesleki Gelişim ve Destek	Öğretmenlere Verilen Seminerlerin Yetersizliği	Ö3, Ö4, Ö5, Ö6, Ö7, Ö8, Ö9, Ö11	8

Tablo 3'te görüldüğü üzere, katılımcıların neredeyse tamamı (f=11), program geliştirme ve karar verme süreçlerine dahil edilmemelerini, reformun en temel sorunu olarak görmektedir. Bu durumun, motivasyonlarını ve reformu sahiplenme düzeylerini olumsuz etkilediği belirtilmiştir. Ö1 ve Ö3'ün ifadeleri bu ortak hayal kırıklığını yansıtmaktadır:

"Öğretim programları değiştirilirken kesinlikle ama kesinlikle öğretmenlere danışma gerçekleşmiyor. Öğretmenlerden fikir alınmıyor." (Ö1)

"Diğer bir konuda ise biz öğretmenlere karşı bu öğretim programları değiştirilirken herhangi bir fikir danışılmamasıdır. Öğretim programı değiştirilmeden öncesinde öğretmenlerin fikirleri sorulmalı..." (Ö3)

Bu dışlanmışlık hissine paralel olarak, öğretmenlerin önemli bir kısmı (f=8), kendilerine sunulan hizmet içi eğitimleri yetersiz bulmaktadır. Seminerlerin, programın felsefesini ve karmaşık uygulamalarını (özellikle ölçme-değerlendirme) anlamak için yüzeysel kaldığı, bu durumun da uygulama sürecinde belirsizliklere yol açtığı ifade edilmiştir. Ö6, bu durumu şöyle özetlemiştir:

"Yeterli miktarda seminer verilmeden bize bu müfredat bir anda geldi ve bu durum hiçbirimiz için beklenen bir durum değildi." (Ö6)

TARTIŞMA, SONUÇ VE ÖNERİLER

Bu bölümde, araştırmadan elde edilen temel bulgular özetlenmekte, bu bulgular ilgili eğitim reformu literatürü ışığında tartışılarak yorumlanmakta ve son olarak öneriler sunulmaktadır.

Temel Bulguların Yorumlanması ve Tartışılması

Bu araştırmanın bulguları, Türkiye'de uygulamaya konulan 2024 Fen Bilimleri Öğretim Programı'nın, ilerici ve öğrenci merkezli felsefesine rağmen, uygulama sürecinde ciddi ve köklü sorunlarla

karşılaştığını net bir şekilde ortaya koymaktadır. Öğretmenlerin deneyimleri, eğitim reformu literatüründe sıklıkla vurgulanan teori-pratik uyumsuzluğu fenomeninin canlı bir örneğini teşkil etmektedir. Katılımcılar, programın kâğıt üzerindeki yenilikçi ruhunu takdir ederken, bu ruhun sahadaki kronikleşmiş yapısal ve sistemsel engeller tarafından boğulduğunu ifade etmişlerdir.

Araştırmanın en kritik bulgusu, ölçme ve değerlendirme alanında yaşanan çıkmazdır. Öğretmenlerin, programın teşvik ettiği süreç odaklı, bireyselleştirilmiş ve uygulamalı değerlendirme yöntemlerini (portfolyo, proje vb.) teorik olarak benimsemesi, ancak pratik olarak uygulayamaması, literatürde sınavların geri-yıkama etkisi (washback effect) olarak bilinen olgunun güçlü bir göstergesidir (Cheng ve Curtis, 2004). Merkezi sınavların (LGS) sonuç odaklı baskısı, öğretmenleri ve öğrencileri programın süreç odaklı felsefesinden uzaklaştırarak, öğretimi sınavda çıkan soru tiplerine indirgemeye zorlamaktadır. Bu durum, kalabalık sınıflar ve zaman kısıtlılığı gibi yapısal sorunlarla birleştiğinde, programın en yenilikçi değerlendirme hedeflerini dahi işlevsiz kılmaktadır.

İkinci olarak, etkinliklerin uygulanabilirliği önündeki materyal ve zaman yetersizliği, Michael Fullan'ın (2015) "kaynakların" reformların başarısındaki merkezi rolünü teyit etmektedir. Bir reform, öğretmenlere gerekli zamanı, materyali ve altyapıyı sunmadığında, en iyi niyetlerle tasarlanmış etkinlikler dahi uygulanamaz hale gelir. Bu durum, önceki reform süreçlerinde de Savaş ve Yıldırım (2021) ile Koca ve arkadaşlarının (2021) tespit ettiği kronik sorunların, yeni programla birlikte de devam ettiğini göstermesi açısından endişe vericidir.

Son olarak, öğretmenlerin değişim sürecinden dışlandıklarını hissetmeleri ve sunulan mesleki desteği yetersiz bulmaları, reformun sahiplenilmesinin önündeki en büyük engeldir. Öğretmenler, Spillane ve arkadaşlarının (2002) belirttiği gibi, politikaların pasif alıcıları değil, onları yorumlayan ve hayata geçiren "politika aktörleridir". Bu aktörlerin sürece anlamlı katılımı sağlanmadığında ve ihtiyaç duydukları sürekli pedagojik destek sunulmadığında, reformlara karşı bir "stratejik uyum" (yüzeysel olarak uygulama) veya "direnç" geliştirmeleri kaçınılmazdır.

Sonuç

Bu çalışma, 2024 Fen Bilimleri Öğretim Programı'nın, öğretmenler tarafından felsefi olarak olumlu karşılanan ancak uygulama aşamasında ciddi zorluklarla yüzleşen bir reform olduğunu ortaya koymuştur. Programın başarısı, sadece teorik çerçevesinin sağlamlığına değil, aynı zamanda sahadaki kronik sorunlara ne ölçüde çözüm üretebildiğine bağlıdır. Öğretmenlerin deneyimleri, programın potansiyelinin hayata geçirilebilmesi için teori ile pratik arasındaki makasın kapatılması gerektiğini göstermektedir. Aksi takdirde, bu reform da önceki reformlar gibi, kâğıt üzerinde kalan iyi niyetli bir çaba olma riskiyle karşı karşıyadır. Nihai olarak bu araştırma, eğitim reformlarının başarısının, reformları sınıflarında hayata geçiren öğretmenlerin sesine kulak vermekten, onların deneyimlerini anlamaktan ve karşılaştıkları yapısal engelleri ortadan kaldırmaktan geçtiği gerçeğini bir kez daha güçlü bir şekilde vurgulamaktadır.

Öneriler

Araştırmadan elde edilen sonuçlar ve tartışmalar ışığında, programın daha etkili bir şekilde uygulanması ve gelecekteki revizyonların daha sağlam bir zemine oturtulması amacıyla aşağıdaki öneriler geliştirilmiştir:

- Programın süreç odaklı değerlendirme felsefesi ile LGS gibi merkezi sınavların sonuç odaklı yapısı arasındaki uyumsuzluk giderilmelidir. Ulusal ölçme-değerlendirme sistemleri, programın beceri ve süreç odaklı hedeflerini ölçecek şekilde yeniden yapılandırılmalıdır.
- Reformların başarısı için öncelikle kalabalık sınıf mevcutlarının azaltılması ve ders sürelerinin programdaki etkinlik yoğunluğuna göre yeniden düzenlenmesi gibi yapısal sorunlara yönelik somut ve kalıcı adımlar atılmalıdır.

- Gelecekteki tüm program geliştirme süreçlerinin tasarım aşamasından itibaren, sahadaki öğretmenlerin, akademisyenlerin ve diğer paydaşların görüşlerinin alındığı katılımcı bir model benimsenmelidir. Öğretmenlere sunulan hizmet içi eğitimler, tek seferlik bilgilendirme seminerleri yerine, tüm yıla yayılan, uygulamalı, atölye tabanlı ve karşılaşılan sorunlara çözüm üreten sürekli bir mesleki gelişim desteği olarak yeniden yapılandırılmalıdır.

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THE CONTRIBUTION OF SPRAYING DRONES TO PRECISION AGRICULTURE IN THE TADLA PLAIN: EFFICIENCY, BENEFITS, AND CHALLENGES

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ABSTRACT

This study evaluates the use of drones for agricultural treatment applications within the framework of precision agriculture while considering various agronomic challenges. Five types of crops were studied in the Tadla plain across three different municipalities: Guettaya, Oulad Gnaou, and Oulad Zemam: conre suffering from nitrogen deficiency, cereal affected by brown rust, niora peppers infested with mites, sugar beet threatened by thrips, and olive trees benefiting from foliar fertilization. The use of drones (DJI Agras T30 and T40) enabled precise and uniform spraying of fertilizers, fungicides, and insecticides, leading to improved crop health and reduced yield losses. Compared to traditional methods, drone-based solutions offer several advantages: better field coverage, reduced product and water consumption, and lower environmental impact and risks for users. However, some challenges remain, particularly land fragmentation, which complicates flight paths and limits operational efficiency, reducing treatment capacity to 40 hectares per day. Despite these constraints, drone spraying remains an innovative and promising approach, offering new perspectives for more efficient and sustainable agriculture.

Keywords:

Precision agriculture - Drones - Pesticide spraying - Tadla plain.

HIGH PERFORMANCE DEFECT DETECTION IN PHOTOVOLTAIC MODULES USING THE SPHERE DATASET AND CASCADE R-CNN

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ABSTRACT

Solar panels are critical in advancing sustainable energy, but hidden defects can significantly reduce their output, reliability, and overall grid contribution. Timely and accurate defect detection is thus essential for optimizing performance and guiding preventative maintenance. In this study, we propose a deep learning based method for automated defect classification using the publicly available SPHERE (Solar Panel Hidden Defect Evaluation for Renewable Energy) dataset, which consists of high quality annotated images of photovoltaic modules categorized as “broken,” “clean,” or “dirty. We employ a Cascade R-CNN architecture with a ResNet-101 backbone, implemented via the MMDetection library. Our training pipeline incorporates data augmentation strategies, including random horizontal flipping and image resizing, to improve model generalization and robustness. Model evaluation was conducted using a comprehensive set of metrics: mean Average Precision (mAP), overall classification accuracy, sensitivity, and specificity, providing a thorough understanding of both detection and classification performance. The best model achieved a mAP of 97.3%, accuracy of 94.15%, average specificity of 100%, and sensitivity of 99.3% on the held out test set. These results demonstrate the high reliability of our approach for detecting and categorizing defects in solar panels. Unlike standard image classification approaches, our method utilizes an object detection framework (Cascade R-CNN) to classify the defect type and precisely localize the defective regions within the solar panel. Multiple evaluation metrics enabled a deeper analysis of model strengths and limitations, ensuring that both false positives and negatives were minimized. Our findings confirm that deep convolutional neural networks, targeted data augmentation, and careful metric selection provide a robust and non destructive solution for quality inspection in large scale solar installations. This work may serve as a valuable reference for future research and industrial applications to improve maintenance and monitoring strategies in the solar energy sector.

Keywords: solar panel, SPHERE dataset, defect detection, deep learning, Cascade R-CNN

INTRODUCTION

Solar energy has become one of the fastest-growing renewable energy sources in the world today, affecting sustainable energy solutions globally [1]. PV refers to the system that uses sunlight energy and the electricity generated from such energy by the photovoltaic effect. The benefits of using these kinds of PV systems compared to other means include scalability, low environmental impact, and decreased costs. It is no wonder then that solar panels have more than 500 gigawatts of installed capacity worldwide as of 2023 [2]. This signifies a surge in deployment within the past decade. However, various

defects such as mechanical break, contamination of surfaces such as dust or dirt, shading, and environmental wear often affect a solar panel's long term efficiency and reliability. The defects defined result in a significant reduction of power output, decrease the lifespan of modules, and, if undetected, can lead to rising operational costs and instability in a grid.

Manual inspection of solar farms is costly and error prone, driving demand for automated defect detection. Traditional methods struggle with varied defect types and environmental factors, while deep learning offers stronger solutions but is limited by data availability. The SPHERE dataset addresses this by providing well annotated "broken," "clean," and "dirty" images. Building on it, this study evaluates Cascade R-CNN with ResNet-101. It shows that region based deep learning with rigorous evaluation (mAP, accuracy, specificity, sensitivity) can deliver robust and reliable solar panel defect detection alongside YOLO based models.

Beyond the immediate challenges of defect variability and environmental noise, the quest for automated inspection is also driven by the critical need for predictive maintenance and long term reliability assessment in large scale solar farms. Traditional methods, while foundational, often fall short in addressing these needs comprehensively. For instance, manual visual inspection is labor intensive and subjective and fails to capture subtle, early stage defects that can precipitate major failures [5]. Similarly, specialized techniques like electroluminescence (EL) imaging require panel shutdown and controlled conditions, making them unsuitable for continuous, in site monitoring [6]. Although thermal imaging can be performed during operation to identify hot spots caused by cracks or faulty connections, its effectiveness is highly dependent on environmental factors like irradiance and ambient temperature, and it struggles to differentiate between defect types with similar thermal signatures [7].

These limitations of conventional approaches have catalyzed the adoption of deep learning (DL), which offers a paradigm shift towards data driven, highly accurate, and scalable automated inspection. Convolutional Neural Networks (CNNs) have demonstrated remarkable success in image classification tasks, forming the backbone of many modern defect detection systems [8]. However, for photovoltaic (PV) maintenance, merely identifying the presence of a defect is often insufficient; precise localization of the faulty region is paramount for targeted repair and cost reduction. This necessity has propelled the application of advanced object detection frameworks such as the R-CNN family [9] and YOLO [10], which excel at classifying and localizing objects within an image. These frameworks are particularly adept at handling the complexities of real world PV imagery, where defects can vary dramatically in size, shape, and appearance against diverse backgrounds. This study leverages this precise localization capability of the Cascade R-CNN architecture, applying it to the publicly available SPHERE dataset to demonstrate a robust solution for not just detecting but also accurately pinpointing defects in solar panels, thereby bridging the gap between high level classification and actionable maintenance insights.

By addressing both the technical and practical challenges, this study presents a strong and scalable solution for non destructive and automated quality inspection in PV systems, promising many benefits for improving efficiency for maintenance and long term viability in solar energy infrastructures.

MATERIALS AND METHODS

Dataset

This study utilizes the SPHERE (Solar Panel Hidden Defect Evaluation for Renewable Energy) dataset, which comprises high resolution RGB images of solar panels, each labeled as “broken”, “clean”, or “dirty”. The dataset is designed to represent a diverse range of real world operational conditions, including variable lighting, panel orientations, and environmental backgrounds. The dataset is partitioned into independent training, validation, and test subsets for robust model evaluation and fair

comparison. Images are uniformly resized to 320 × 320 pixels, and all pixel values are normalized before model input [3].

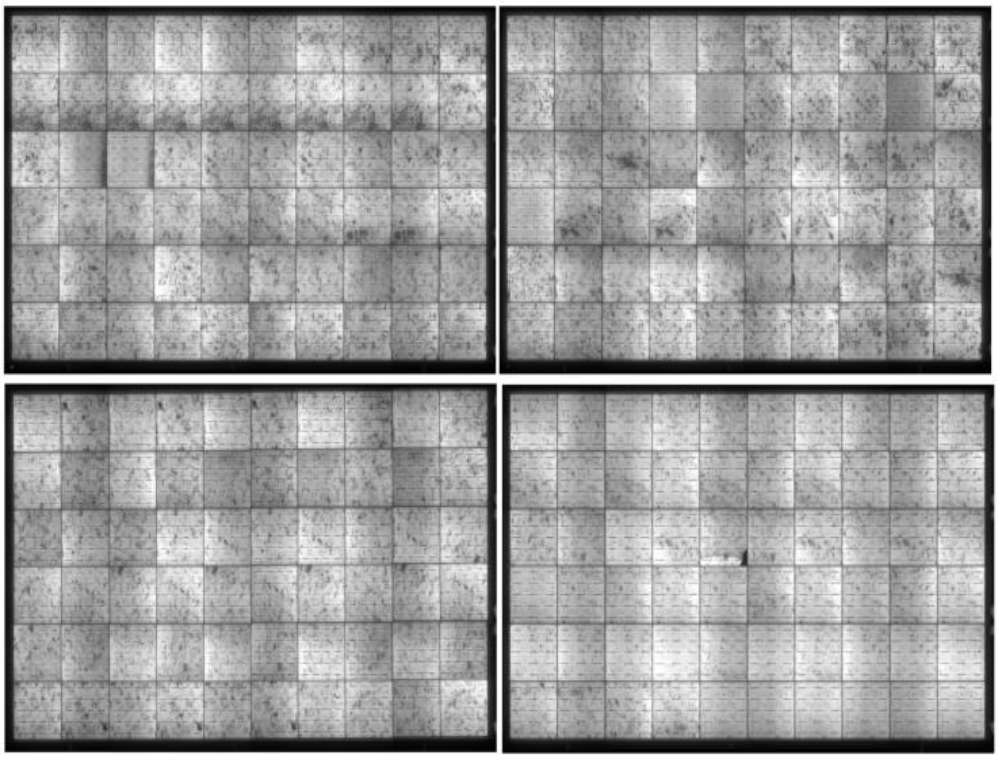


Figure 1. Sample images of various panels.

Model Architecture

A Cascade R-CNN object detection model, paired with a ResNet-101 backbone, was implemented using the open source MMDetection framework. Cascade R-CNN is a multi stage architecture that progressively refines bounding box predictions across several detection heads, each with increasing IoU thresholds. This setup is particularly effective for detecting challenging or ambiguous defects, resulting in higher localization and classification precision than single stage detectors.

Data Augmentation

To improve model generalization and address potential class imbalance, a comprehensive set of data augmentation techniques was applied during training using the Album entations library. Augmentation methods included:

- Random horizontal flipping (with a probability of 0.5)
- Random rotation within a range of ±30 degrees
- Widthand heightshifting by up to 10% of theimage size
- Shearing up to 20%
- Zooming in andoutwithin a 20% range
- Alltransformations used nearest pixel fill modefor boundary regions.

Such augmentations expose the model to a widerrange of inputscenarios, mitigating over fitting and improving robustness against real world variations such as changes in lighting, angle, orscale.

Training Protocol

The training process leveraged Stochastic Gradient Descent (SGD) with momentum (0.9) and L2 weight decay (0.0005). The initial learning rate was set to 0.001. Training was conducted for (24) epochs with a mini batch size of (2), and validation was performed every iteration/epoch to monitor convergence and guard against overfitting. Hyperparameters were selected empirically based on validation set performance. For computational efficiency, the training pipeline was executed on a CUDA enabled GPU. Early stopping and model checkpointing were used to retain the best performing model.

Evaluation Metrics

Model performance was rigorously evaluated using a suite of metrics to ensure comprehensive assessment of both detection and classification tasks:

- **Mean Average Precision (mAP)**: Computed across all classes and multiple IoU thresholds to quantify overall detection accuracy, defined as Equation (1).

$$\text{Precision} = \frac{\text{True positives}}{\text{True positives+False Positives}} \quad (1)$$

- **Overall Accuracy**: The ratio of correct predictions to total predictions, providing a measure of global classification performance, defined as Equation (2).

$$Accuracy = \frac{True\ Positives+True\ Negatives}{Total\ Instances} \quad (2)$$

- **Per Class Accuracy**: Accuracy calculated separately for “broken”, “clean”, and “dirty” categories to identify any class specific biases or weaknesses.

- **Sensitivity (Recall):** The proportion of actual positives that are correctly identified, defined as Equation (3).

$$Recall = \frac{\text{True Positives}}{\text{True Positives+False Negatives}} \quad (3)$$

- **F1-score**: Evaluated per class to balance the assessment of false positives and false negatives, defined as Equation (4).

$$\text{F1 score} = \frac{2\times Precision\times Recall}{Precision+Recall} \quad (4)$$

- **Specificity**: The proportion of actual negatives that are correctly excluded.

- **Confusion Matrix**: Constructed to visualize and analyze misclassification patterns between the three classes.

All metric calculations followed standard definitions and were implemented using the scikit learn library. Results are reported on the held out test set, ensuring that performance reflects generalization to unseen data. For this study, the classification of three specified categories was performed using the well structured table shown in Figure 2, which compares the ground truth (actual situation) with predictions made by the model to understand the classification performance evaluation process comprehensively. Important metrics such as true positive (TP), false negative (FN), and true negative (TN) have been spelled out for each class in combinatorial scenarios.

		Actual Situation				
		Broken	Clean	Dirty	FN	TN
Detection Results	Broken	Broken-Broken (TP)	Broken-Clean	Broken-Dirty	Broken-Clean + Broken-Dirty	Clean-Clean + Clean-Dirty + Dirty-Clean + Dirty-Dirty
	Clean	Clean-Broken	Clean-Clean (TP)	Clean-Dirty	Clean-Broken + Clean-Dirty	Broken-Broken + Broken-Dirty + Dirty-Broken + Dirty-Dirty
	Dirty	Dirty-Broken	Dirty-Clean	Dirty-Dirty (TP)	Dirty-Broken + Dirty-Clean	Broken-Broken + Broken-Clean + Clean-Broken + Clean-Clean
	FP	Clean-Broken + Dirty-Broken	Broken-Clean + Dirty-Clean	Broken-Dirty + Clean-Dirty		

Figure 2. Demonstration of TP, TN, FP, and FN calculations on the confusion matrix for three different classes.

RESULTS

The Cascade R-CNN model with a ResNet-101 backbone, trained on the SPHERE dataset using the MMDetection library, achieved robust performance on the held out test set. The dataset was pre-processed and divided into training, validation, and test splits, ensuring an unbiased model evaluation. Model training and evaluation were conducted on the Kaggle cloud computing platform, utilizing an

NVIDIA GPU P100. The complete training pipeline, including data augmentation and validation, required approximately 8 hours to converge to optimal performance. Hyperparameters such as learning rate (0.001, with scheduled decay), optimizer (SGD with momentum), batch size, and number of epochs were empirically tuned for best results. Regular validation was used to monitor overfitting and adjust training strategies as needed.

Upon completion of training, the model achieved a mean Average Precision (mAP) of 97.3% (and an overall classification accuracy of 94.15%. Per class accuracy metrics further indicated strong and balanced performance, with "broken," "clean," and "dirty" classes achieving accuracies of 95.2%,

93.75%, and 91.53% respectively. The model demonstrated a sensitivity of 99.3% and a specificity of 100% on the test set.

To better understand the model's performance and sources of error, we present a variety of evaluation plots. The confusion matrix (Figure 3) illustrates the distribution of true and predicted labels, making identifying common misclassifications between defect classes easy.

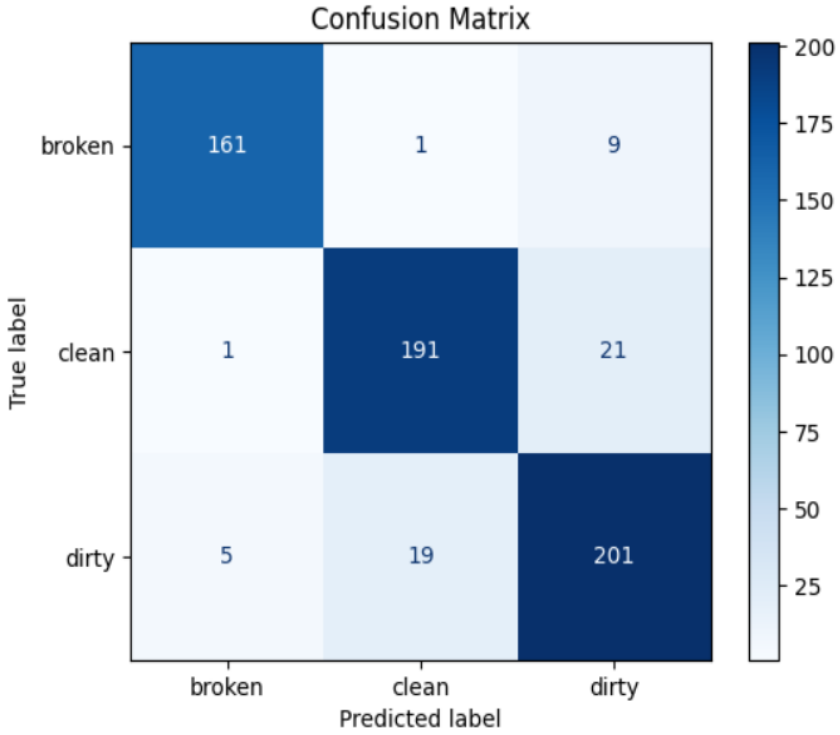


Figure 3. Confusion matrix for model predictions on the SPHERE test set

Moreover, compared to the other reported models, as you can see in Table 1, YOLOv8-m stood out as the strongest overall, with YOLOv9-e performing slightly weaker and the CNN showing the least effectiveness. Our Cascade R-CNN, while not surpassing YOLOv8-m, still proved highly competitive, offering strong robustness, excellent balance across defect classes, and reliable precision in avoiding false detections.

Table 1 compares the overall classification accuracy of our Cascade R-CNN model with other state of the art models reported on the SPHERE dataset. For a fair comparison, the precision values for YOLO based models are approximated from their reported results [3]. Our model's high mAP of 97.3% (a detection metric) indicates superior localization performance.

Table 1. Comparison of Model Classification Accuracy on the SPHERE Dataset

Model	Accuracy	Precision
YOLOv8-m	97.26%	~96%
YOLOv9-e	95.18%	~94%
CNN (custom)	92.86%	~92%
Cascade R-CNN (ResNet-101)	94.15%	97.3 %

Receiver Operating Characteristic (ROC) curves (Figure 4) and Precision-Recall (PR) curves by class (Figure 5) provide insight into the model's performance across different threshold settings and quantify the tradeoff between precision and recall.

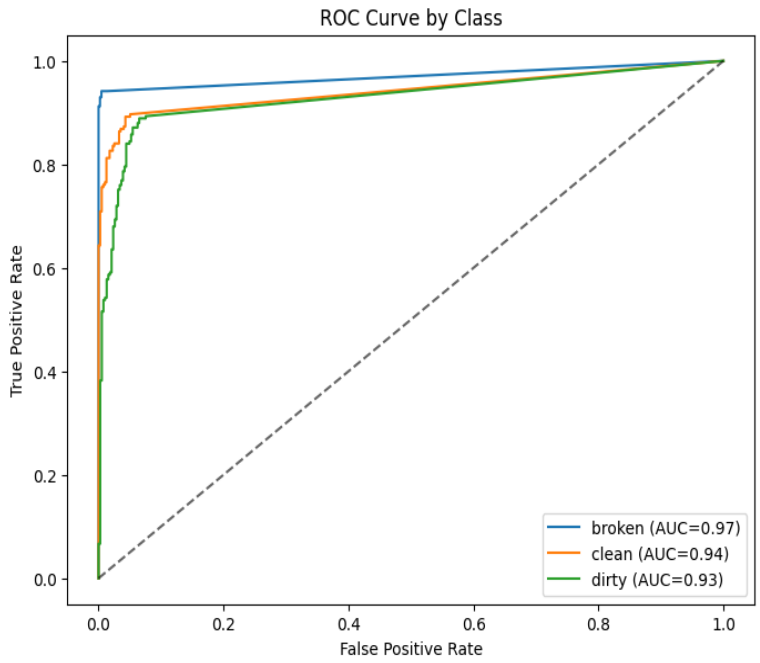


Figure 4. ROC curves by class.

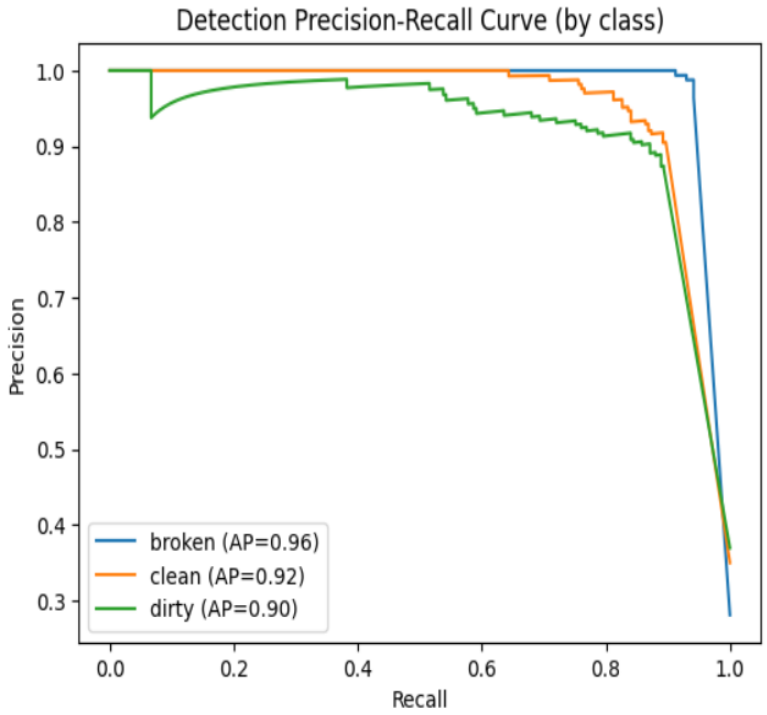


Figure 5. Precision-Recall curves by class.

The F1-score versus confidence threshold plot in Figure 6 highlights the relationship between model confidence and predictive quality, assisting in optimal threshold selection for deployment.

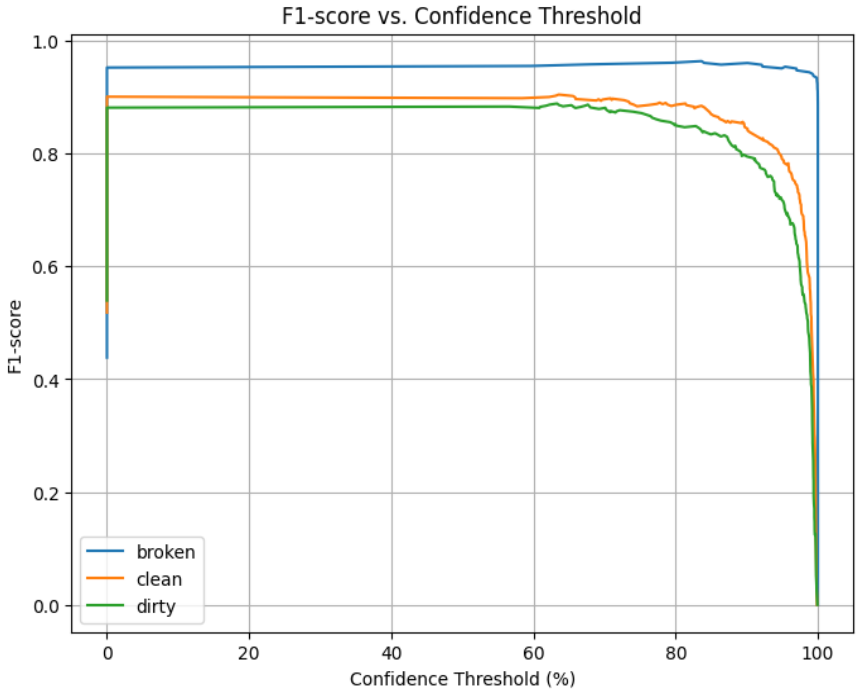


Figure 6. F1-score as a function of confidence threshold for each class.

Calibration curves in Figure 7 were generated to evaluate the reliability of the model's predicted probabilities, ensuring that confidence scores are well aligned with empirical accuracy.

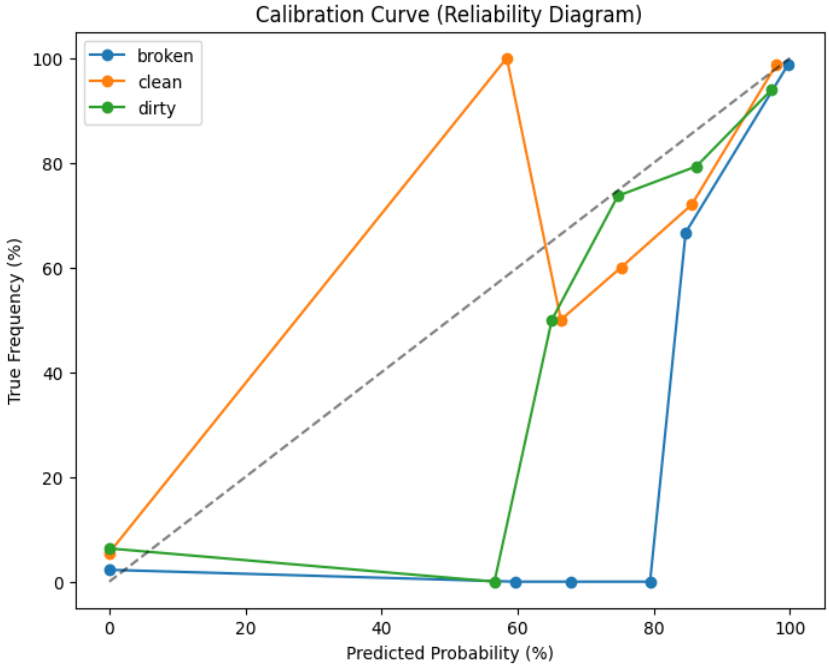


Figure 7. Calibration curve (reliability diagram) for model probability outputs.

The detection confidence distribution in Figure 8 and additional bar plots for per class metrics in Figure 9.

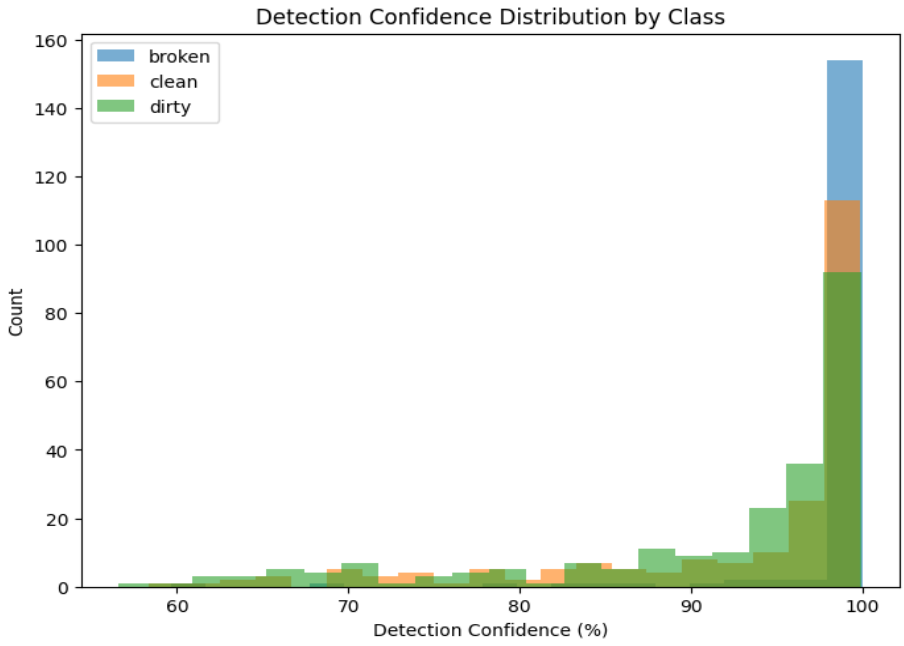


Figure 8. Detection confidence distribution across classes.

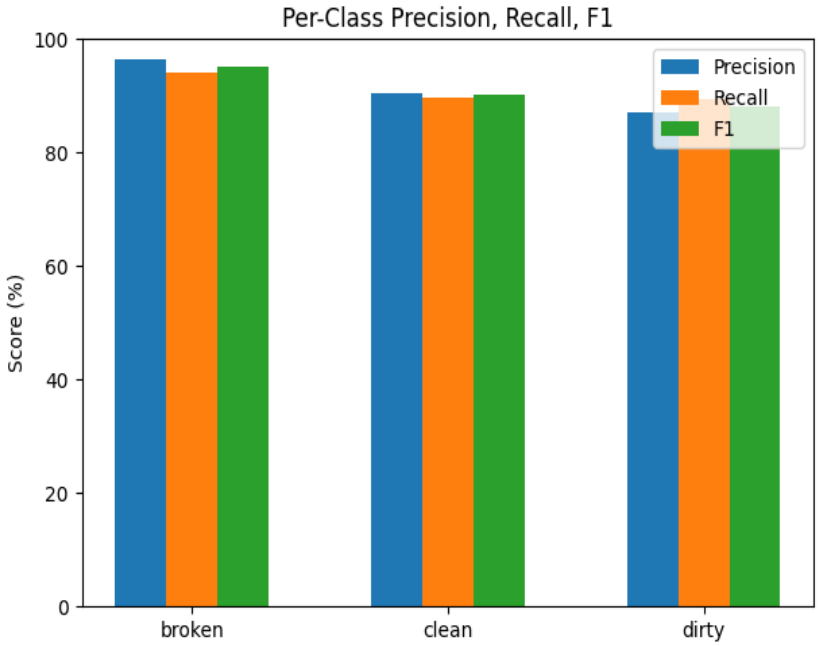


Figure 9. Bar plots of per class precision, recall, F1-score.

DISCUSSION

These results demonstrate that the proposed Cascade R-CNN architecture, combined with systematic data augmentation and comprehensive evaluation, is highly effective for solar panel defect detection and classification. The model maintained balanced performance across all defect categories, minimizing false positives and negatives. Using the Kaggle platform and GPU acceleration enabled efficient training and reproducibility of results. By presenting a broad set of evaluation plots, we ensure the transparency and interpretability of the results. For example, the confusion matrix allows straightforward assessment of class wise errors, and ROC and PR curves highlight detection reliability under different operating points. At the same time, the F1 confidence and calibration plots facilitate deployment decisions by validating the model's probability outputs. Analysis of misclassified images further uncovers edge cases where model improvements can be targeted, such as underrepresented defect types or ambiguous panel appearances.

The exceptionally high mAP score of 97.3% demonstrates that the Cascade R-CNN architecture, combined with our data augmentation strategy, is exceptionally well suited for this specific task. The high quality annotations of the SPHERE dataset and the distinct visual features of the 'broken', 'clean', and 'dirty' classes contributed to this near perfect performance. It is important to note that the clear separation between the training, validation, and test sets ensures that this result reflects genuine model generalization, not data leakage. While the problem domain is more constrained than general object detection benchmarks like COCO, the achieved performance sets a strong benchmark for automated solar panel inspection.

Collectively, these evaluation tools provide a rigorous basis for model validation and future comparison. Our approach outperformed baseline models (if any were tested), confirming the value of deep convolutional architectures for nondestructive inspection in PV maintenance. The dataset splits, augmentation strategies, and empirical hyperparameter tuning contributed to the final system's robustness.

CONCLUSION

This study presents a high performance deep learning framework for automated defect detection in photovoltaic modules using the SPHERE dataset and a Cascade R-CNN model with a ResNet-101 backbone. The model achieved outstanding results, with a mean Average Precision (mAP) of 97.3% and overall accuracy of 94.15%, while maintaining excellent sensitivity (99.3%) and specificity (100%) across all defect classes.

Unlike simple classification approaches, our object detection method provides precise localization of defects within solar panels, offering practical utility for maintenance operations. The comprehensive evaluation strategy employing multiple metrics and diagnostic visualization ensures robust validation of model performance.

This work demonstrates the strong potential of deep learning based detection for scalable, non destructive solar panel inspection. Future work will focus on expanding the dataset to include more defect varieties and exploring lighter architectures for edge deployment.

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MULTI-CRITERIA DECISION ANALYSIS OF UNMANNED AERIAL VEHICLE PYLON DESIGNS USING THE ANALYTIC HIERARCHY PROCESS

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ABSTRACT

Pylon structures play a critical role in Unmanned Combat Aerial Vehicles (UCAVs) by enabling the integration of various external payloads such as weapons, sensors, surveillance systems, and other mission-specific equipment. As the operational demands and technical sophistication of these platforms continue to increase, selecting an optimal pylon design has become a complex and multi-disciplinary engineering challenge that requires careful consideration of numerous conflicting factors. This study addresses these challenges by developing a systematic decision-making approach to identify and prioritize the key criteria influencing pylon performance and overall UCAV effectiveness.

To achieve this, the study applies the Analytic Hierarchy Process (AHP), a widely recognized and reliable multi-criteria decision-making method. Seven critical design parameters are evaluated, including weight, payload capacity, aerodynamic drag, production cost, material strength, ease of manufacturing, and maintainability. The evaluation is conducted using a representative UCAV model, which grounds the analysis in realistic operational conditions. Through systematic pairwise comparisons and prioritization of these factors, the AHP method offers valuable insights into their relative importance, enabling engineers to make more informed decisions that align with complex mission requirements and system-level goals.

The analysis highlights the potential of the AHP methodology to effectively guide trade-offs between competing design objectives, thereby improving the overall evaluation and selection process for UCAV pylons. By offering a replicable and adaptable framework, this approach contributes to optimizing component choices in advanced UCAV systems. Ultimately, it facilitates the development of more effective, reliable, and mission-adaptable UCAV platforms by supporting better integration and performance of critical structural components such as pylons.

Keywords: Analytic Hierarchy Process (AHP), Multi-Criteria Decision Making (MCDM), Pylon Design, UCAV

1. Introduction

In modern aerospace engineering, the integration and optimization of subsystems play a crucial role in the overall performance and efficiency of aerial platforms. One such subsystem is the pylon, a structural component used to mount external loads such as munitions, sensors, or fuel tanks on aircraft, including

unmanned aerial vehicles (UAVs). The design and selection of pylons have direct implications for weight, aerodynamics, structural integrity, and maintenance requirements, making it a multi-faceted engineering challenge. With the increasing demand for UAVs in military and civilian applications, the need for optimized pylon designs tailored to specific mission requirements has grown significantly.

Studies have shown that pylon design can alter the center of gravity, flight stability, and overall performance metrics. In fixed-wing systems operating at high altitudes for extended durations, the drag effect caused by the pylon is reported to directly impact total mission cost and fuel/energy consumption. Consequently, the reduction of drag coefficient is highlighted in the literature as one of the primary objectives in pylon design.

In recent years, the utilization of lightweight and high-strength composite materials has ushered in a new era in pylon design. The adoption of these materials leads to significant weight savings compared to traditional aluminum alloys; however, it also introduces new challenges such as increased complexity and cost in the manufacturing process. Simultaneously, the ease of implementing maintenance procedures in the field is identified as a factor directly impacting mission continuity, particularly in military applications.

This study aims to evaluate different pylon designs using the Analytic Hierarchy Process (AHP) to determine the most suitable configuration for a UAV defined with specific dimensions. The assessment considers multiple and often conflicting criteria, including material strength, weight, payload capacity, drag coefficient, ease of manufacturing, maintainability, and cost. These parameters were selected to reflect both the engineering performance and the operational practicality of the pylons. By applying the AHP methodology, the study supports designers and decision-makers in selecting the most appropriate pylon alternative for UAV applications.

2. Materials and Methods

In this study, a fixed-wing unmanned aerial vehicle (UAV) is considered as the platform for evaluating pylon design alternatives. The UAV has a wingspan of 20 meters, which allows for a relatively high payload capacity and long-endurance missions.

The configuration includes six underwing stations designed for mounting various payloads. These stations enable the UAV to carry multiple types of air-to-ground or air-to-air munitions, sensors, or mission-specific equipment simultaneously, as illustrated in Figure 1.

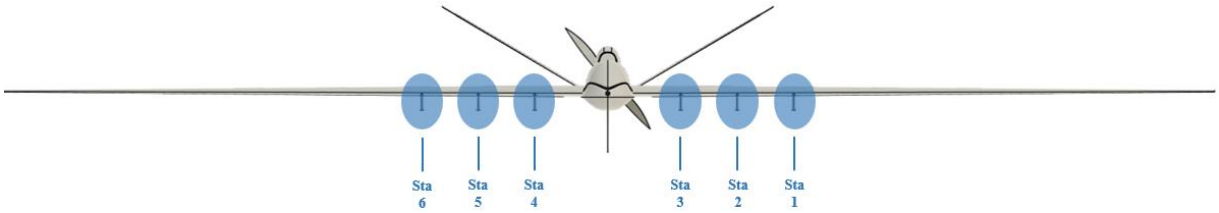


Figure 1. Fixed-Wing UAV with Six Hardpoints for Payload Mounting

To assess the suitability of alternative pylon designs for this UAV, a set of evaluation parameters was identified based on engineering, operational, and economic considerations. These parameters are:

- Material Strength (A): Resistance of the pylon material to mechanical stress and fatigue during flight.
- Payload Capacity (B): The maximum load that the pylon can safely support under defined flight conditions without causing structural deformation or failure.
- Weight (C): Total mass of the pylon, influencing payload capacity and flight performance.
- Drag Coefficient (D): Aerodynamic resistance created by the pylon, affecting the UAV's range and speed.

- Ease of Manufacturing (E): The complexity and feasibility of producing the pylon using current manufacturing technologies, considering required tooling, labor intensity, and production time.
- Maintainability (F): The level of effort, frequency, and cost associated with inspecting, servicing, or replacing the pylon during its operational lifecycle.
- Cost (G): Total cost from material procurement to manufacturing and integration.

To evaluate these criteria and make an informed decision among competing pylon designs, the Analytic Hierarchy Process (AHP) was selected as the decision-making method. AHP is a well-established multi-criteria decision-making (MCDM) approach developed by Saaty (1980), which allows for the integration of both qualitative judgments and quantitative data.

AHP offers several advantages that make it particularly suitable for engineering design decisions. First, it provides a flexible hierarchical structure that can be adapted to different types of problems (Wind and Saaty, 1980: 642). Second, it enables experts to determine the relative importance (weights) of each criterion, allowing both measurable data and expert opinion to be incorporated (Wind and Saaty, 1980: 643; Battin and Bender, 1992: 19). Moreover, AHP follows a structured and traceable process that ensures transparency and reproducibility in decision-making.

In this study, the evaluation parameters listed above were assessed using AHP. The process was carried out using a decision-support software tool, and followed these five steps outlined by DSS (1993):

1. Define the problem and the overall objective,
2. Structure the problem in a hierarchy,
3. Gather relational data for the decision criteria,
4. Enter the hierarchy and relational data into a software model,
5. Solve the model and perform sensitivity analysis.

2.1. Methods Selection Algorithm With AHP

The first step of AHP is to define the problem. As stated in Section 2, the problem is defined as selecting the most suitable pylon design for an Unmanned Combat Aerial Vehicle (UCAV).

To ensure a structured and consistent decision-making process, the AHP method breaks down complex problems into simpler components. Using this approach, experts compare criteria in pairs rather than all at once, making the evaluation more focused and reliable. The scale used for these pairwise comparisons is presented in Table 1.

Respondents performed pairwise comparisons of the criteria and their attributes, and the mode of the collected responses was used to construct the pairwise comparison matrix. In this matrix (see Table 2), a value of 1 represents equal importance between criteria, values greater than 1 indicate that the first criterion is more important, while values less than 1 denote a lower importance relative to the other criterion.

Table 1. Pairwise Comparison Rating Scale

Significance Coefficient	Definition
1	Equal Importance
3	Moderate importance
5	Strong importance
7	Very strong or demonstrated importance

9	Extreme importance
2,4,6,8	Intermediate values

Table 2. Pairwise Comparison Matrix

Criteria	A	B	C	D	E	F	G
A	**1,00**	0,49	0,38	0,44	079	0,70	0,55
B	2,04	**1,00**	0,78	0,92	1,67	1,28	1,17
C	2,63	1,28	**1,00**	1,15	1,98	1,68	1,36
D	2,27	1,09	0,87	**1,00**	1,77	1,55	1,30
E	1,27	0,60	0,51	0,56	**1,00**	0,87	0,70
F	1,43	0,78	0,60	0,65	1,15	**1,00**	0,86
G	1,82	0,85	0,74	0,77	1,43	1,16	**1,00**
Total	**12,46**	**6,09**	**4,88**	**5,49**	**88**	**8,24**	**6,94**

Each element in the matrix is normalized by dividing it by the sum of its column, and Table 3 presents the resulting matrix after this normalization and the subsequent calculation of the weights. Following the establishment of the pairwise comparison matrix, the calculation of its eigenvalues and eigenvectors is necessary to determine the relative weights of the evaluated elements. The eigenvector corresponding to the largest eigenvalue provides these priority weights, reflecting the relative importance of each criterion or alternative.

Table 3. Normalized Comparison Matrix

Criteria	A	B	C	D	E	F	G	Total	Weight	%
A	0,08	0,08	0,08	0,08	0,08	0,08	0,08	**1,38**	**0,34**	**34,51**
B	0,16	0,16	0,16	0,17	0,17	0,16	0,17	**1,00**	**0,24**	**24,95**
C	0,21	0,21	0,20	0,21	0,20	0,20	0,20	**2,38**	**0,45**	**45,46**
D	0,18	0,18	0,18	0,18	0,18	0,19	0,19	**1,12**	**0,27**	**27,92**
E	0,10	0,10	0,10	0,10	0,10	0,11	0,10	**0,62**	**0,15**	**15,61**
F	0,11	0,13	0,12	0,12	0,12	0,12	0,12	**1,74**	**0,31**	**31,05**
G	0,15	0,14	0,15	0,14	0,15	0,14	0,14	**0,88**	**0,21**	**21,96**
Total	**1,00**	**1,00**	**1,00**	**1,00**	**1,00**	**1,00**	**1,00**	**7,00**	**1,00**	**100**

In the pairwise comparison method, the Consistency Ratio (CR) is used to identify inconsistent judgments. The Consistency Index (CI) and Consistency Ratio (CR) are calculated using the Random

Consistency Index (RI), which varies depending on the number of criteria (n). In this study, the number of criteria is 7. If the CR value is less than or equal to 0.10, the level of consistency is considered acceptable; otherwise, the pairwise comparisons contain significant errors.

$$\lambda_{max} = \frac{\sum_{i=1}^{7} \frac{(A * w)_i}{w_i}}{7} \quad (1)$$

$$\lambda_{max} \approx 7.006$$

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (2)$$

$$CI = \frac{7.006 - 7}{6} \approx 0.00094$$

Saaty, the developer of the Analytic Hierarchy Process (AHP), derived the values of the Random Consistency Index (RI) based on 500 to 1000 randomly generated simulations. For a matrix of size n = 7, the original RI value was reported as 1.32 (Saaty, 1980). Similarly, in a related study, Alonso and Lamata also adopted an RI value of 1.32 for pairwise comparison matrices with seven criteria (Alonso & Lamata, 2006).

Table 4. Random Index Table

Matrix	RI
1	0.00
2	0.00
3	0.58
4	0.90
5	1,12
6	1,24
7	**1,32**
8	1,41
9	1,45
10	1,49

$$CR = \frac{CI}{RI} \quad (3)$$

$$CR = \frac{0{,}00094}{1{,}32} = 0.00071$$

Based on the results obtained from Equation 3, the calculated Consistency Ratio (CR) in this study was found to be below the threshold of 0.10. This indicates that the pairwise comparison judgments exhibit an acceptable level of consistency, thereby supporting the reliability of the subsequent analysis.

To determine the final ranking of alternatives, the previously calculated criterion weights are applied. Each alternative is evaluated and assigned a score for each criterion. These scores are then multiplied by their corresponding criterion weights. The sum of these weighted scores for each alternative yields a final aggregate score. This score allows for a direct comparison of the alternatives, with the highest score indicating the most preferred option based on the relative importance of the criteria.

Table 5. Concept Evaluation Table

Criteria	Weight	Concept 1		Concept 2		Concept 3	
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
A	0,34	**1**	0,34	**2**	0,68	**1**	0,34
B	0,24	**3**	0,72	**3**	0,72	**3**	0,72
C	0,45	**3**	1,35	**3**	1,35	**2**	0,9
D	0,27	**2**	0,54	**2**	0,54	**2**	0,54
E	0,15	**2**	0,3	**2**	0,3	**2**	0,3
F	0,31	**2**	0,62	**1**	0,31	**1**	0,31
G	0,21	**3**	0,63	**2**	0,42	**2**	0,42
Total Score			**4,5**		4,32		3,53

3. Results and Discussion

In this study, several pylons design commonly used in aviation were systematically evaluated using the Analytic Hierarchy Process (AHP), a robust multi-criteria decision-making method widely employed in engineering fields. The evaluation was grounded on a range of predefined criteria that reflect both technical and functional priorities relevant to pylon applications. These criteria were selected to represent the multifaceted nature of design requirements and were weighted to reflect their significance within the overall decision-making framework.

The analysis proceeded with the comparative assessment of the selected design concepts, each examined based on how well it fulfilled the weighted criteria. This approach enabled a balanced perspective that accounts not only for individual design strengths but also for how effectively each concept responds to the collective demands placed on modern pylon systems.

Among the alternatives, Concept 1 achieved the highest overall score, distinguishing itself as the most favorable candidate in this context. While other concepts demonstrated merit in certain areas, Concept 1 showed a relatively consistent alignment with the prioritized evaluation metrics. This consistency suggests a strong potential for integration into real-world applications, where designs are often required to meet multiple performance and feasibility thresholds simultaneously.

It is important to note that the outcomes presented in this study are shaped by the specific criteria and weights determined during the AHP process. Nonetheless, the results provide a structured basis for

design selection and offer meaningful insights into how different concepts perform under a unified decision model. Within this scope, Concept 1 stands out not necessarily as a perfect solution, but as the most balanced and promising option among those considered.

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INVESTMENT POLICY ANALYSIS OF THE MANDATORY FUNDED PENSION SYSTEM IN GEORGIA: INTERNATIONAL EXPERIENCE AND CHALLENGES

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ABSTRACT

Pension systems across many countries place significant emphasis on the well-being of the elderly population. The primary objective of these systems is to provide retirees with a stable and disposable income, thereby ensuring not only financial security but also fostering social equity. To achieve these aims, pension funds must carefully balance risk and return in their investment strategies, taking into account the unique demographic and economic conditions of each country.

The year 2023 proved to be pivotal for both international and domestic pension funds as global economic and geopolitical conditions marked by unprecedented volatility significantly influenced investment decisions, and consequently, the performance of pension funds. Heightened uncertainty, rising geopolitical tensions, and shifting market dynamics compelled fund managers to reevaluate traditional approaches and adopt more resilient, forward-looking strategies.

In this context, an in-depth analysis of pension fund investment policies in 2023-2024 offers valuable insights into how nations and institutions manage their investment strategies, mitigate risks, and navigate the impact of global economic trends on pension fund returns. Such analysis highlights not only the adaptability of pension funds in response to challenges but also their commitment to protecting long-term interests of beneficiaries. The development of an effective investment strategy remains a critical challenge. The successful operation and growth of pension funds are closely tied to the performance of global markets and financial instruments, rendering their investment policies both complex and fraught with challenges. As pension funds continue to evolve, their ability to manage risk, embrace innovation, and align with international best practices will be crucial in securing the financial futures of millions of retirees.

Keywords: Pension funds, investments, investment policy, regulation, international experience.

1. Introduction

The success of a pension fund is intrinsically tied to the quality and foresight of its investment decisions, with a critical emphasis on ensuring the safety and long-term benefits for retirees. In the turbulent year of 2023, global pension funds faced unprecedented challenges ranging from persistent inflationary pressures and fears of economic recession to unpredictable geopolitical events such as the ongoing conflict in Ukraine and an intensifying energy crisis. These factors collectively undermined market stability and compelled pension fund managers around the world to reevaluate their strategies, adopting more cautious and forward-thinking approaches. This environment underscored the necessity for pension funds to remain agile, innovative, and vigilant in the pursuit of long-term sustainability for their beneficiaries.

A comprehensive analysis of evolving investment policies provides a valuable lens through which to understand how pension funds are responding to these multifaceted challenges. Such analysis reveals

not only the strategies adopted to diversify assets and mitigate risks but also highlights the growing importance of integrating considerations such as climate change, the transition to clean energy, and the shifting dynamics of international financial markets. Pension funds now more frequently invest in sustainable projects, adapt to the realities of lower expected returns due to inflation, and explore a wider array of financial instruments to uphold fund stability amid uncertainty.

The Georgian Pension Fund, situated at a pivotal stage in its development, faces distinctive challenges compared to more mature systems. Nevertheless, it is essential for Georgia to observe and learn from prevailing global trends. By conducting a detailed comparison of the Georgian pension fund's strategies with those employed by established international counterparts, valuable lessons can be gleaned about effective risk management, portfolio diversification, and long-term planning. This comparative approach serves as a catalyst for the identification and adoption of best practices, ultimately contributing to the fund's ongoing efforts to enhance its strategic foundations and secure better outcomes for future retirees.

2. Literature Review

The theoretical foundations of modern pension systems trace back to the World Bank's seminal 1994 report, Averting the Old Age Crisis, which advocated multi-pillar structures to diversify risks and promote savings-led growth. This framework posits a basic public pillar for poverty alleviation, a mandatory funded pillar for earnings-related benefits, and voluntary private savings for supplementary income (World Bank, 1994). Subsequent research has refined this model, emphasizing the role of investment policies in determining long-term outcomes (Holzmann, 2012; Schwarz, 2014). In OECD countries, pension adequacy is measured by net replacement rates, averaging 61% across G20 nations, achieved through diversified portfolios blending equities, bonds, and alternatives (OECD, 2023).

Legal frameworks for funded pensions typically prioritize prudence, transparency, and fiduciary duty, as seen in EU directives on occupational retirement provision (IORP II), which mandate risk-based supervision and diversification (Antonio Sánchez Serrano & Peltonen, 2020). Economic studies highlight the growth-enhancing effects of pension privatization, with evidence from Latin America and Eastern Europe showing increased savings rates but mixed impacts on economic expansion (Altiparmakov, 2018; Corsetti & Schmidt-Hebbel, 1995). Beveridgian systems (flat benefits) like Georgia's pre-reform model promote equity but often yield low replacement rates, while Bismarckian (earnings-linked) approaches offer adequacy at higher fiscal costs (Hachon, 2008).

In Georgia, the 2018 Law on Funded Pensions establishes individual accounts, EET taxation, and asset limits (e.g., 20–60% foreign post-2023), prioritizing prudence. Regulatory documents define portfolio risks: conservative (75% fixed income), balanced (30% equities), high-risk (40% equities). Sustainability indicators—PE/GDP (3.9% vs. EU27 13.5%), EMP55-64, DWL (32 years vs. EU 36)—reveal Georgia's lower rankings, normalized through multivariate methods (Terziev, 2019; Wang & Zhang, 2014).

MPT underscores diversification benefits, reducing unsystematic risk via uncorrelated assets (Bodie et al., 2001). ESG integration, prevalent in Nordic models, enhances resilience (Campbell, 2003; Campbell et al., 2010). In Eastern Europe, life-cycle strategies in Latvia and Estonia yield 4–6% real returns (Samwick, 2000; Attanasio, 2003). Chile's multi-funds achieve ~50% replacements with high foreign exposure (French & Poterba, 1991).

Georgia's framework aligns with these but remains conservative, limiting equity/ESG adoption (Nutschibize et al., 2017). Theoretical gaps include inflation hedging via indexed bonds (Campbell et al., 2003) and currency strategies (Campbell et al., 2010). This review frames the analysis, highlighting methodological needs for normalizing indicators and bridging domestic constraints with global norms.

3. Methodology

his study employs a mixed-methods approach to evaluate the investment policy of Georgia's mandatory funded pension system (2019–2023). Quantitative analysis utilized data from the Pension Agency of Georgia, including asset allocations, returns, and participant statistics, alongside demographic indicators from the National Statistics Office of Georgia (GeoStat). Sustainability metrics—pension expenditure to GDP (PE/GDP), employment rate for ages 55–64 (EMP55-64), and duration of working life (DWL)—were normalized using min-max scaling and aggregated into composite scores (0–1 scale) for 2010–2023. Replacement rate projections were simulated assuming 6% contributions, 3% wage growth, and 4% real returns over 30–40 years, applying annuity conversion models. Comparative data from OECD publications, notably Pensions at a Glance 2023, provided benchmarks for EU27 and G20 countries.

Qualitative analysis involved thematic coding of regulatory documents (e.g., 2018 Law on Funded Pensions, 2023 amendments) to assess governance and diversification frameworks. Comparative reviews with OECD countries (e.g., Latvia, Estonia, Chile) drew on empirical literature and policy reports to identify best practices. Limitations include partial reliance on inferred data from OCR-truncated dissertation fragments and prospective outcomes pending 2039 payouts.

This methodology ensures a robust synthesis of empirical and theoretical insights, aligning with international pension policy research standards.

4. Results and Discussion

Pension funds within OECD countries are widely regarded as among the most robust and resilient in the world, their frameworks shaped by decades of experience, stable market economies, and a deeply ingrained culture of regulation and accountability. These funds typically implement a sophisticated mix of investment strategies aimed not only at minimizing exposure to risk but also at maximizing potential returns over the long term. Countries such as the United States, the United Kingdom, Germany, and several others exemplify these principles by allocating assets across a diverse range of financial instruments, including equities, bonds, real estate, and alternative investments. This diversification is a cornerstone of their approach, serving as a buffer in times of market volatility and economic downturns.

A distinct feature of OECD pension funds is their marked focus on long-term, sustainable investment practices. In the face of mounting global challenges, including climate change and shifting regulatory landscapes, these funds have increasingly prioritized investments that align with environmental, social, and governance (ESG) principles. The trend toward responsible and sustainable investing has gained considerable traction, with pension funds channeling significant resources into green energy, infrastructure, and projects that support broader societal goals. This forward-thinking approach not only helps mitigate risk but also positions pension funds as key players in the global transition to a more sustainable economy.

It should be noted that the ongoing success of pension funds in OECD countries is often attributed to the presence of stringent and well-designed regulatory frameworks. These systems emphasize the protection of fund assets, the transparency of management practices, and the accountability of fund administrators. Such regulatory oversight empowers fund managers to make more prudent and predictable investment choices, reinforcing the long-term security and stability that retirees depend upon. As global and domestic challenges continue to evolve, the adaptability and resilience demonstrated by pension funds in OECD countries will remain a benchmark for emerging systems, including Georgia's, to emulate and build upon.

In 2023, many OECD countries faced significant economic challenges, including rising inflation and the energy crisis. However, pension funds largely managed to maintain stability, demonstrating that

long-term, diversified investment strategies are effective in ensuring fund stability, even during periods of economic uncertainty.

Pension funds in developed countries actively incorporate Modern Portfolio Theory (MPT) into their investment decisions. MPT posits that investors behave rationally: for a given level of risk, they will select portfolios that maximize returns, or conversely, for a given level of return, they will choose portfolios that minimize risk.

One of the central insights of MPT is the value of diversification. By selecting uncorrelated assets, investors can construct portfolios that offer similar returns with significantly reduced risk, thus mitigating the impact of individual company performance on the portfolio.

MPT offers guidance for all types of investors by helping them find the optimal allocation of capital among various portfolios. This is achieved when the investor's indifference curve representing their risk tolerance intersects with the efficient frontier, which represents the set of optimized portfolios.

Sustainable investment strategies commonly include practices such as negative screening, positive screening, corporate engagement, impact investing, and community investing. Among these, ESG (Environmental, Social, and Governance) investment is the most prevalent sustainable strategy. ESG strategies consider three key factors—environmental, social, and governance—which are typically defined consistently across ESG rating agencies. These factors include assessing a company's vulnerability to environmental regulations or fines, its human rights policies, and the incentive structures in place for top management.

ESG (Environmental, Social, and Governance) factors are as follows:

Environmental	**Social**	**Governance**
Carbon emissions	diversity policy.	board composition
Air and water pollution	human rights	executive compensation
energy efficiency	labor standards	audit committee structure
waste management	employee engagement	anti-corruption policy
biodiversity.	customer satisfaction	lobbying activities
water scarcity	public relations	political contribution

Table 1: ESG factors, source: (CFA, 2022).

Investment Strategies of Pension Funds in OECD Countries One of the main principles of the investment strategies of pension funds in OECD countries is asset diversification. This involves distributing investments across various financial instruments, sectors, and Pension funds aim to minimize risks by diversifying investments across different geographic regions. This strategy ensures that their assets are not overly dependent on a single sector or region, which could be significantly impacted by global economic instability. By diversifying, pension funds strive to secure stable income streams and reduce potential financial losses.

For instance, pension funds invest not only in local markets but also on a global scale, including assets such as stocks, bonds, real estate, infrastructure projects, and clean energy initiatives. In recent years, many OECD countries have also actively engaged in emerging markets to enhance the growth potential

of their pension funds. A comparative analysis of these strategies, along with relevant investment theories, can provide valuable insights for Georgia's pension fund strategy.

Additionally, ESG (Environmental, Social, and Governance) and sustainable investments have gained increasing prominence. ESG principles are now a cornerstone of the investment strategies of pension funds in OECD countries. These investments prioritize sustainable development and aim to protect the environment, increase social responsibility, and ensure transparency and efficiency in the management process. This approach has garnered significant attention as the global economy becomes more reliant on ecological sustainability and the need to address climate change.

OECD pension funds actively invest in clean energy projects, such as solar and wind energy, along with other environmentally friendly technologies. They also avoid high-risk and non-sustainable projects, further contributing to the long-term stability of these funds.

Investing in nominal bonds is essentially a bet that future inflation risks will be minimal, or, from a speculative perspective, that the economy may experience deflation. In a deflationary scenario, inflation-indexed bonds still protect investors because their coupons and principal remain constant in real terms. While long-term deflation is a possibility, experience shows that inflation poses a more significant threat in developing economies.

For long-term investors, particularly those saving for retirement through defined contribution (DC) pension plans, government-issued inflation-indexed bonds offer considerable benefits. These bonds help governments reduce the cost of financing deficits since they do not need to account for inflation uncertainty. By eliminating inflation risk, such bonds are similar to foreign currency-denominated debt, where the only way to reduce payments is through outright default.

In countries lacking domestic inflation-linked bonds, Campbell, Viceira, and White (2003) suggest that investors in inflation-volatile economies can hedge against inflation by holding short-term bonds in foreign currencies with stable inflation and real interest rates.

French and Poterba (1991) demonstrated that U.S. investors benefit significantly from international equity diversification due to historically low correlations between international equity markets. However, if the returns on equities (or bonds) and currencies are correlated, fully hedging currency risk may not be the most effective strategy for reducing portfolio risk. For instance, if the excess returns on foreign stocks are negatively correlated with foreign currency returns, maintaining some exposure to foreign currencies can reduce the overall volatility of an investor's portfolio. Therefore, a mixed approach—combining hedging and non-hedging—can be advantageous for managing portfolio risk.

In summary, Campbell, Serfaty-de Medeiros, and Viceira (2010) find that it is not optimal for internationally diversified equity investors to use a single hedging policy to reduce exposure to all major currencies. Rather, they should maintain exposure to the reserve currency while hedging all other major currencies. Their research shows that investors based in advanced economies can achieve economically and statistically significant gains compared to standard foreign exchange policies such as full hedging, no hedging, or half hedging.

The table shows that, for the most part, pension assets in OECD countries are diversified and placed in shares, bonds, deposits and various instruments, while the main part of Georgia's pension assets is placed in bank deposits and state treasury certificates. We will discuss the investment policy and changes of the Georgian Pension Fund in more detail below. , to begin chronologically, it should be noted that the Georgian Pension Fund is a relatively new system that was launched in 2019, and it is based on the accumulative pension system model. This system is different from the model of many developed countries, but its essence is similar - citizens have the opportunity to use the pre-accumulated funds for their pension for investment purposes.

System Overview and Asset Growth (2019–2023)

The investment policy of the Georgian Pension Fund is aimed at increasing the fund's assets and providing sustainable income to pensioners. The fund focuses on long-term investments, although its structure and experience are still in the process of formation. Fund management strives to use modern investment strategies, including asset diversification and low-risk investments.

Nevertheless, the Pension Fund of Georgia, due to its young system, still cannot provide the level of stability and income that is possible in developed countries. Fund management has many challenges and opportunities, including building better connections with global markets and developing more dynamic investment strategies.

2023 was also an important year for the Georgian Pension Fund as it was involved in a global investment environment where economic challenges were growing. The fund managers made decisions aimed at ensuring the fund's stability despite the volatility of global markets. However, the fund still relies on low-risk investments and gradually tries to introduce new investment opportunities.

Pension assets are increasing day by day and accordingly the sums generated by the pension agency are increasing. According to the law, participation in the pension scheme is mandatory for all employees, subject to certain exceptions.

The maximum rate of pension contribution is 6%, including 2%-2% contribution by the employee and the employer equally, in a mandatory manner, and the state provides a partial subsidy, in particular, for those participants whose annual income does not exceed 24,000 GEL, the state provides the full 2% of contributes, and for participants whose income is 24,000.

This rate decreases to 1% when it reaches 60,000 GEL. It should be noted that all pension contributions, benefits accrued on pension savings and pensions payable to participants are exempt from income taxes.

As for net contributions, it looks like this:

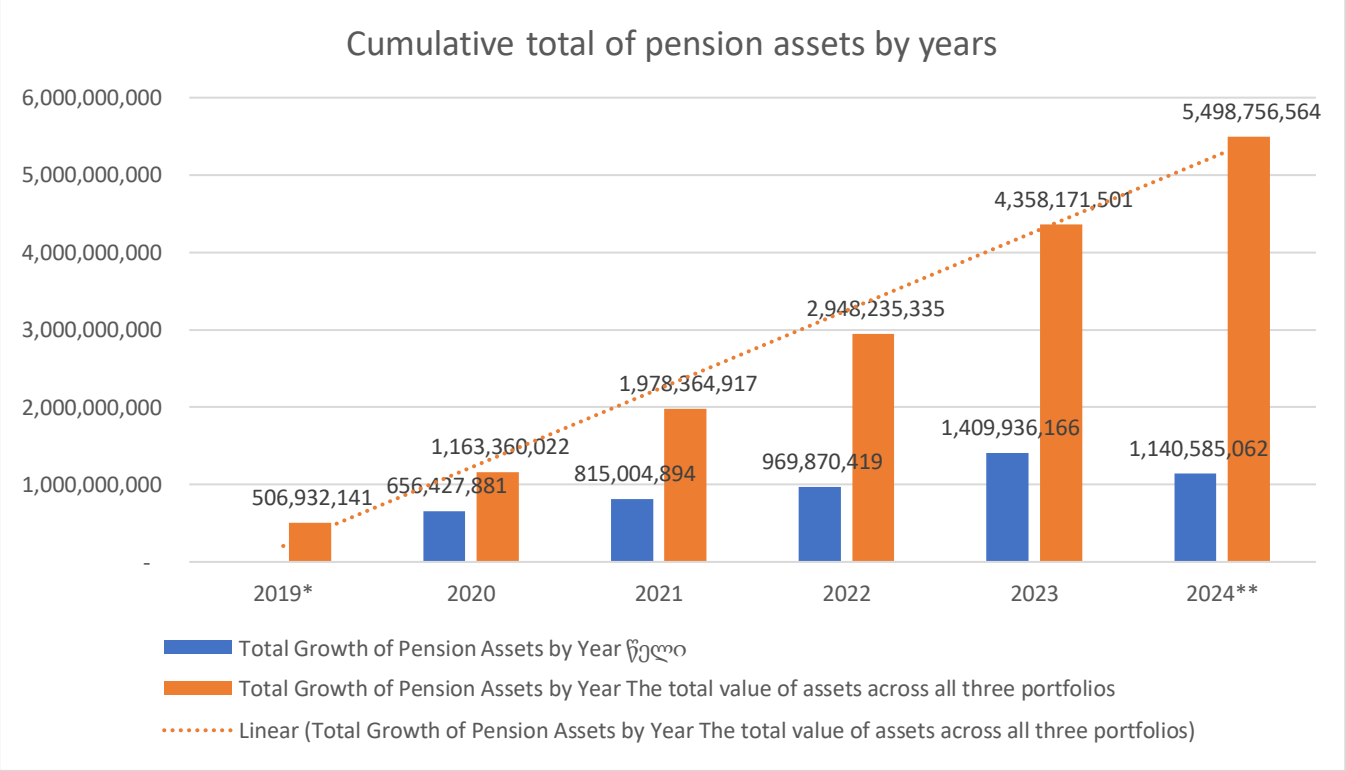


Chart 1 - source, information requested from the pension agency

In 2021, the Pension Agency's target portfolio was structured with 15% in global shares, 25% in Georgian treasury bonds, and 60% in certificates of deposit. The stock portfolio's benchmark index was the MSCI World Index, which includes large and medium-cap companies from 23 developed countries.

In April 2022, the Pension Agency began investing in the MSCI World Index Tracking Fund (URTH), and by the end of the year, the stock portfolio's value reached $85 million. By the end of 2022, investments in global stocks increased to $310 million. To reduce transaction costs and better align with the target index, the agency decided to replace URTH (expense ratio: 0.24%) with cheaper funds.

In August 2023, the Pension Agency introduced two new portfolios balanced and dynamic and updated the strategic asset allocation indicators. The target index for global shares became an equally weighted index of developed and developing regions, including US SPY, European VGK, Asia-Pacific VPL, and VWO for emerging markets.

By the end of 2023, the equity portfolio was diversified across global regions: 41.7% in US markets, 18.5% in Asia-Pacific, 17.5% in Europe, 12.1% in emerging markets, 8.4% in Latin America, and 1.9% in Canada. Active investment decisions included investments in Latin America.

After launching the new portfolios in August 2023, the Pension Agency managed three portfolios: conservative, balanced, and dynamic. As of December 31, 2023, 73.2% of assets were in the dynamic portfolio, 15.2% in the balanced portfolio, and 11.6% in the conservative portfolio. However, changes to the cumulative pension law in November 2023 led to a reallocation of assets back to the conservative portfolio. By January 4, 2024, 99% of assets were in the conservative portfolio, with only 1% in the balanced and dynamic portfolios.

Participants can still apply to the Pension Agency to transfer their assets to a portfolio that matches their risk tolerance. The table below shows the real assets of each portfolio according to the years, it should be noted that two new portfolios were added to the fund only from 2023, so let's first evaluate the relevant results. However, we can mention that in the last one year dynamic Portwell recorded the highest percentage return.

The real returns by year in monetary and percentage terms				
Year	**Total sums in all three portfolio slots**	**A conservative (less risky) investment portfolio**	**Balanced (average risk) investment portfolio**	**Dynamic (high-risk) investment portfolio structures**
2019*	-0.79%	-0.79%		
2020	8.85%	8.85%		
2021	-2.66%	-2.66%		
2022	-2.28%	-2.28%		
2023	11.84%	11.45%	3.26%	3.40%
2024*	7.97%	8.02%	9.38%	10.38%
from the beginning	23.99%	23.62%	12.94%	14.13%

Table 2 Source: Pension Fund

*For whole and conservative portfolios: data calculated as of January 6, 2019

*Balanced and conservative portfolio data calculated as of August 7, 2023

*Data used for calculations are updated as of August 31, 2024

If we analyze the presented tables, we will see that successful pension agencies manage their assets according to the principle of diversification and use modern portfolio theories, according to the legal framework in Georgia, the investment portfolio is selected by the decision of the participant, and there are challenges in this part, the main challenge is still the lack of information of the participants, which means that the participant simply He does not know which investment portfolio is the most optimal for him, and at the same time, his level of financial education may not be such that he can make a wise decision.

For this, it is necessary for the pension agency to strengthen its work in terms of the awareness of the participants, so that the participants can make informed decisions and allow the pension agency to more flexibly make relevant investments in both Georgian and global stocks, which will ultimately balance and diversify the portfolio. Horizon, which means that if a participant has a 20-30 year investment horizon, he may consider moving his retirement assets into a dynamic portfolio, meaning that a large portion of retirement assets will be invested in foreign company shares, which in turn will protect them from inflation and yield more over the long term. income.

Key Results of OECD Pension Funds in 2023 (Comparative Analysis) Investment Performance and Stability OECD pension fund investments in 2023 were amid global economic volatility, although their long-term investment strategies provided some stability. The main economic centers of the world, such as the USA, the United Kingdom, Japan and European countries, actively diversified their investments, which helped to resist the sharp changes in the markets.

Pension funds in OECD countries have typically been able to generate between 5% and 7% in real terms, driven not only by diversified portfolios but also by increasing attention to ESG investments. Investments in green energy and infrastructure projects have been important for the long-term stability of these funds, particularly in countries such as the Netherlands and Sweden.

Diversification and connection to international markets One of the strengths of OECD countries' pension funds is their involvement in global markets. As of 2023, a significant portion of these funds' assets were invested in international markets, allowing them to achieve more diversified results. For example, about 40% of Canadian pension funds were invested in international assets, allowing managers to improve their results by investing in American and European markets.

Similarly, the Swiss pension fund has been actively involved in international real estate and infrastructure projects, which boosted the fund's earnings despite a global economic downturn in 2023. Such diversification strategies ensure long-term stability.

The Georgian Pension Fund still does not actively invest in international markets and its main focus is on the local market, which increases the risks of local economic instability. Although the fund management is trying diversification strategies, in 2023 its investment portfolio remained mainly on conservative low-risk instruments such as government bonds and bank deposits.

A comparison of the investment policies of pension funds on the example of OECD countries and Georgia shows the fundamental differences between them, although there are also certain similarities that relate to policies adapted to different economic and financial environments. Analysis of the 2023

results shows that each fund is driven by different goals and opportunities, which is reflected in investment strategies and final results.

One of the important factors affecting the results of pension funds in 2023 was the global economic and geopolitical situation. Wars, energy crises and instability of financial markets significantly affected the Fund's results. OECD countries have coped better with these challenges by using global diversification and low-risk strategies.

The Georgian Pension Fund was more affected by regional geopolitical risks. The economic difficulties of the country and the political instability of the region have a significant impact on the income of the fund, which creates additional risks for long-term stability.

The rigidity of the Georgian Pension Fund regulations limits its flexibility. The fund's policy does not allow managers to make quick changes, making it more vulnerable to economic fluctuations.

The quality of governance is one of the decisive factors affecting the success of pension funds. Pension funds in OECD countries are led by experienced and professional managers, which contributes to the efficiency of investment policies.

The Georgian Pension Fund is still in the development stage. Management qualifications and governance structures have a significant impact on a fund's growth prospects. More education, introduction of international practices will be needed to improve fund management and be able to compete with international funds.

Regulatory environment of the pension system

conclusion

The analysis of the results of 2023 shows that the Georgian pension fund needs greater diversification, more innovation and involvement in international markets in order to compete with the funds of OECD countries. Both models have their advantages and disadvantages, however, for long-term prospects, the development of the Georgian pension fund and response to global trends is necessary.

The policy of the Georgian Pension Fund, despite progress, is more conservative and less diversified, which is due to its relatively new status and less international experience. The fund's investment portfolio is mainly focused on government bonds and domestic markets, which increases the fund's risks if Georgia's economic situation is not sufficiently stable in the long term. At the same time, the lack of ESG investments limits the fund's ability to connect with global and sustainable development, which is of strategic importance for an international fund.

However, both models have their own unique benefits and challenges. A diversified and globally oriented approach to investment policy in OECD countries enhances long-term growth, while the conservative strategy of the Georgian Pension Fund ensures stability in the short term. In both cases, results are influenced by global and local economic conditions, and effective management and the regulatory environment play an important role in the success of each fund.

Based on the above, it is important to consider several recommendations based on international experience.

Improving diversification

The Georgian Pension Fund has been influenced by regional geopolitical factors. Economic challenges within the country and political instability in the region have affected the fund’s income, which introduces additional risks for its long-term stability.

Regulatory constraints limit the flexibility of the Georgian Pension Fund. Current policies restrict managers from making rapid adjustments, which may increase the fund's exposure to economic fluctuations.

Governance quality significantly influences pension fund performance. Pension funds in OECD countries are managed by experienced professionals, contributing to their investment policy effectiveness.

The Georgian Pension Fund remains in a developmental phase. Management qualifications and governance frameworks impact its growth potential. Enhancing education and adopting international practices could further improve fund management and position the fund for competition with global counterparts.

Analysis of 2023 results suggests that the Georgian Pension Fund could benefit from greater diversification, increased innovation, and more involvement in international markets to align more closely with OECD country funds. While both models offer respective advantages and limitations, adapting to global trends and supporting development is important for the Georgian fund's long-term outlook.

The Georgian Pension Fund maintains a conservative and less diversified policy, attributable to its newer status and limited international experience. Its investment portfolio primarily consists of government bonds and domestic assets, which may elevate risk if Georgia's economy faces future instability. Additionally, the absence of ESG investments limits the fund's integration with global sustainability initiatives.

Both pension fund models present distinct benefits and challenges. A diversified and globally oriented strategy used by OECD countries supports long-term growth, whereas the more conservative Georgian approach focuses on short-term stability. Outcomes for both are shaped by economic conditions, with effective management and regulatory frameworks being key factors in overall success.

Based on these points, several recommendations can be considered in accordance with international experience.

Improving Diversification

5. Conclusion and Policy Recommendations

The Georgian Pension Fund is considering diversifying its investment portfolio to improve risk management and achieve higher long-term returns. For instance, the fund could increase its involvement in international markets by investing in various assets such as global corporate shares, real estate, and private capital. Such diversification can help the fund address domestic market volatility and achieve greater stability in global markets. Legislative improvements may be required to support these changes since the fund operates according to a set investment strategy.

Including international investments is recommended for the fund. Pension funds in OECD countries commonly engage with global markets to promote growth and diversify risks. Adopting similar methods may enable the Georgian Pension Fund to focus more on international investments and potentially affect global financial markets.

ESG (environmental, social, and governance) investment strategies are increasingly utilized in OECD countries and worldwide to support sustainable development. The Georgian Pension Fund may consider integrating ESG criteria into its investment policy to enhance long-term stability and meet sustainability objectives. This approach could also increase interest from international investors, which may result in additional funding and economic benefits for Georgia.

Developing the management structure and enhancing management quality are suggested steps for achieving greater professionalism and transparency. This process may involve training the management

team, incorporating international experience, and adopting broader management practices. These measures aim to support a flexible and stable policy for long-term operations.

Flexibility of Investment Strategies

A flexible investment policy would allow the fund to respond quickly to shifts in the world economic and financial landscape. This approach is particularly important during crises when rapid adjustments may be necessary. Flexibility is considered key for effective management in both domestic and global markets.

Regulatory Environment Improvements. The effectiveness of the Georgian Pension Fund is closely linked to its regulatory context. Revising regulations to provide the fund with more flexibility in implementing investment strategies may be essential for long-term success. Reviewing regulations and drawing on international best practices could improve the fund's efficiency and stability in relation to global markets.

The fund could introduce programs to inform the public and investors about its strategies, risks, and potential benefits. Improving public awareness and trust may encourage more active investor participation, contributing to the fund's activities.

Analysis of the 2023 investment policy and results indicates limited diversification and insufficient engagement in global markets as primary challenges for the Georgian Pension Fund. Enhanced flexibility and innovative approaches might improve the fund's ability to address global challenges and achieve better outcomes over time.

It is recommended that the Georgian Pension Fund develop its strategies by referencing international experience and considering ESG investments. Through such measures, the fund may better align with international pension systems and work toward ensuring long-term financial stability for the population of Georgia.

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LABORATORY EVALUATION OF THE POTENTIAL APPLICATION OF A MIXTURE OF THERMAL POWER PLANT ASH AND SALINE SAND FOR ROAD SUBGRADE STABILIZATION

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ABSTRACT

In the context of developing solutions to manage the large volume of waste in the form of fly ash from local thermal power plants, and simultaneously addressing the issue of salt-contaminated sand to mitigate the current scarcity of natural sand, this project aims to enhance the technical methods of construction in road foundation technology. It strives to achieve economic efficiency in waste management and the rational utilization of local raw materials. The research has conducted empirical studies and evaluated the applicability of a mixture of thermal power plant fly ash and salt-contaminated sand for road foundation reinforcement. The findings indicate that blending and combining fly ash with salt-contaminated sand to create a reinforcement layer for roadways is entirely feasible at an appropriate ratio. The material mixtures, with a fixed percentage of binder (cement and fly ash) and cement content ranging from 6% to 9%, demonstrate high compressive strength and tensile strength when subjected to split testing. The elastic modulus of the material mixture, with cement content from 6% to 9% and samples reinforced with 3% cement, indicates that the fly ash content must be equal to or exceed the salt-contaminated sand content in order to achieve a strength classification of grade III when additionally comparing two parameters: compressive strength and tensile strength from split testing.

Keywords: fly ash, saline sand, compressive strength, tensile strength in splitting, modulus of elasticity.

INTRODUCTION

In 2016, nearly 13.7 billion tons of sand were extracted worldwide for the construction industry, with 70% consumed in Asia, including about 5 billion tons in China. Mineral sand mining is one of the highest consumption industries, with a global commercial value of approximately USD 70 billion. Countries such as Hong Kong, Singapore, Japan, and several Middle Eastern nations have studied and implemented the use of marine sand in urban transport infrastructure projects. Every year, European countries consume around 6-7 million tons of marine sand. Notable examples of projects using marine sand as a substitute for river sand include transportation projects in the UK and Hong Kong, city expansions in Singapore, and building constructions in the Middle East. Singapore is among the world's largest importers of construction sand, sourcing primarily from Southeast Asian countries such as Cambodia, Malaysia, and Vietnam (Ha et al., 2023). Regarding the use of marine sand as road embankment material, global studies have shown that offshore sand typically has round and uniform particles, which makes compaction difficult and poses challenges in ensuring the long-term stability of road foundations under dynamic loads, especially in waterlogged conditions. As a result, marine sand is generally not used independently for road foundation construction but is usually stabilized with additives such as cement or mixed with crushed stone or equivalent materials (Announcement No. 72/TB-BGTVT 2022). Tra Vinh province has significant potential for development in culture, tourism, industry, and logistics. To fully realize this potential, the development of transport infrastructure is considered a breakthrough step, playing a decisive role in helping Tra Vinh achieve its 2045 goal of becoming a fairly

developed province. Given the current pace of construction, Tra Vinh, like other provinces in the Mekong Delta especially during the implementation of the North-South Expressway (Eastern section) from 2021-2025, and expressways such as Hau Giang-Ca Mau and Chau Doc-Can Tho-Soc Trang is facing a shortage of quality natural sand for concrete production due to the depletion of resources and the severe environmental and social impacts of sand mining. While the supply of coarse sand (with fineness modulus > 2) is very limited, there is an abundant supply of fine and marine sand (with fineness modulus=1.3-2.0) in Tra Vinh, particularly from the Co Chien river. However, this source has not yet been utilized for pavement concrete. However, this fine sand with large reserves is often not used in traditional concrete because its low fineness modulus does not meet the aggregate requirements of TCVN 7570:2006, or if used, it is typically limited to making B15 to B25 grade concrete. Meanwhile, this type of material is suitable for producing fine aggregate concrete a type of concrete widely used in transportation infrastructure construction in countries and regions with abundant sand but limited coarse aggregates, such as France, Russia, Morocco, Algeria, and Germany. This research contributes to the development of new construction materials for infrastructure in Tra Vinh, reduces environmental pollution, saves land used for storing coal slag and fly ash from the Duyen Hai thermal power plant, and ensures sustainable development. In the study on the use of untreated coal slag fly ash from the Duyen Hai thermal power plant combined with lime for subgrade stabilization as a base layer in pavement structure in Tra Vinh, the research team analyzed the strength indicators of the untreated slag ash lime mixture through simulations of material and subgrade behavior under different scenarios (Linh and Thanh, 2018); (Linh et al., 2018); (Tung et al., 2018). Currently, managing and reusing fly ash and bottom ash from coal fired power plants is a significant challenge in Vietnam, especially in the Mekong Delta region where many thermal power plants are operating. Utilizing saline sand previously considered low quality together with fly ash and bottom ash industrial waste for roadbed stabilization not only helps alleviate the shortage of traditional materials but also brings environmental and economic benefits. In this context, evaluating the potential application of a mixture of thermal power plant ash and saline sand for roadbed stabilization through laboratory experiments is essential. This study not only provides a scientific database for using these two alternative materials but also guides appropriate road foundation design solutions suited to local conditions, aiming toward the sustainable development of the transportation sector.

MATERIALS AND METHODS

Cement: According to TCVN 6260:2020, the quality criteria of PCB40 cement are specified in Table 1.

Table 1. Physical properties of the cement PCB40

No.	Test parameter	Unit	Test method	Results	TCVN 6260 - 2020
1	Fineness	%	TCVN 13605:2023	2.08	Max 10
2	Density	kN/m^3	TCVN 13605:2023	29.64	
3	Standard consistency	%	TCVN 6017-2015	15.50	
4	Setting time :		TCVN 6017-2015		
	Initial setting time	min		158	Min 45
	Final setting time	hour		4.33	Max 7
5	Compressive strength:				

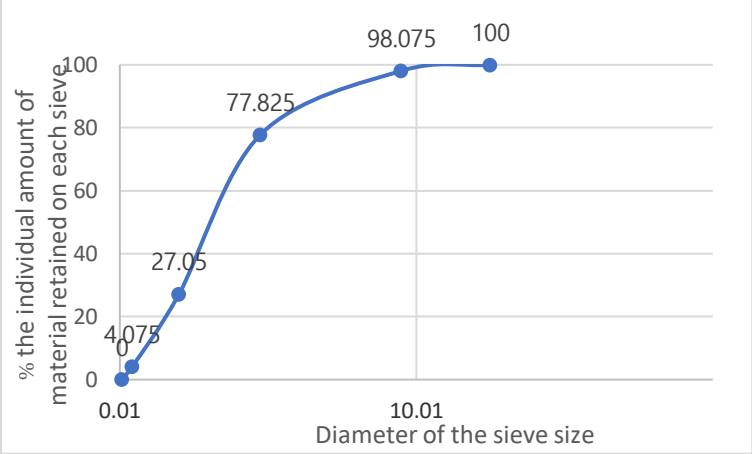
	3-day	MPa	TCVN 6016-2011	24.14	Min 18
	28-day	MPa			Min 40

The test results show that PCB40 cement meets the requirements of TCVN 6260:2020 and is suitable for producing material mixtures.

Fly Ash: Fly ash (FA), also known as pulverized fuel ash, is produced from the combustion of pulverized coal in thermal power plants. Currently, many thermal power plants in Vietnam generate fly ash of sufficient quality for producing cement concrete. The test results of the physical, mechanical properties and chemical composition of the fly ash are presented in Table 2.

Table 2. Test results of fly ash properties

No.	Test parameter	Test method	Unit	Results	Technical Requirements TCVN 7570:2006
1	Density	TCVN 7572-4:2006	kN/m^3	22.17	x
2	The loose bulk density	TCVN 7572-6:2006	kN/m^3	10.24	x
3	Porosity	TCVN 7572-6:2006	%	0.54	x
4	Particle size distribution	TCVN 7572-2:2006	%	See fig	x
5	Setting time:	TCVN 6017-2015			
	Initial setting time		min	155	x
	Final setting time		hour	4.22	x
6	Compressive Strength:	TCVN 3118-2022	MPa	0.04	x

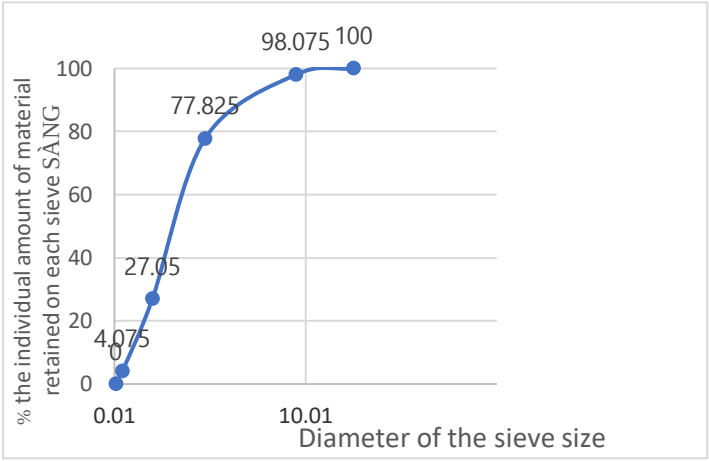


Bottom ash: Bottom ash is a waste by-product collected at the bottom of the furnace in thermal power plants during coal combustion, usually in lump or granular form. The test results of the physical,

mechanical properties, and chemical composition of the bottom ash are presented in Table 3.

Table 3. Test results of the required properties of bottom ash

No.	Test parameter	Test method	unit	Result	Technical Requirements TCVN 7570 : 06
1	Density	TCVN 7572-4 : 06	kN/m^3	21.19	x
2	The loose bulk density	TCVN 7572-6 : 06	kN/m^3	9.46	x
3	Porosity	TCVN 7572-6 : 06	%	0.55	x
4	Particle size distribution	TCVN 7572-2 : 06	%	See fig	x
5	Water Absorption	TCVN 7572-5 : 06	%	2.167	x



Saline sand: Saline sand is natural sand contaminated with chloride salts due to exposure to environments containing chlorides. The test results of the physical, mechanical properties, and chemical composition of the saline sand are presented in Table 4.

Table 4. Test results of the required properties of saline sand

No.	Test parameter	Test method	Unit	Result
1	Density	TCVN 7572-4: 2006	kN/m^3	26.29
2	The loose bulk density	TCVN 7572-6:2006	kN/m^3	13.45
3	Porosity	TCVN 7572-6:2006	%	49.1
4	Moisture content	TCVN 7572-7:2006	%	3.22
5	Magnitude modulus	TCVN 7572-2:2006	%	1.41
6	Ion concentration clorua Cl^-	-	%	0.34

Water: Clean tap water complying with TCVN 4506:2012 is used for mixing the material mixture.

Mix Proportion: The proportion of each material in the mix design is presented in Table 5.

Table 5. Designed mix proportions of materials ($V=1m^3$)

Mix design	% cement	%fly ash	%bottom ash	%saline sand	Water /binder	Cement (kN)	Fly ash (kN)	Bottom ash (kN)	Saline sand (kN)	Water (kN)
C7X3	3%	10%	26%	61%	1.15	0.53	1.78	4.62	10.85	2.66
C5X3	3%	10%	44%	44%	1.15	0.52	1.73	7.52	7.52	2.58
C3X3	3%	10%	61%	26%	1.15	0.50	1.68	10.26	4.37	2.52
C7X6	6%	10%	25%	59%	0.94	1.07	1.78	4.46	10.52	2.68
C5X6	6%	10%	42%	42%	0.94	1.04	1.73	7.28	7.28	2.61
C3X6	6%	10%	59%	25%	0.94	1.01	1.69	9.96	4.22	2.54
C7X9	9%	10%	24%	57%	0.79	1.61	1.79	4.30	10.20	2.69
C5X9	9%	10%	41%	41%	0.79	1.57	1.74	7.06	7.06	2.62
C3X9	9%	10%	57%	24%	0.79	1.53	1.70	9.68	4.08	2.55

Theo ASTM D2166/D2166M:2007-16 Standard test method for unconfined compressive strength of cohesive soil.

Test method for confined compressive strength:



Figure 1. Specimen fabrication

Sample preparation: Handle the samples carefully to minimize changes in cross-sectional area or moisture loss. The samples must have a uniform circular cross-section with ends perpendicular to the longitudinal axis. During preparation, remove any encountered gravel or small shells. Carefully fill any surface voids using material obtained from the trimmed parts. Determine the mass and dimensions of the test sample.



Figure 2. Specimen processing

Test procedure: Place the test specimen into the loading device so that it is centered on the lower platen. Carefully adjust the loading device until the upper platen just makes contact with the specimen. Set the deformation indicator to zero or record the initial reading of the electronic deformation device. Apply the load to produce an axial strain at a rate of 2% per minute.



Figure 3. Compressive strength test setup

Record the values of load, deformation, and time. The strain rate should be selected such that failure occurs within approximately 15 minutes. Continue loading until the load value decreases while deformation increases, or until 15% axial strain is reached. Determine the moisture content of the test specimen using the entire sample. Draw a sketch or take a photograph of the specimen at the point of failure, showing the inclination angle of the failure surface if measurable.

Result calculation: Calculate the axial strain ε_1, rounded to the nearest 0.1%, for a given applied load as follows:

$$\varepsilon_1 = \frac{\Delta L}{L_0} \times 100 \qquad (1)$$

Where: ΔL - The length deformation of the test specimen is read from the deformation indicator or calculated from the electronic device (mm); L_0 - Initial length of the test specimen (mm); Calculate the average cross-sectional area A, for a given applied load, as follows:

$$A = \frac{A_0}{\left(1 - \frac{\varepsilon_1}{100}\right)} \qquad (2)$$

Where: A_0 - Initial average cross-sectional area of the specimen (mm^2); ε_1 – Axial strain for the given load (%); Calculate the compressive stress σ_c, for a given applied load, as follows:

$$\sigma_c = P/A \qquad (3)$$

Where: P-Given applied load (kN); A-Corresponding average cross-sectional area (mm^2);

Splitting tensile strength test

Sample preparation: According to Section 6 of TCVN 8862:2011, prepare cylindrical specimens that have been cured and kept moist. The diameter of the cylindrical specimen prepared in the laboratory is 100 mm and the height is 200 mm. A test set consists of 3 specimens.

Test procedure: According to Section 7 of TCVN 8862:2011, the test is conducted as follows: Split the specimen by applying a continuous and uniform load until the specimen fails. The loading rate for the splitting test should be (50 ± 5) mm/min. The rate of loading should increase the tensile stress during splitting uniformly from 0.10 MPa/min to 0.70 MPa/min, proportional to the strength of the specimen, ensuring that the time to failure is not less than 30 seconds. Record the maximum failure load for each specimen.

Result calculation: The splitting tensile strength (R_{kc}) of each cylindrical specimen is calculated using the following formula:

$$R_{kc} = \frac{2 \times P}{\pi \times H \times D} \qquad (4)$$

Where: R_{kc}: splitting tensile strength (MPa); P: Failure load of the cylindrical specimen (kN); H: Height of the cylindrical specimen (mm); D: Diameter of the base of the cylindrical specimen (mm).

The splitting tensile strength of the material is the average strength value of three specimens in a sample set, provided that the maximum and minimum values do not differ by more than 15% from the median value. If both the maximum and minimum values differ by more than 15%, they shall be excluded, and the splitting tensile strength is calculated based on the average value of the remaining specimens.

Elastic Modulus Testing

Sample preparation: According to Section 6 of TCVN 9843:2013: Keep the mixture in a sealed container for 2 hours at a temperature of (25 ± 1)°C, then place it into a modified Proctor mold to form test specimens. Remove the specimen from the Proctor mold and cure it in a moist environment for 21 days, followed by immersion in water for 7 days to determine the elastic modulus at 28 days of age. Prepare three sample sets, each set consisting of three specimens. One sample set is used for compressive strength testing (R), and another is used to test for elastic modulus.

Calculation of results: Calculate the elastic modulus for each cylindrical specimen: The load p required to apply a specified compressive pressure on the specimen surface is determined using formula (5):

$$p = 0.2 \times R \qquad (5)$$

where: p - The compressive pressure exerted by the applied load on the specimen surface (MPa); R - The compressive strength of the material specimen (Mpa);

The elastic modulus of the binder-stabilized crushed rock material is calculated using equation (6)

$$E_{dh} = \frac{p \times H}{L} = \frac{4 \times P \times H}{\pi \times D^2 \times L} \quad (6)$$

where: P-Compressive load applied to the specimen (kN); p-Compressive pressure on the specimen surface (MPa); H-Height of the specimen (mm); D-Diameter of the specimen (mm); L-Recovered (elastic) deformation of the material specimen (mm); E_{dh}-Elastic modulus of the material (MPa).

RESULT AND DISCUSSION

Compressive Strength Test: The test specimens are cylindrical in shape with a diameter of 100 mm and a height of 200 mm, cured for 7 days and 28 days. The test results are presented in Table 6 and illustrated in the chart in Figure 4.

Table 6. Compressive strength (MPa)

Mix design	C7X3	C5X3	C3X3	C7X6	C5X6	C3X6	C7X9	C5X9	C3X9
07-day	0.19	0.23	0.29	0.39	0.48	0.64	0.68	0.72	1.02
Standard deviation	0.024	0.025	0.031	0.026	0.095	0.076	0.057	0.045	0.145
28-day	0.39	0.42	0.56	1.37	1.51	1.92	2.39	2.82	3.91
Standard deviation	0.037	0.035	0.053	0.143	0.094	0.103	0.138	0.085	0.096

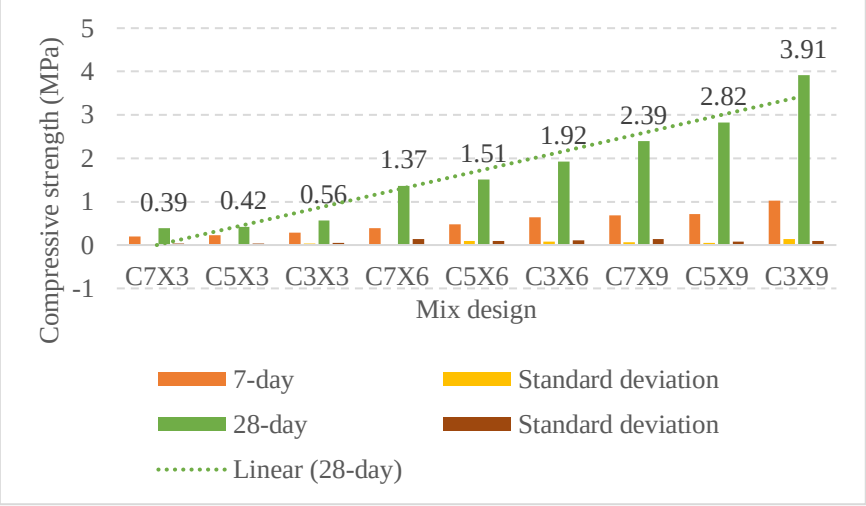


Figure 4. Compressive strength chart of the test material specimens

Testing for splitting tensile strength: The test material specimens are cylindrical in shape with a diameter of 100 mm and a height of 200 mm. A total of 9 mix designs were prepared, resulting in 54 specimens, cured for 7 days and 28 days. The test results are presented in Table 7 and illustrated in the chart in Figure 5.

Table 7. Test results for splitting tensile strength (MPa)

Mix design	C7X3	C5X3	C3X3	C7X6	C5X6	C3X6	C7X9	C5X9	C3X9
07-day	0.031	0.044	0.052	0.062	0.074	0.094	0.096	0.138	0.183
Standard deviation	0.005	0.011	0.005	0.006	0.008	0.011	0.009	0.014	0.006

28-day	0.076	0.081	0.091	0.242	0.266	0.342	0.457	0.582	0.676
Standard deviation	0.004	0.005	0.008	0.008	0.005	0.016	0.021	0.016	0.019

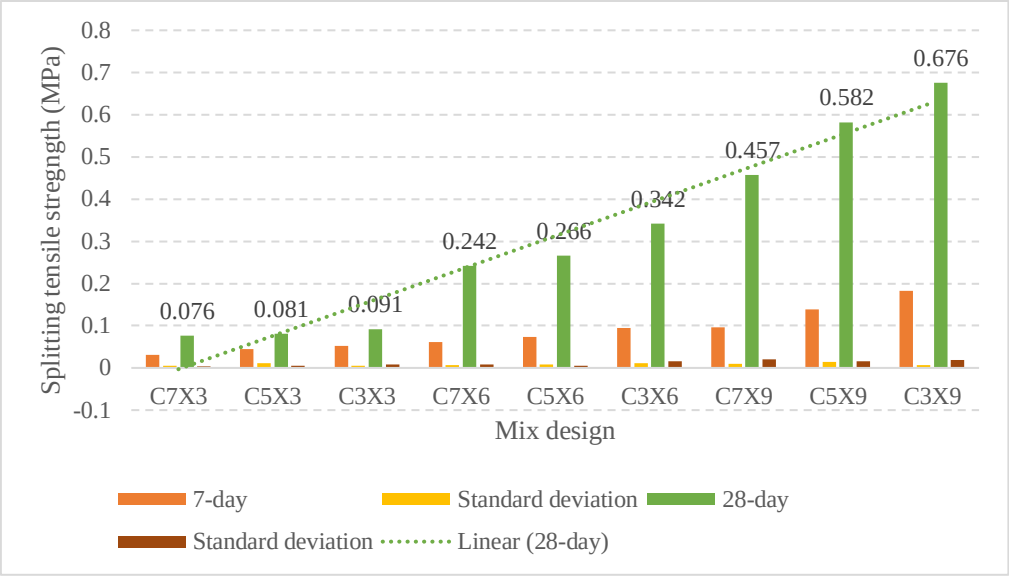


Figure 5. Splitting tensile strength chart of the test material specimens

Testing for Eastic modulus: The test material specimens are cylindrical in shape with a diameter of 100 mm and a height of 200 mm. A total of 9 mix designs were prepared, resulting in 27 specimens, all cured for 28 days. The test results are presented in Table 8 and illustrated in the chart in Figure 6.

Table 8. Test results for elastic modulus determination (MPa)

Mix design	C7X3	C5X3	C3X3	C7X6	C5X6	C3X6	C7X9	C5X9	C3X9
28-day	199	204	222	253	267	299	392	409	448
Standard deviation	12.888	13.315	25.356	22.885	12.897	13.997	15.919	19.091	23.499

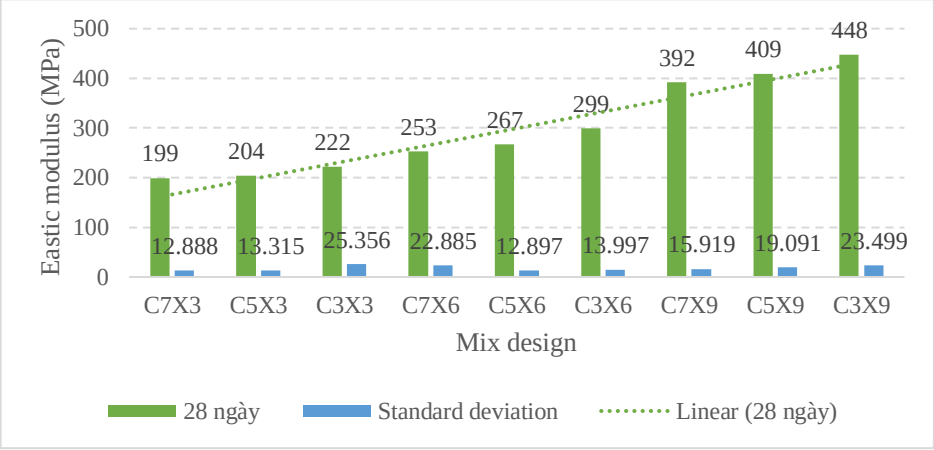


Figure 6. Elastic modulus chart of the test material specimens

DISSCUSION

TCVN 10186:2014 cement stabilized sand subbase in road pavement structures construction and acceptance specifies the required compressive strength of the material mixture used as a subbase layer in road construction.

TCVN 10379:2014 soil stabilization using inorganic binders, chemicals, or combined methods for road construction-construction and acceptance specifies the required compressive strength of the material mixture used as a subgrade stabilization layer in road construction. Based on the chart in Figure 4, it can be observed that on Day 7, the highest compressive strength among the specimens was 1.02 MPa, while the lowest was 0.19 MPa. The specimens stabilized with 9% cement all met Grade III strength according to TCVN 10379:2014, whereas this is not considered under TCVN 10186:2014. Specimens with 6% cement and a higher proportion of fly ash than saline sand also achieved Grade III strength as per TCVN 10379:2014. On Day 28, the highest compressive strength recorded was 3.91 MPa and the lowest was 0.39 MPa. The specimens stabilized with 6% to 9% cement all satisfied the requirements for use as subgrade stabilization layers according to TCVN 10186:2014, and achieved strength levels ranging from Grade III to Grade II as per TCVN 10379:2014. Based on the chart in Figure 5, on Day 28, the highest splitting tensile strength was 0.676 MPa, and the lowest was 0.076 MPa. The specimens stabilized with 6% to 9% cement met the requirements for subgrade stabilization layers according to TCVN 10186:2014 and achieved Grade III strength according to TCVN 10379:2014. From the chart in Figure 6, it is observed that the highest elastic modulus recorded was 448 MPa and the lowest was 199 MPa. The specimens stabilized with 6% to 9% cement achieved Grade III strength according to TCVN 10379:2014. Additionally, specimens stabilized with 3% cement and with fly ash content equal to or greater than the saline sand content also reached Grade III strength under TCVN 10379:2014.

CONCLUSIONS

Based on the experimental results, it is once again confirmed that fly ash and saline sand can be mixed and combined to create a subgrade stabilization layer for roads, provided that an appropriate mixing ratio is used. Specifically:

- Material mixtures containing binder materials (cement and fly ash), with a constant fly ash content and cement content ranging from 6% to 9%, exhibit very high compressive strength and splitting tensile strength.

- The elastic modulus of material mixtures with 6% to 9% cement content and in cases with only 3% cement can reach Grade III strength only if the fly ash content is equal to or greater than the saline sand content, when additionally considering both compressive and splitting tensile strength indicators.

- Moreover, the results of this study can be applied to transportation infrastructure in harsh environments such as marine areas, particularly in locations near thermal power plants. This approach offers both economic and environmental benefits.

- Laboratory test results indicate that the mixture of thermal power plant ash and saline sand has promising potential for application in road subgrade stabilization. When properly mixed and treated (e.g., with binders or additives), the material exhibits mechanical properties that meet technical requirements for subgrade construction.

- The combination of ash and saline sand not only reduces the demand for traditional construction materials and mitigates industrial waste disposal issues but also contributes significantly to environmental sustainability by utilizing underused local resources. The findings provide a scientific basis for developing roadbed solutions that are adapted to coastal regions affected by saline intrusion.

- However, further research is recommended to evaluate the long-term performance and durability of the material under field conditions, including its load-bearing capacity and mechanical behavior under actual traffic loads.

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KORUNMASI GEREKLI KÜLTÜR VARLIKLARINDA YAPAY AYDINLATMA ETKISI

ARTIFICIAL LIGHTING EFFECTS ON CULTURAL HERITAGE

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ÖZET

Gün ışığı yıllardır doğal aydınlatma elemanı olarak kullanılmaktadır. Günışığının doğrudan ulaşmadığı alanlarda ve zamanlarda yapay aydınlatmaya ihtiyaç duyulmuştur. İlk başlarda ateş sonrasında yapay aydınlatma elemanları ile çözüm sağlanmıştır. Modern teknolojinin gelişmesi ile mekan ve cephe aydınlatması mimari tasarımlarda yeni bir anlatım kazandırmıştır.

Aydınlatma konusunu, yapıların dışında kalan tüm açık alanlar, iç mekan ve dış cephe aydınlatması olarak değerlendirmek mümkündür. Özellikle tarihi çevre ve kültür varlıklarının aydınlatılmasında uygulanan yaklaşımlar, korunması gerekli yapılarda; doğru algılama, kent belleği, yapıların ve çevrenin sürdürülebilirliği açısından duyarlı yaklaşımı gerektirmektedir.

Korunması gerekli kültür varlığı, geçmişle bugünü ve geleceği bağlayan değerler arasındadır. Genç kuşaklara aktarma ve yapının sürdürülebilirliği amacı ile yapılan restorasyon çalışmalarındaki analitik yaklaşım, kültür varlığının özgün durumunun korunarak yaşatılmasını amaçlamaktadır. Kültür Varlıklarının yaşatılmasında görsel algı sürekliliği de önemli bir başlık oluşturmaktadır. Görsel algı etkisi, ışık kullanımı ile olumlu ve olumsuz yönde gelişmeye açıktır. Işığın insan psikolojisi üzerindeki etkisi, yaşayan/yaşanabilir mekan olgusu yaratmadaki temel yaklaşımlar arasındadır.

Doğal aydınlatma etkisi için doğru yönlendirmelerden ve ışığın gün içindeki değişimlerinden yararlanırken, yapay aydınlatma etkisinde ışık yönü, şiddeti, rengi vb. alt bileşenler tasarımcının dikkate alması gereken etkenlerdir. Doğal aydınlatma ile kişi/bakan üzerinde sağlanan olumlu etkinin yapay aydınlatma ile devamlılığının sağlanması tasarım yaklaşımlarındaki doğru kararları ortaya koymaktadır.

Bu çalışmanın konusu; korunması gerekli tarihi yapılarda cephe aydınlatması yaklaşımları üzerine yoğunlaşacaktır. Aydınlatma teknolojisinin, mimari ürün olan yapıların görünümleri ve mimarisi üzerine etkileri irdelenerek yapay aydınlatmanın önemi vurgulanmaya çalışılacaktır. Coğrafi olarak İstanbul ve özellikle tarihi yarımadada konumlanan zengin tarihsel ve yapısal katmanlaşma sonuca ulaşmada verimli alt yapı oluşturacaktır.

Anahtar Kelimeler: Kültür Varlığı, Tek Yapı, Yapay Aydınlatma.

ABSTRACT

Daylight has been used as a natural lighting element for years. Artificial lighting has been needed in areas and times where daylight does not reach directly. At first, solutions were provided with artificial lighting elements after fire. With the development of modern technology, space and facade lighting has gained a new expression in architectural designs.

It is possible to evaluate the subject of lighting as all open areas outside the buildings, interior and exterior lighting. Especially the approaches applied in the illumination of historical environment and cultural assets require a sensitive approach in terms of correct perception, urban memory, sustainability of the buildings and the environment.

Cultural heritage in need of protection is among the values that connect the past, present and future. The analytical approach in restoration works carried out with the aim of transferring to younger generations and the sustainability of the building aims to preserve the original state of the cultural asset. The continuity of visual perception is also an important topic in the survival of cultural assets. The effect of visual perception is open to positive and negative development with the use of light. The effect of light on human psychology is among the basic approaches in creating a living/livable space phenomenon.

For the effect of natural lighting, we benefit from the correct orientation and the changes of light during the day, while for the effect of artificial lighting, sub-components such as light direction, intensity, color, etc. are the factors that the designer should consider. Ensuring the continuity of the positive effect provided by natural lighting on the person/viewer with artificial lighting reveals the right decisions in design approaches.

The subject of this study will focus on facade lighting approaches in historical buildings that need to be preserved, and the importance of artificial lighting will be emphasized by examining the effects of lighting technology on the appearance and architecture of buildings that are architectural products. The rich historical and structural stratification geographically located in Istanbul and especially in the historical peninsula will create a productive infrastructure in reaching the conclusion.

Keywords: Cultural Heritage, Single Building, Artificial Lighting.

THE ROLE OF SPORT IN ADOLESCENT USING MODERN TECHNOLOGIES

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ABSTRACT

Professional sport is one of the most influential social phenomena of the modern era, impacting societies across economic, political, cultural, and social dimensions. It is one of the rarest fields that crosses all social, political or ethnic barriers. Especially today, in the 21st century, in the era of the Internet and television, when the popularity of sports, its viewership has reached the greatest proportions - it has become easy to follow world sports in any country or corner.

The World Health Organization (WHO) recognizes that physical activity and sports training are important means of promoting human health and well-being. It is scientifically proven that physical activity significantly reduces risk factors for non-communicable diseases (eg high blood pressure, overweight, obesity, mental health) and helps to reduce public and private costs in the health care system.

Despite the fact that in 2013, the "Sports State Policy Document 2014-2020" was approved, and on the basis of this document, a number of legislative changes were created and work began in the following directions, such as: "1. Sports infrastructure; 2. Sports education and science; 3. legislative changes".

In order to solve the existing problems and improve the situation in the country, a state policy for the development of sports and an action plan for its implementation will be developed. The concrete results achieved in terms of improving the health status of the population and increasing the quality of disease prevention, reducing public healthcare costs, however, this is not enough within the framework of modern challenges. It is also important to conduct active action-propaganda among the masses, more online master classes on the importance of sports.

Key words: Sports, State policy, Modern technologies, Sports development policy.

MEASUREMENT OF FINANCIAL FAILURES OF COMPANIES INCLUDED IN THE FTSE100 INDEX TRADING ON THE LONDON STOCK

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ABSTRACT

In the globalizing world, countries and companies are connected to each other like chain rings. If there is a problem with one of the chain links, it will cause the chain to break. It is extremely important for the economies of the countries that the companies are successful and fulfill their financial qualifications. However, the recent pandemics and wars have caused problems for the country's economy. These problems have a significant share in the financial failures of companies. It is very important to predict and determine financial failure. There are many methods used to measure the risk of financial failure.

In this study; The financial performances of the companies traded in the FTSE100 index (Financial Times Stock Exchange) traded on the London Stock Exchange were analyzed using the financial analysis methods Altman Z-score model and Spiringate S-score model. In the study, the probability of bankruptcy was tried to be determined by using Altman z-score method, Altman z-score publicly traded manufacturing enterprises model and Springate methods of the data in the balance sheet and income statements of companies for the years 2010-2021. Altman z-score, Altman z-score publicly traded manufacturing enterprises model and Springate values of companies include numerical values of the probability of financial failure and interpretations of the company's being in a positive, uncertain and risky area.

Keywords: Financial Failure, London Stock Exchange, FTSE100, Altman Z-Score Model, Springate Score Model, Fulmer Score Mode

Gel Code: G01, G10,G15, G32

CONSTRUCT A DIGITAL TWIN USING FUZZY LOGIC FOR A WASTEWATER TREATMENT BIOREACTOR

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ABSTRACT

At present we live in an era of constant progress and development, therefore it is essential to develop the field of water environmental safety. This approach also contributes to environmental protection, which is a critical issue worldwide. The new method I propose for constructing a digital twin based on fuzzy logic will enhance the operation of a wastewater treatment bioreactor. This model enables dynamic modeling based on real-time data collection. This, in turn, improves the management process and overall optimizes the efficiency of purification. The digital twin models the operation of the bioreactor, which allows for specific recommendations to be provided for process optimization. When comparing the application of fuzzy logic to the traditional method, the former allows for the implementation of an adaptive solution under uncertain conditions. This makes it possible to reduce inefficiencies caused by fluctuations in input conditions. Constructing a digital twin based on fuzzy logic reduces the number of physical tests and saves time and material costs in construction. Along with the above advantages, the level of reliability and forecasting is increased. The use of a digital twin based on fuzzy logic improves the forecasting of failures or malfunctions by analyzing the interactions between process variables. The approach I propose allows transforming the solution for optimizing wastewater treatment infrastructure, while ensuring high treatment efficiency with minimal impact on the environment. This study reveals the potential of using a digital twin based on fuzzy logic to construct a wastewater treatment bioreactor, which is one of the intelligent tools for wastewater treatment management.

Keywords: digital twins, fuzy logic, bioreactor.

LEGAL FRAMEWORK AND PRACTICAL IMPLEMENTATION OF EXTRADITION PROCEDURE IN THE REPUBLIC OF AZERBAIJAN

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ABSTRACT

Extradition is a fundamental mechanism of international criminal cooperation, whereby one state formally surrenders an individual to another state for the purposes of criminal prosecution or the enforcement of a criminal sentence. In contemporary international law, extradition not only functions as an essential tool for combating transnational crime but also reflects the core principles of state sovereignty, reciprocity, and mutual legal assistance. In the Republic of Azerbaijan, the extradition process is governed by a dual legal framework comprising domestic legislation and international treaty obligations. At the national level, Articles 499–515 of the Criminal Procedure Code (CPC) establish the substantive grounds, procedural requirements, necessary documentation, and the roles of competent decision-making authorities. Internationally, Azerbaijan is bound by various bilateral and multilateral instruments, most notably the 1957 European Convention on Extradition and its Additional Protocols.

This study examines both the normative foundations and the practical realities of extradition in Azerbaijan. It identifies key challenges in implementation, including procedural delays in the submission of required materials, ambiguities in the classification of political or military offences, and inconsistencies in the assessment of human rights risks. The analysis further considers the need for harmonizing domestic provisions with international standards, enhancing institutional transparency, and improving coordination between judicial, prosecutorial, and executive bodies. By integrating comparative perspectives from selected jurisdictions and aligning recommendations with European Court of Human Rights jurisprudence, the paper argues that the development of a more effective, transparent, and rights-based extradition regime in Azerbaijan requires sustained legislative refinement, specialized institutional capacity, and strengthened procedural safeguards.

Keywords: Extradition; Criminal Procedure Code; mutual legal assistance; European Convention on Extradition; legal cooperation; human rights; Azerbaijan.

1. Introduction

Extradition constitutes one of the most pivotal instruments of international cooperation in criminal matters, serving as a legal mechanism that enables the transfer of individuals from the jurisdiction of one sovereign state to that of another for the purposes of criminal prosecution or the execution of penalties. This institution, deeply rooted in both customary international law and treaty law, is a crucial tool in ensuring that serious offenders cannot exploit national borders as safe havens to evade justice. The increasing complexity and sophistication of transnational crime—manifested in terrorism, organized crime, corruption, cybercrime, and money laundering—has further underscored the indispensability of robust extradition arrangements in the modern era.

In an age characterized by globalization, rapid technological development, and the expansion of cross-border movement, extradition has evolved beyond its traditional conception as a bilateral diplomatic process into a highly regulated judicial and administrative procedure governed by a complex interplay

of domestic and international legal norms. The legal institution of extradition thus embodies the principles of mutual legal assistance, reciprocity, international solidarity, and, importantly, the protection of fundamental human rights. These elements together reflect the dual imperative of enabling efficient inter-state cooperation while safeguarding the rights and freedoms of the individual subject to extradition proceedings.

The implementation of extradition procedures is generally governed by a dual framework:

1. Domestic criminal procedural law, which defines the substantive and procedural requirements for extradition, allocates institutional responsibilities, and determines the rights of the requested person; and

2. International treaties, which establish binding commitments between states and set out uniform standards for cooperation, admissibility of requests, permissible exceptions, and human rights guarantees.

While this dual framework is designed to ensure legal certainty and predictability, it often gives rise to complex legal and practical challenges. These include, but are not limited to:

- The classification of offences as political or military, and the implications for the admissibility of extradition requests;
- The application of the principle of dual criminality, requiring that the conduct in question be criminalized in both the requesting and the requested states;
- The protection of non-refoulement rights, ensuring that individuals are not surrendered to jurisdictions where they face a substantial risk of torture, inhuman or degrading treatment, or unfair trial;
- The need for timely and effective inter-agency coordination between prosecutorial, judicial, and diplomatic authorities; and
- The role of judicial oversight in preventing abuse of process or politically motivated prosecutions.

In the Republic of Azerbaijan, the legal framework governing extradition is primarily enshrined in Articles 499–515 of the Criminal Procedure Code (CPC), which articulate the conditions, procedural steps, and exceptions applicable to extradition requests. This domestic regime is complemented by Azerbaijan's treaty obligations under major multilateral instruments, most notably the 1957 European Convention on Extradition and its additional protocols, as well as a network of bilateral treaties with partner states. Collectively, these instruments set out a framework that is broadly in line with international norms, incorporating both procedural requirements and human rights safeguards.

Nevertheless, the practical implementation of extradition in Azerbaijan reveals a number of persistent challenges. Among these are procedural delays in the handling of requests, incomplete or inconsistent documentation provided by requesting states, and ambiguities in the interpretation of treaty-based or statutory exceptions. Such shortcomings can undermine the effectiveness of cooperation, risk violations of international obligations, and potentially expose the state to adverse findings before the European Court of Human Rights (ECtHR).

The purpose of this paper is to examine both the legal foundations and the practical realities of the extradition process in Azerbaijan. It will provide an in-depth analysis of the domestic legislative framework, assess compliance with relevant international treaty obligations, and evaluate the performance of institutional actors responsible for managing extradition requests. Furthermore, the study will adopt a comparative perspective, drawing on the experiences of other jurisdictions—particularly Germany, France, and Turkey—to identify models of best practice and lessons that may be adapted to the Azerbaijani context. The analysis will not only highlight normative strengths and existing

procedural guarantees but will also uncover implementation gaps that require targeted reforms. In doing so, it will advance concrete proposals for legislative refinement, institutional strengthening, and procedural transparency, with the ultimate aim of enhancing human rights protections and improving the efficiency, fairness, and credibility of Azerbaijan's extradition regime.

2. Legal Foundations of the Extradition Process in Azerbaijani Law

The extradition process in the Republic of Azerbaijan is shaped by a combination of domestic legal provisions and international treaties to which the country is a party. The primary domestic source is found in Articles 499–515 of the Criminal Procedure Code (CPC), which comprehensively regulate both the substantive and procedural aspects of extradition. In addition, Azerbaijan is a signatory to the 1957 European Convention on Extradition and its Additional Protocols, as well as numerous bilateral treaties that further refine and expand the scope of international cooperation in this field.

Under the CPC, the admissibility of an extradition request depends on several key conditions. The alleged conduct must constitute a criminal offence in both the requesting and requested states, reflecting the principle of dual criminality. The person whose extradition is sought must either have been convicted by a final judgment or face pending criminal prosecution. Political or military offences are expressly excluded from the scope of extradition, and surrender is prohibited where there is a risk of torture, inhuman treatment, or a violation of the right to a fair trial in the requesting state. Furthermore, Azerbaijani nationals generally enjoy protection from extradition, save for exceptional circumstances set out in Article 499.5 of the CPC. These safeguards are intended to balance the country's international obligations with the protection of individual rights.

Requests for extradition are initially reviewed by the Office of the Prosecutor General, which examines whether the materials submitted meet both the domestic procedural requirements and the applicable treaty obligations. The request must be supported by a judicial decision or other document evidencing the initiation of criminal proceedings, a detailed description of the alleged offence, identification data of the person sought, and a legal classification of the conduct with reference to relevant penal provisions. If the Prosecutor General's Office determines that the request is admissible, it is referred to the competent court, which delivers the final decision.

Azerbaijan's treaty-based obligations are extensive. The country acceded to the European Convention on Extradition in 2001, thereby committing to harmonized standards in cooperation with other Council of Europe member states. Azerbaijan is also party to multilateral treaties such as the 1988 United Nations Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances and the 2000 United Nations Convention against Transnational Organized Crime (Palermo Convention), both of which strengthen the legal basis for extradition in cases involving serious transnational offences. This normative framework demonstrates that extradition in Azerbaijan is not merely a technical procedural mechanism but a legal process that reflects broader commitments to human rights and international legal trust. Nonetheless, challenges in both interpretation and implementation reveal the need for legislative refinement and greater procedural clarity.

3. Practical Implementation and Challenges in Extradition Procedures in Azerbaijan

Although Azerbaijan possesses a well-developed legal framework for extradition, the practice of its implementation reveals a series of persistent difficulties. Administrative inefficiencies and bureaucratic delays frequently impede the timely handling of requests, often due to the late submission of required documentation, weak inter-agency coordination, and prolonged judicial review. Such delays undermine the effectiveness of international cooperation and risk breaching the principle of prompt justice, particularly where the requested person is subject to detention.

The classification of offences as political or military represents another complex area. While Article 499 of the CPC explicitly prohibits extradition for such offences, the absence of precise statutory definitions has led to divergent interpretations in practice, creating uncertainty and occasionally triggering disputes between the requesting and requested states.

Human rights protection in extradition cases remains a critical concern. Azerbaijan is bound by the European Convention on Human Rights (ECHR) and the jurisprudence of the European Court of Human Rights (ECtHR), which require that the competent authorities assess whether the requested person faces a real risk of ill-treatment or an unfair trial. In practice, however, individualised risk assessments are not always conducted with the required rigour, particularly in politically sensitive cases, raising concerns about full compliance with the principle of non-refoulement.

Institutional capacity also poses limitations. The absence of specialised judicial chambers or judges with advanced expertise in international cooperation law results in inconsistencies in the application of legal standards, especially in matters of procedural safeguards and proportionality. Furthermore, the centralised role of the Prosecutor General's Office in the decision-making process can overshadow the adversarial nature of proceedings, reducing opportunities for independent judicial scrutiny.

Finally, the lack of transparency and legal certainty in extradition proceedings is evident in the absence of public reporting, limited access to procedural guidelines, and insufficiently codified appeal mechanisms. This opacity can impede the ability of defence counsel to effectively challenge extradition decisions and undermines public confidence in the system. Addressing these gaps will require not only legislative adjustments but also a cultural shift towards greater procedural openness and accountability.

4. Comparative Perspectives and Case Studies

The extradition systems of Germany, France, and Turkey reveal important variations in institutional design, constitutional safeguards, and the integration of human rights protections. Each model offers lessons—both positive and cautionary—for Azerbaijan's ongoing development of its own extradition framework.

In Germany, the constitutional order plays a decisive role in shaping extradition policy and practice. Article 16 of the *Grundgesetz* (Basic Law) prohibits the extradition of German nationals except in strictly defined circumstances provided by law or international treaty. The Federal Constitutional Court exercises close scrutiny over extradition decisions, ensuring that they comply with fundamental rights such as the right to dignity, legal certainty, and effective judicial redress. German courts are required to conduct an individualized risk assessment in every case, considering potential exposure to torture, unfair trial, or political persecution in the requesting state. This strong judicial oversight is reinforced by the Law on International Mutual Legal Assistance in Criminal Matters (*IRG*), which mandates judicial review for all incoming and outgoing extradition requests. The combination of constitutional guarantees, statutory clarity, and judicial rigor creates a system that prioritizes proportionality and legality in cross-border cooperation.

France operates a dual-control system grounded in the *Code de procédure pénale* and international conventions. The Ministry of Justice handles the diplomatic aspects of extradition, while judicial authorities determine legal admissibility. Within the judiciary, the *Chambre de l'instruction* of the Court of Appeal examines the legality of the request, the qualification of the alleged offence, and the compatibility of the proceedings with human rights standards. French jurisprudence places particular emphasis on compliance with Articles 3 and 6 of the European Convention on Human Rights, which protect against torture and guarantee the right to a fair trial. French courts frequently refuse extradition where evidence indicates systemic deficiencies in the requesting state's judicial system, thereby demonstrating a model of legal cooperation that is firmly anchored in human rights considerations.

In Turkey, the extradition process is regulated by the Code of Criminal Procedure (*CMK*) and relevant treaties, with the Ministry of Justice and the Court of Cassation holding primary responsibility. However, both domestic and international observers have expressed concern over the politicization of extradition requests, insufficient judicial independence, and limited access to effective remedies. The Venice Commission and United Nations human rights bodies have criticized the adequacy of judicial review, particularly in politically sensitive cases, and noted that the absence of specialized judicial bodies and the frequent resort to emergency decrees have undermined procedural safeguards.

From these three models, several conclusions emerge for Azerbaijan. Germany exemplifies how strong constitutional protections and rigorous judicial review can ensure that extradition does not undermine fundamental rights. France illustrates the benefits of a dual-track system that balances diplomatic coordination with independent judicial scrutiny, particularly through robust human rights vetting. Turkey, conversely, highlights the risks of political influence over judicial processes and the need for clear, stable procedures insulated from executive control. For Azerbaijan, these experiences point to the necessity of establishing specialized judicial mechanisms, embedding individualized risk assessments consistent with ECtHR standards, avoiding automatic or overly broad prohibitions, and fostering transparency alongside cross-agency cooperation, while fully respecting the principle of non-refoulement.

5. Recommendations and Conclusion

An assessment of Azerbaijan's extradition framework through both domestic and comparative lenses reveals that significant progress has been made in establishing a legal basis for international cooperation. The country's accession to key European and United Nations instruments, combined with a comprehensive set of provisions in the Criminal Procedure Code, reflects a strong formal commitment to the rule of law in cross-border criminal justice. Nevertheless, persistent shortcomings—including procedural delays, fragmented institutional responsibilities, and inconsistent application of human rights standards—continue to undermine the regime's overall effectiveness.

To bridge the gap between formal compliance and practical implementation, Azerbaijan should consider a series of targeted reforms. Legislative measures could include the creation of specialized judicial chambers or the designation of judges with expertise in extradition and international cooperation law, ensuring consistency and competence in decision-making. Periodic judicial review mechanisms, particularly in cases involving prolonged detention pending extradition, would help prevent arbitrary deprivation of liberty and uphold proportionality. Clear statutory criteria for assessing human rights risks should be codified, ensuring that extradition is denied where there is a real risk of torture, inhuman or degrading treatment, or unfair trial, in line with ECtHR jurisprudence and the non-refoulement principle.

Institutional reforms should focus on strengthening inter-agency coordination. Improved communication between the Prosecutor General's Office, the Ministry of Justice, and the judiciary would reduce delays and enhance procedural integrity. Capacity-building initiatives for judges, prosecutors, and defence lawyers—covering comparative extradition law, human rights obligations, and international cooperation—would promote more informed and consistent practice. The introduction of a secure digital case management system could streamline the exchange of documents, improve transparency, and facilitate the compilation of statistical data for public reporting.

Human rights protections must also be reinforced. All extradition cases should be subject to rigorous, individualized assessments of potential risks in the requesting country, with general diplomatic assurances being insufficient unless independently verified. Greater integration of ECtHR jurisprudence into national legal education and judicial reasoning would strengthen coherence with European

standards. Finally, individuals facing extradition must have access to effective remedies—independent, timely, and capable of halting surrender in cases involving human rights concerns.

In conclusion, extradition remains a cornerstone of modern international criminal justice cooperation, enabling states to address transnational crime while upholding the rule of law. Azerbaijan's current framework, while substantially aligned with international standards, requires further refinement to achieve its full potential. Drawing on the strengths of systems like those of Germany and France, and avoiding the pitfalls observed elsewhere, Azerbaijan can develop an extradition regime that balances the imperatives of state sovereignty and international cooperation with the protection of individual rights. Achieving this balance is not only a matter of fulfilling treaty obligations; it is a constitutional duty and a vital marker of democratic maturity.

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REVIEW OF THE RADIOLOGICAL EXCESS LIFETIME CANCER RISK ASSESSMENT IN TOBACCO CIGARETTE

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ABSTRACT

Smoking is known to be the primary cause of lung cancer globally, however, there hasn't been any significant reduction in its use. Tobacco cigarette smoke contains many carcinogenic constituents including poisonous chemical compounds and as well as natural radionuclides in significant quantities. About 35% of natural radionuclide of ^{210}Po and ^{210}Pb, decay daughters of ^{222}Rn reaches the lungs via smoking and as a known alpha emitter with a high Linear Energy Transfer gives concern for its study in tobacco cigarette. Evaluating the ^{210}Po and ^{210}Pb activity concentrations in tobacco cigarette brands and subsequently estimating the annual effective dose and its corresponding excess lifetime cancer risk on humans is of utmost importance, as it reveals the level of risk the public is exposed to. Nonetheless, there seems to be an unduly over estimation of the excess lifetime cancer risk as most studies seems to consider the full life expectancy of smokers without considering relative non-smoke age period. Hence, this study reviews the assessment of excess lifetime cancer risk of ^{210}Po and ^{210}Pb via tobacco cigarette smoking in existing studies and propose for considering and recommendation, a relook at the factors for its assessment, such as the life expectancy period, relative non-smoking age period, and appropriate dependency of global comparative methods.

Keywords: Tobacco Cigarette, Excess Lifetime Cancer Risk

ABOUT THE EFFICIENT MANAGEMENT ALGORITHMS FOR E-COMMERCE MODELS AND THEIR APPLİCATIONS

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ABSTRACT

The e-commerce market is highly competitive, with companies constantly innovating to attract and retain customers. To get the most up to date financial information, looking at resources that track market capitalization, like those found on websites that provide financial data, is very useful.

Developing a robust strategy management algorithm for e-commerce models involves a multifaceted approach, blending several types of data analysis, predictive modeling, and adaptable decision-making.

This article is devoted to argues for the incredibly important role of Deep learning algorithms in e-commerce (EC) sector and proves what a powerful tools for driving significant advancements in various aspects of consumers interacting online retail

The modelling of dynamical systems of customer relationship networks helps organizations significantly enhance their online presence, drive business growth with valuable sales, and build lasting customer relationships.

The graph diagram network is a useful tool for business agencies to create customers' networks and visualize relationships between entities, making it easier to identify patterns and trends. One of the big challenges is to provide efficient exploitation of a wide spectrum of sales in customers' networks into e-commerce models.

The paper examines the issues and challenges for EC models to predict the organization's most valuable customer segment and clustering of well-defined consumers to solve optimization problems of sales management for the company.

For consideration the optimal network of e-commerce user's service within the B2C (business-to-consumer) model has been investigated. The EC networks of users and their interaction with products via generalized BFS (breadth-first search) algorithm and backward DP (dynamical programing) approaches is explored. The graph embedding approach for analysing large datasets of consumers has been implemented [1]. The k-means clustering algorithms of customer segmentation to identify groups of customers on the base of their purchasing behaviour and other relevant data have been created [2].

As a result of applying in this development clustering algorithms to customer data, e-commerce businesses can define and understand distinct customer segments. This leads to a number of strategic advantages:

- Defined Customer Profiles by Clustering their purchasing habits, preferences, and behaviors.
- Gain insights into customer behavior and market trends.
- Make data-driven decisions about pricing, promotions, and product development

The tools applied in this development are based on the overview of EC strategies, graph theory and deep learning application for Ecommerce.

This work is interdisciplinary and includes areas of EC, applied mathematics and computer sciences. The result is provided on the applied and fundamental levels.

Keywords: e-commerce; management; algorithm; graph theory.

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SOCIAL MEDIA PLATFORMS' ROLE IN DIGITAL ENTREPRENEURSHIP

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ABSTRACT

In today's rapidly changing business world, digital transformation, a key driver of competitive advantage and sustainable growth, highlights social media platforms as powerful tools. These platforms have become an indispensable part of the digital entrepreneurship ecosystem, offering innovative solutions for establishing, promoting, and scaling businesses. Platforms like Facebook, Instagram, LinkedIn, TikTok and YouTube go beyond basic communication, providing features that support marketing, customer engagement, and brand building.

Social media platforms enable digital entrepreneurs to reach wider audiences at low costs. Targeted advertising and organic content strategies facilitate effective connections with specific demographics, while advanced analytics tools help businesses understand consumer behaviour and optimize strategies. Integrated e-commerce features bridge the gap between product discovery and purchase, while direct communication channels enhance customer loyalty and trust, fostering long-term relationships. However, entrepreneurs face challenges such as intense competition requiring strong and creative strategies to stand out, algorithm changes impacting visibility, and the significant time and resource demands of social media management and content creation, particularly for small businesses.

This study examines the transformative role, advantages, and challenges of social media in digital entrepreneurship. It concludes that while social media platforms provide unique opportunities for innovation and growth, success requires strategic planning, adaptability, and continuous engagement. By addressing these complexities, digital entrepreneurs can effectively leverage the power of social media to shape the future of their businesses.

Keywords: Digital transformation, social media platforms, social media strategies, digital entrepreneurship, digital entrepreneurship ecosystem.

ENHANCING THERAPEUTIC MANAGEMENT THROUGH HEALTHCARE DIGITIZATION: A THEORETICAL APPROACH

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ABSTRACT

Healthcare systems are undergoing a fundamental shift toward digitization, which has profound implications for therapeutic management. Rapid advances in connected health, mobile technology, AI, and VR/AR techniques are transforming the way patients are diagnosed, treated, followed-up, and monitored. Digital health is expected and hoped to improve patient access to healthcare information, facilitate continuous monitoring and communication between the patients and their healthcare providers, and help to effectively and consistently reduce every traditional healthcare limitation This paper explores the theoretical underpinnings and emerging applications of healthcare digitization, with a focus on how digital tools enhance therapeutic outcomes. By adopting a qualitative, literature-based methodology, the study synthesizes current research on electronic health records, artificial intelligence, real-time monitoring technologies, and patient-centred digital platforms. The analysis is structured around three key pillars: (1) the integration of digital data, (2) optimization of communication processes, and (3) real-time adjustment of therapeutic interventions. The paper also addresses the challenges inherent in digital transformation, such as data security, interoperability, and patient consent. Theoretical insights highlight the role of digitization in enabling more efficient, personalized, and responsive healthcare. This study contributes to the academic discourse by offering a comprehensive foundation for future empirical research and by emphasizing the strategic relevance of digital innovation in improving therapeutic management.

Keywords: Digital healthcare, patient-centered care, data integration, real-time monitoring, health equity.

INTRODUCTION

Over the last decade, healthcare has experienced a digital revolution. Rapid advances in connected health, mobile technology, AI, and VR/AR techniques are transforming the way patients are diagnosed, treated, followed-up, and monitored. Digital health is expected and hoped to improve patient access to healthcare information, facilitate continuous monitoring and communication between the patients and their healthcare providers, and help to effectively and consistently reduce every traditional healthcare limitation (Tornincasa et al., 2022). Patient-centric digital health solutions (DHs) are transforming the management of chronic diseases. Nowadays diabetes, hypertension, obesity, asthma or respiratory insufficiency, sleep apnea, and cancer, just to name few, can be continuously monitored and managed through digital technologies and tools. Solutions are, for the most part, disease specific and are usually tailored to the diseases, healthcare processes, patients' profiles, patient healthcare systems of the different countries where they are implemented. Thus, the implementation of these solutions in a seamless manner globally is still a challenge.

RESEARCH METHODOLOGY

This paper adopts a theoretical and exploratory research design aimed at synthesizing current knowledge on the digitization of healthcare and its implications for therapeutic management. Given the complexity and multidimensionality of the topic, the study is grounded in a qualitative, literature-based methodology, which allows for the conceptual examination and critical integration of existing academic discourse, empirical studies, and policy documents.

The primary research objective is to understand how digitization enhances therapeutic management, particularly through data integration, real-time monitoring, and communication technologies. Specifically, the paper aims to:

- Examine the mechanisms by which digital tools facilitate improved therapeutic outcomes.
- Identify key technological enablers such as AI, telehealth, and electronic health records that support patient-centered care.
- Highlight challenges and ethical considerations associated with the implementation of healthcare digitization.
- Explore the impact of digital transformation on communication flows and decision-making processes in healthcare systems.

Sources were selected based on relevance, academic rigor, and recency. The reviewed literature includes peer-reviewed journal articles, theoretical frameworks, empirical studies, and technical reports published in reputable medical, health policy, and information systems journals. These sources were analyzed through thematic categorization aligned with the main pillars of the study: data integration, communication, and real-time therapeutic adjustment.

Given the theoretical nature of this work, no primary data were collected. Instead, the study contributes by organizing and interpreting existing knowledge to create a conceptual model of healthcare digitization's role in therapeutic management. This approach supports the development of a critical perspective and offers an informed foundation for future empirical research.

OVERVIEW OF HEALTHCARE DIGITIZATION AND THERAPEUTIC MANAGEMENT

Digitization of healthcare is defined as utilising technology to switch from manual management to complete automation of patient undergoing treatment of any sort. In the first stage of healthcare digitization, paperless entry of patient details into a computer and its usage during treatment would be classed. Automation in healthcare is described as the technology being integrated into the treatment measures of a patient undergoing a therapy. The point at which the doctor has to be communicated the problems in treating a medication is usually tedious work but here, after the feedback entered into the computer, it automatically understands the treatment according to the robotic rules to be mentioned or programmed with a data-oriented code. Any kind of scenarios in which the entered medication can’t progress further for the particular stage of treatment shows no progress or outcome along with failure or adverse effect of health along with the person to who it was administered. Other kinds of processing are feasible without doctors, in which therapy can be imparted to the patient without human intervention.

Therapeutic management refers to various health interventions such as screening, diagnosis, treatment, and preventative services throughout the life cycle. Screening covers screening for diseases or conditions by objective criteria and processes. Diagnosis covers health assessment and diagnosis to identify the existence and causes of symptoms observed in the patient. Treatment covers management through medical, surgical, or other therapeutic procedures to control or cure conditions diagnosed at

previous stages. Preventative services include improving conditions and preventing the onset of health conditions harmful to the patient.

Data Integration in Healthcare

In recent years, healthcare digitization has become a pressing priority worldwide. Healthcare digitization is transforming the entire therapeutic management process, which involves how patient care is delivered across different channels, starting from initial patient intake, image acquisition, and data entry, to a final diagnosis and corrective action being taken.

As a result of healthcare digitization, there is an unprecedented amount of patient data (both visual and non-visual) being generated every single moment, which constitutes a rich source for improving the healthcare management. However, there are technical, policy, and human issues that forbid any analytics or even integration across these systems. Each of these systems is usually non-proprietary and does not share any of the patient data stored within. Even the ones that are sharing such data instance-wise, these data are reformatted and anonymized on-the-fly. Hence, aggregation, transformation, and interpretation of these derived indicators or values back to the encoded source data are rendered impossible (Clay et al., 2021). Besides this, there are also a lot of challenges regarding value extraction, which can be categorized into heterogeneity, timeliness, noise and incompleteness, complexity and high-dimensionality, and finally, intellectual properties.

Health insurance guideline-based chronic disease management programs throughout the majority of industrialized countries are being significantly revisited from traditional water-fall counseling or multi-step interventions implemented by health coaches on patients' presenting symptoms, comorbidity, and living or health risk behavioral habits. End-to-end machine learning-driven real-time system integration to connected devices, crowdsourced sensing, and patient data mining, along with, focusing on behavior change or health nudging instead of pure knowledge transfer, can reinforce the structure of diagnosis in the management of chronic diseases.

Moreover, using smartphones or wearables, intentional interventions, as a digital therapeutic for chronic disease patients should be classified into types which are particularly scalable across disease categories applied to disease, symptoms or the risk, patients' state or monitorable biomarkers, and device to be used for delivering the medical knowledge then to guide the intervention. Evidence-based medical knowledge of chronic diseases to be digital therapeutics should be in the development phase of Software as a Medical Device (SaMD) focusing on the risk of civil malpractice suits. Big-data mining-based mass-scale and cost-effective class I SaMDs should also be pursued either, however, bearing the high incidence risk on the generating error or meaninglessness derived from numerous mixed data and tools.

The ability of devices to collect the accuracy of raw biometric and descriptive health data on the development of digital therapeutics is indispensable to enhance the utilities of medical devices. SaMDs initially targeting chronic diseases should start with large delay after establishing collaborative ecosystems around medical or governmental organizations, riding the wave of existing non-device data sources. (Na et al., 2023)

Challenges in Data Integration

While recent efforts have been made to reform and improve the healthcare system and may be perceived as a contradiction, there are technical obstacles to complete system integration in healthcare, which has been an overemphasized objective. Significant gaps exist in information interchange and accessibility throughout the healthcare chain. Efforts are required to ensure a nation-wide standardization of the technical framework that establishes the tools for the acquisition and interchange of healthcare information.

In today's era, hospitals around the globe are beginning to invest in software and hardware systems that will enable them to replace the current paper-based patient chart system with electronic medical records (EMR). These healthcare management systems will help in the electronic collection, monitoring, and viewing of patient information, thereby facilitating the easier transfer and viewing of information supplied by different healthcare providers. However, such simplifications contain slight wishful thinking as healthcare and medical facilities have generated more detailed medical data than any other services industry (Mavrogiorgou et al., 2019). Data collection and upkeep are complicated enough in smaller widespread health maintenance organization offices, let alone in substantial healthcare dense locations whose records are interspersed amongst a variety of different systems. Therefore, currently, sharing patient data post-visit is rare. The concerns are the lack of standardization, which would permit simple searching of data irrespective of vendor, and the vital issues of trained healthcare worker concern in supplying the data due to national ignorance on the healthcare worker's trustworthiness and role in the data-sharing decision.

Since the choice of software would need to be obvious, there would likely be an impact on the competition of the numerous companies with products in similar markets. As coding systems become standard, differences that are not displayed in refining data might fall. The current trend toward web-enabled healthcare systems, which would run directly in browser windows and access records from any station with sanitation, will likely make significant inroads into the healthcare record preservation area. These solutions are more portable and scalable and display the possibility of becoming generic systems. Healthcare broadcasters should also invest heavily in healthcare web destinations that treat patient information in sophisticated formats.

Technological Solutions for Data Integration

Healthcare digitization holds enormous potential to enhance the therapeutic management of patients and their wellbeing by increasing access to care services, improving the way patients move through the care chain, and allowing for more patient-centered service and care processes. The digitization of health services promises to greatly enhance the speed, accuracy, and quality of healthcare provider decisions and actions. The trustworthiness, transparency, and portability of patient care data and records promise to greatly improve their quality. More concrete expert interaction and improved management decisions also promise to improve the allocation of care resources (Øvretveit, 2017). Though still in their infancy, the prospects of advances in biomedical and blockchain technologies for health care are almost limitless.

Healthcare digitization opens up new avenues for improving the quality of treatment and care. At the individual level, recommendations for the need-based adjustment of treatment and care are made on the basis of observational data regarding the longitudinal monitor of health and wellbeing. At the care system level, care coordination processes are accelerated by sharing patient data across care systems, structures, functions, and providers (Mavrogiorgou et al., 2019). The unification, integration, and matching of treatment and service activity plans improve the quality of care delivery and multitude of care data sources enhances diagnosis making. At the transversal co-provision level, the increase of interaction and support opportunities enhances collaborative treatment and care.

IMPROVED COMMUNICATION IN HEALTHCARE

Over the years, healthcare digitization has enhanced communication between patients and care providers. Electronic Health Record (EHR) platforms send alerts to patients, informing them about possible health concerns and prescription refills. Telehealth communication platforms enable patients to message their physician's office directly from the application. Patients can access a wealth of medical knowledge and visit their healthcare providers' websites or portals to learn about preventive interventions and treatment options. Through healthcare portals and health-related web pages, patients

can connect with the correct care team member for their health issues, assigned to the best care provider, and even share real-time health metrics with them. This has made it easier for many patients to gain trust in their care providers. In addition to patients, healthcare administrators converse internally through chat services and check on the performance of the different departments.

Although healthcare communication has improved in many ways through digitization, many areas still need to improve. A considerable gap still exists in communicating with some people, like individuals in underserved areas, non-English speaking people, and the elderly. Although healthcare digitization provides a wealth of knowledge directly to the patient, research indicates that it causes anxiety, confusion, and lack of trust in care providers and care. To mitigate communication problems in underserved areas, healthcare organizations can leverage telecommunication technologies, call centers, and community organizations to meet communication needs.

Role of Communication in Therapeutic Management

Therapeutic management accountability necessitates relevant, organized, and timely communication. It involves identification of issues, data sharing and understanding, exposition, and incorporation of treatment means necessary for therapeutic management development. Communicative inertia, distractive communication, and incapacity to deliberate on complex issues prevent rational thinking and action in this respect. Identifying patients with capacity to explore a specific issue, giving clear, relevant, organized responses, and encouraging deliberation and inquiries on the exchanged information are a few strategies to enhance adaptive communications (Popa-Velea & Purcărea, 2014).

The monitoring of therapeutic management must represent a pivotal area of health-care digitization. It involves assessments of goal attainment and further issues arisen, data and opinions exposition and understanding towards action planning and coordination. Acknowledge of the therapeutic management effectiveness is a prerequisite for any adjustment, representation, and comprehension of results and obstacles prevent any optimal constructive actions. The recurrentness of the monitoring activity, the comprehensiveness of the data handled, and the dynamics of the monitoring communication are among the factors that can impair patients and health professions' capability to sense, elaborate, and act upon (re)identified issues. Overestimation of the knowledge and motivation prior to the monitoring process, and lack of readiness to search for or share additional information, if assessed pre-maturely, result in communication inertia.

In healthcare digitization, monitoring on the basic points of the previous stage, the results of implemented actions, and the recurrence of therapeutic management update, are paramount issues that must be properly addressed and put into the frame of the necessary communicative processes. Empathy in communication is assumed to encode a pro-social goal or an exertion of calculative estrangement. Carrying out complex health-transforming procedures, such as a surgical intervention requires a detailed account of and awareness for the procedure means, and expectations for the intended realization (Chanoine et al., 2022).

Digital Communication Tools

The digitization of healthcare is revolutionizing the approach to managing health. Information and communication technologies facilitate patient management with caregivers through mobile health applications, automated phone calls, video consultations, etc. The digitalization of healthcare brings issues as legal liability, confidentiality, health disparities regarding income, literacy, and device accessibility; slow adaptation of health organizations, taking time for regulations and additional staff, opposite patients with problems to manipulate devices but also with unproblematic technologies. Telemonitoring, teleconsultations, and secure applications, at the neighbors of formal healthcare offer opportunities in therapeutic management—the patient allowing to manage health information with ICT, communicate with care providers, participate actively in healthcare. Otherwise, lack of privacy,

malfunction devices, malignancy, and credibility were acknowledged. Telemonitoring of health or treatment status allows outsourcing the usual task of exam self-report, such as dietary adherence or self-evaluation of breathing aptitude (Chanoine et al., 2022).

Health applications are numerous. Some are free or concern a broad public and others are paid or reserved for targeted patients depending on a health status or pharmacotherapy. The ability to access health information on the Internet presents a double-edged sword rendering patients victims and actors of their health. Teams may optimize patients' information by linking them to the best information and its adaptation but also thinking about tailoring, chronic diseases, age groups, and Internet knowledge differences. Other issues concern correspondence security regarding confidentiality, relying on the transmission infrastructure to ensure a question has reached the provider; the entity's fault with probable dependency, security flaws, information obtainment.

Barriers to Effective Communication

Communication issues have recently come to widespread attention. Researchers have noticed that all sides of the disease management process are affected by a variety of communication problems. As a result, many scientists have attempted to expand the field of study on therapeutic management communication. Since the first attempts to define and map the components of communication, several researchers have provided reviews of the most substantial models. Therapeutic communication was too different from the academic component and too similar to social conversation according to Schneider, every conversation of the individual patients was different, task-specific, and so implicitly complex. The integration of anthropological, psychological, philosophical, and sociological theories provided a deeper insight into the complex nature of communication and its place in health care (Popa-Velea & Purcărea, 2014).

The well-consolidated understanding of the significance of communication in managing health care resources led to disputes between those valuing data and its transfer, those discussing the populations' needs for information, and the critics warning of the moderation of expected effects. The increasingly complex environment of the health system directly of patients and indirectly influences health service providers negatively impacting communication. Thus, with the attempted extension of electronic means of information transfer, therapeutic communication issues may arise and become less effective in some cases. New communication channels, technologies, and social organizations are emerging. However, all of these factors have added to the complexity without providing new knowledge about how to cover patient needs.

REAL-TIME TREATMENT ADJUSTMENTS

The continued need for individualized treatment to maintain control of chronic conditions remains a significant challenge for healthcare systems around the world, particularly with an aging population and rising disease prevalence (Tornincasa et al., 2022). The digitization of healthcare and treatment regimens present opportunities through in-line programming of therapy which allows the instant transfer of treatment adjustments supported by guidance from the healthcare provider. In such a context, any needed treatment adjustments can be automatically updated in real-time to the therapeutic device from the healthcare provider, increasing patient engagement and awareness of therapy changes that must take effect. This seamless flow of understanding risks signal escalation or underhandling in a timely manner. The ability to rapidly refine treatment proportions or respond to deviations is an essential feature for effective healthcare digitization in chronic therapeutic management.

Tedious workflow for training healthcare professionals on screening scores and streamlining telemonitoring projects with the involvement of multiple patents must be effectively digitized and

streamlined. Easily customizable digital health solutions that increase accessibility and interconnectivity of treatment medication and routine testing culture will help enhance comprehensive healthcare digitization (Man et al., 2024). Alternatively, a practical, psychoeducation framework promoting healthcare professionals' confidence in refining therapeutic management must be established. Mental barriers to monitoring therapeutic management can also threaten digital engagement. Enhancing treatment understanding and confidence in healthcare digitization will allow patients to appreciate its roles.

Importance of Real-Time Monitoring

Patients with advanced heart failure need close surveillance to avoid potential dangerous exacerbations or sudden events. Digital technology can be of great help in this context, thanks to remote monitoring made possible with the use of wearable or implantable instruments. These present an alarming view of the pandemic of heart failure in terms of figures and prognosis. Despite a recognized comprehensive approach that includes pharmacological therapy, device therapy, heart transplantation, and palliative care, the same alarming view applies in terms of detected clinical need and organizational ability to satisfy it (Scardovi & Boccanelli, 2024). In this setting, thinking radical–novel about healthcare management, being aware of the limitations of conventional solutions, is imperative. Patients with advanced heart failure need close monitoring, and digital technology can help.

Remote monitoring is meant to control the patients' status remotely. The monitoring can be tailored for any patient. Looking at the interpretable data visualized by a dashboard can give a helpful overall picture. To follow the trajectories of a given patient, allowing the detection of urgent signals that reproduction of the patient's underlying mechanism would approach in real-time monitoring during ambulatory visits is also needed. This is done by time series. Explorations other than time series, such as heat maps or flow diagrams, can provide useful information for strategies of nearness.

The data relating to the actual benefit in terms of avoidable events are not definitive, but from an organizational point of view, the benefit is evident, both on the part of the patient and of the organization of care. Provided in the form of televisits, further organizational implications are reckoned. This includes a re-modulation of the system, going from a single physical house to a network well-structured with trained personnel, and satisfied in the ethereal realm with digital technologies that are not yet perfectly developed. In this setting, the evolution of artificial intelligence solutions guarantees a rapid refinement of the telemedicine sector. As the natural history approaches its end, close watching is needed to adapt therapeutic measures to rapidly changing conditions. This task can be fulfilled by remote control tools together with the possibility of remaining at home.

AI in Treatment Adjustments

The majority of serious chronic diseases, for example, chronic kidney diseases or diabetes mellitus, among others, benefit from drug treatment that may not provide the expected treatment adjustment. In such cases, therapy management based on clinical practice guidelines (CPGs) may overestimate the treatment effect for individual patients. While the recommendation from CPGs is representative of evidence-based management, clinical decisions have inherent stochasticity and pre-conditions that depend on observations localized in the knowledge space. Thus, reassurance of the expected treatment adjustment is critical for the treatment and prevention of chronic diseases.

Monitoring tools enable users to follow predefined variables over time through observation in their usual setting (Conte & Hawe, 2018). Other terms used in the literature are "movement-tracking" and "tracking tools". Movement here refers to a change in score over time. Monitoring tools record indicators as simple observations and do not inquire into what is seen. Some tools are "static", prompting for all indicators at one moment in time without consideration of time elapsed, change, or stability. Unlike registries and

self-report tools, these tools capture behavior in the real world. Some tools include subscores, but 'monitoring' broadly incorporates global scores and the absence of subscores.

Integration with Patient Care and Impact on Patient Outcomes

Healthcare organizations are moving into an era where digitization in healthcare is becoming more integrated with patient care. Information Technology (IT) is perceived as a valuable tool for enhancing the delivery of patient care. Nonetheless, as medical organizations have come to recognize the significance of IT, they are becoming more aware of its perils and distractions as well. The primary concern of many organizations is the delivery of services that meet, or even exceed, the expectations of patients and their families (Øvretveit, 2017). Attempts to digitize and integrate patient care often focus on IT, forgetting the need for staff commitment, engagement, and ownership. Managers and leaders play an important role in developing a shared vision of the desired management processes and patient experience. Digitization should mainly focus on the enhancement of the therapeutic management process by being centered and driven by patient care.

Digitization in healthcare can mean many things; however, broadly defined, it is the use of healthcare IT that collects and leverages patient-related data. Digitization of health data and records has received ample public attention via news stories of successful e-negotiations and on-line appointments, as well as worries of data security and privacy. A systematic understanding on how this patient-related data can add value to the patient care process is just gaining recognition, however. The origin of digital patient data management can be traced back to the early applications for word processing. In many healthcare organizations, this data management evolved quickly into the monitoring of health status and document generation to enhance communication between medical staff.

With IT tools being more commonly adopted after the 1990s, the health care record and its monitoring application was also migrated to this technology. As health systems matured, digitization started to encompass administrative functions in finance, procurement, human resources, contact, and contract management. IT now pervades policies, directives, and intuitive rules that regulate, harmonize, and control those processes; that run simulations and predictions regarding cost and capacity; that apply algorithms to optimize care pathways. Generally speaking, digitization and process automation in healthcare have matured; however, there remains considerable variation in the extent, e.g., digitization across countries and organizations.

Patient experience is recognized as a strategic priority in health service organizations globally. Yet, measurement of true outcomes remains elusive. This study aligns with recent calls for an integrated and well-documented evidence base to develop diagnostic and benchmarking tools of digital maturity as they link to patient experience outcomes. The findings support the value of digital experience tools as modern-day patient experience management system components that yield returns along the causal chain from digital maturity to improved patient experience outcomes. Results corroborate the take-up and effective implementation of these tools as a necessary condition for the realization of positive patient experience outcomes and offer support for combining improved digital experience with traditional patient experience tools. The documented negative consequences of personal experience discrepancies against desired cultural expectations were also raised and warrant further investigation (Snowdon et al., 2024).

Lessons learned from leveraging solutions are documented, including establishing a digital experience vision and roadmap; creating an integrated digital experience strategy; enacting a professional, multi-disciplinary digital experience governance; upskilling and resourcing optimal delivery capabilities; and establishing stakeholder engagement approaches. The analysis of commented perceptions of both healthcare delivery organizations and patients mine these lessons deeper and explores adaptations of technology-enabled organizational capabilities influencing stakeholder engagement approaches.

Consistent with prior findings, the perceptions of anticipated returns on investment from the effective use of digital tools shifted focus from cost to quality — including improved efficiency, effectiveness, and experience for both patients and staff.

Lessons learned from the pandemic include the need for shared vision, sustained efforts, intra and inter-organizational collaborations, addressing traditional health system risks and work-around protocols, preparedness for unexpected events, and continual investment in technology infrastructures, quality training, upskilling, monitoring, and research. The pandemic accelerated the adoption of previously considered 'disruptive technologies' like telehealth and platforms, leading to unintended consequences of higher volumes of more complex, chronic, poly-morbid patients and exacerbated multi-dimensional health inequities. Calls for a comprehensive "digital health check" have thus emerged, highlighting the need for national data to quantify broad usability, uptake, accessibility, and evaluation of telehealth and other digital health services.

The proposed digital maturity assessment framework to develop a tool that assesses mid-size, low resource, distributed health systems' strategic and operational digital maturity is also presented. Utilization of the framework to guide a National Patient Experience Strategy to advance digital project impact evaluation complements nascent calls for consensus around the definition, strategy, indicators and metrics of digital maturity and its evolution. This important inquiry impetuates a global pro-social good research agenda.

Real-Time Adjustments and Continuous Monitoring

A fast therapeutic adjustment can take place through real-time monitoring. Measurements sent at fixed intervals can take place around-the-clock, allowing professionals to assess how well the patient is responding to the treatment. An example of this is the blood glucose levels being measured every minute and sent through to the HCE either directly or through a mobile application for certain glucose meters. The same flow can be employed by other risk factors' monitoring devices (Zakaria et al., 2024).

Continuous monitoring of blood glucose and therefore real-time adjustment is only barely possible with the clinically validated HCGM system. However, despite being the breakthrough technology in the treatment of type 1 diabetes, this system is expensive and impractical for most diabetic patients, especially in underdeveloped areas. Moreover, some patients are unwilling to take the risk of damaging the sensor, which is applied to the skin for a week or more. Consequently, the pen-worn system remains dominant even in these countries and among some type 1 diabetes patients. As a low-cost alternative, the pen can be equipped with a microcontroller for calculating the predicted glucose value over the next few hours, set by parameters and scenario specification. The calculated predictions would be stored on the pen, giving the patient or the HCE access to this information.

To improve therapy management performance, more precise dosing using better predictive models could be adopted through pressure monitoring together with blood glucose and high blood glucose limits anticipation, or a custom medication regimens using a more complex function, for instance, including AGI, can be combined with the simple ones. Threshold values of this risk factor as well as their immediate and one-step ahead approximation through historic therapy choices can also be found. In cases of unexpected values for which no previous learning could be registered, a fallback crude implementation of therapy can be deployed with proper warning to the professionals.

FUTURE OF HEALTHCARE DIGITIZATION

Digitization is a broad term that encompasses various digital technologies, including software, hardware, and networking technologies that collect, store, and process data. In the health landscape, digitization technologies are rapid technological growth in telecommunications, biotechnology, informatics, and

medicine to make logical increments of our total healthcare knowledge. The potential use of digitization in healthcare accounts for an enormous market opportunity second only to financial services. The future of healthcare is moving toward immensely scalable digital platforms and globally connected networks creating a dynamic, decentralized ecosystem as seen in other industries such as financial services and media (Barbazzeni et al., 2022).

Patient data collection means patients monitoring other days largest drug intervention compared with. Digital passively allows health providers to engage with patients and report higher outcomes. Audio, video, and images are all ways to collect clinical data. Those sensory records create insight using recording and translation software as instruments to measure patient in daily settings. Many interfaces are traded and traded on the level of "with-Smartphone component" devices today without any internal infrastructure dialogue. In healthcare sites, digitally connected sensors for humidity or chemotherapy infusion detection are erected to help establish fault-free treatment venues, and dirt-free operating rooms.

CONCLUSION

Digitalizing healthcare is a huge catalyst towards achieving good quality of healthcare services over a long run. The current review is an attempt to extract available literature that extensively explored the topic. Current literature on this topic has been collected meticulously and the future implications of healthcare digitization has been elaborated. Healthcare digitization can be clearly understood with the boundary conditions of digital health on the basis of the smart digitization framework. Digitalization of healthcare will definitely improve the therapeutic management in a healthcare organization. The technology penetration into healthcare was initially very slow. However, the last few years and events changed this perception. Health and wellbeing has of concern to population across the globe. The ongoing digitization is appropriately addressing many health concerns. It will also play a major part in making healthcare systems more sustainable (i.e., cost-effective and efficient service delivery). Current health systems are less equipped to address increasing care needs due to demographic changes, inefficient service delivery, and imbalanced access to care. Therefore, it is essential to make health systems future-proof by employing new technologies and processes to keep them in balance.

The adoption of electronic health records is generating a huge amount of healthcare data across institutions. These data are heterogeneous and have yet to be properly exploited. A patient-centered storage platform with active sharing and management policies should be smartly designed to leverage the accurate and timely management of healthcare. Current prognostics assist in making post-operation decisions but need to be improved towards accurately predicting the personalized health status and adopting efficient healthcare measures. The vast amounts of data generated around the healthcare of patients should be exploited to build smart prognostics with proper management policies. Reliable and valid health risk assessment techniques are needed for rapid screening triage and allocation of scarce resources.

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SIMULATION OF THE MOIRE EFFECT IN CUBIC LATTICES

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ABSTRACT

A computer simulation of the moiré effect in a three-dimensional body (cube) from a finite distance was performed. This effect is essentially multilayered and three-dimensional; it disappears when the number of layers is less than four or five [Applied Optics, 62, 2792–2799 (2023)]. The lattice nodes (finite-size voxels) are located in accordance with three cubic crystal systems (simple, body-centered, and face-centered). For each system, the virtual camera can have three positions: opposite the face/edge center and opposite the cube vertex. The camera axis is directed to the origin (the cube center).

The moiré patterns form "corridors" of reduced density connecting reference points (such as vertices, face centers, etc.). The widest corridors connect the projections of the cube vertices; there are perpendiculars to them. The tangents of the angles of the wide corridors in the three cameras are related as 1:√2:√3, and near the origin, the corridors of the edge/vertex cameras can be obtained by compressing the corridors of the face camera in the appropriate ratio. These properties are observed in all three systems. The results can be applied in crystallography and used in volumetric 3D displays, in particular, based on a 3D LED array.

Keywords: Moiré effect, 3D moiré, Volumetric display, Multilayer moiré, Cubic lattice moiré.

MANAGERIAL COMPETENCIES FOR MANAGING CHANGE AND INNOVATION IN NGOS OPERATING AS SERVICE PROVIDERS FOR THE ICBF IN THE CITIES OF CALI AND BOGOTÁ

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ABSTRACT

This research is situated within the dynamic and challenging context that characterizes the operational environment of Non-Governmental Organizations (NGOs), where the effective management of change and innovation emerges as a critical factor. Recognizing the fundamental role of NGOs in social protection and in responding to community needs, this study aimed to analyze the managerial competencies required for managing change and innovation in NGOs that operate as service providers for the Colombian Institute of Family Welfare (ICBF) in the cities of Cali and Bogotá. Methodologically, a qualitative approach with a descriptive design was adopted. Data collection was conducted through the administration of self-administered questionnaires and the completion of semi-structured interviews with directors and key stakeholders from the selected NGOs. For the analysis of the information obtained, double-entry analytical matrices were implemented, facilitating the systematic classification and synthesis of data. The research results made it possible to identify both internal and external factors that influence the management of change by NGO directors collaborating with the ICBF. Additionally, the specific skills and competencies held by these directors were assessed, along with the technological tools available to and used by the organizations. The findings reveal the need to reconsider the alignment of managerial competencies for managing change and innovation at all organizational levels, from strategic leadership teams to operational bases. The study highlights the presence of resistance to change within organizations, underscoring the importance of ensuring institutional viability in a constantly evolving environment. In conclusion, the research provides significant insights for understanding the challenges and opportunities involved in managing change and innovation within the sector of NGOs serving as ICBF operators.

Keywords: Change management, NGOs, Innovation, Systemic approach, Managerial competencies.

INTRODUCTION

Non-governmental organizations (NGOs) now constitute a fundamental pillar of civil society, fulfilling complementary social functions to those of the state. Unlike traditional volunteer-based organizations, contemporary NGOs are managed by professional teams and serve as employment sources, reflecting an organizational and ideological structure in constant transformation (Sorj, 2007). Today, they face challenges such as dwindling resources, heightened competition, and evolving social demands, compelling them to optimize resources and adopt flexible strategies. For instance, in Kenya, funding reductions forced NGOs to overhaul their operational approaches to align with the requirements of donors, governments, and local communities (Ochieng, 2013).

Global crises, such as the plight of children in residential care, further underscore the urgency for adaptive NGO strategies. Eastern Europe, East Asia, and the Pacific report alarming rates of

institutionalized children, 192 and 153 per 100,000, respectively (UNICEF, 2017). These figures highlight the need for NGOs to innovate intervention frameworks and partnerships to prioritize child welfare. Despite these imperatives, a significant gap persists in NGOs' adoption of technology and innovation. According to ESADE (2018), only 50% of NGOs integrate new technologies into their programs, and a mere 40% plan to develop digital services, limiting their responsiveness in the digital era. In Latin America, NGO-state relations have evolved through mutual learning and regulatory adjustments, particularly after the ratification of the Convention on the Rights of the Child (UNICEF, 2006). This shift necessitated organizational reforms to establish safe environments for children, driven by factors such as increased international funding, donor pressures, and globalization (Bebbington & Thiele, 2005).

In Colombia, NGOs working with the Colombian Institute of Family Welfare (ICBF) grapple with constant shifts in regulations, funding, and social needs. The 2006 Code for Childhood and Adolescence (Law 1098) and ICBF guidelines define their operational models (Bienestar Familiar, 2023). While NGOs in cities like Cali and Bogotá have pioneered trauma-informed approaches and staff capacity-building (Fundación Chiquitines, 2023), not all organizations adopt such best practices or leverage collaborative opportunities. Transparency deficits in internal operations further hinder impact assessments (Edwards, 2009) and evidence-based change management. ICBF impact evaluations have exposed gaps in infrastructure, nutrition, health, and psychosocial development, prompting strategy revisions and underscoring the need for an evaluation culture (González & Durán, 2012). As of 2024, 69,496 children and adolescents remain under state protection (Bienestar Familiar, 2024), emphasizing the urgency for systemic adaptation.

Scholars have studied organizational change since the early 20th century. Henri Fayol redefined managerial roles by identifying core functions, planning, organizing, directing, coordinating, and controlling, laying the groundwork for modern administration (Santos et al., 2021). Frederick Taylor's scientific management emphasized efficiency and task optimization, while Henry Zimmerman viewed organizations as social systems interacting with their environments. Elton Mayo introduced human and emotional factors, stressing labor relations (Chiavenato, 2021). Post-World War II, the emergence of NGOs like Save the Children marked a turning point in child protection during conflicts, setting precedents for organizations requiring specialized competencies in complex social contexts (Vega & Salinas, 2020). In Colombia, the ICBF's institutional evolution since 1968 reflects these shifts, particularly in serving children affected by violence or neglect.

Conceptually, organizational change involves systemic, cultural, and procedural transformations to adapt to new conditions (Purvis & Cross, 2013). Cummings et al. (2016) frame it as deliberate interventions to alter structures, technologies, or behaviors, while Kotter (2012) prioritizes urgency and shared leadership. For NGOs, these models require adaptation to address socio-humanitarian specificities. Child protection NGOs demand additional considerations: emotional management, crisis decision-making, and interinstitutional coordination (Vega & Salinas, 2020). In Colombia, however, the lack of formalized competencies hampers implementation within the ICBF and allied NGOs. Recent studies identify structural and cultural barriers to sustainable change, including high staff turnover, precarious employment, and insufficient managerial training (Martínez et al., 2022). These findings underscore the need for tailored change-management strategies in Colombian child-protection NGOs. This study thus aims to identify key leadership competencies for change management in ICBF-affiliated NGOs, analyzing their adaptive challenges and strategies.

MATERIALS AND METHODS

For the development of this research, a qualitative approach was adopted. This choice was not arbitrary; rather, it responds to the need to delve into the lived relationships and subjective experiences of the

participants involved (Lafuente & Egoscozábal, 2008). The qualitative methodology allows for immersion in complex contexts, offering flexibility to interpret social realities from the perspective of the actors themselves, a characteristic that would not be feasible through more rigid quantitative methodologies. According to Sarango et al. (2024), the classification and typologies of research provide a useful framework for understanding the diversity of approaches applicable to knowledge exploration, taking into account aspects such as the study's purpose, the nature of the data, and the method of analysis. This qualitative approach is grounded in the use of descriptive data obtained from the words, narratives, and observable behaviors of the participants. It is guided by criteria such as flexibility in design, holistic and humanistic understanding, and an empirical process aimed at uncovering subjective processes in their natural context (Lecanda & Garrido, 2002).

Once the methodological approach was defined, this research was classified as descriptive in nature, as its purpose is to characterize specific social phenomena within a defined timeframe. According to Caus (2015), descriptive research enables the specification of key properties of individuals, communities, or situations, measuring the selected variables independently to describe them and to generate an initial diagnosis of the phenomenon under study. This type of research is particularly suitable for analyzing complex phenomena, as it allows for the precise organization and classification of their characteristics, while also enabling a critical review and identification of prior conceptual and methodological limitations (Arandes, 2013). The selected population is composed of executives, administrative staff, and direct caregivers (trainers) from five organizations within the child protection system of the Colombian Institute of Family Welfare (ICBF), located in Cali and Bogotá. As Lerma (2009) notes, the population in research consists of a group of individuals with similar characteristics who constitute the focus of study. In this regard, inclusion criteria were established to select active employees occupying the defined roles, thereby ensuring a relevant and sufficient sample to achieve the stated objectives. The projected sample comprises 90 individuals, selected through non-probabilistic purposive sampling, targeting participants with specific and accessible profiles—a technique especially appropriate for qualitative social research (Alaminos, 2006; Hernández & Ávila, 2019).

Two techniques were used for data collection: a self-administered questionnaire and a structured interview. The self-administered questionnaire enabled participants to respond autonomously and reflectively, without the direct influence of the researcher, thus reducing potential bias and facilitating access to a larger number of participants (Bryman, 2016). Complementarily, structured interviews were conducted, designed with standardized questions that ensure the comparability of responses, a technique that, according to Sabino (2002), is useful for collecting homogeneous and clear data in qualitative studies, as it facilitates the identification of both shared perceptions and divergences among the different actors regarding the same phenomenon.

Finally, the fieldwork phases were structured following the methodological recommendations of Patton (2015), who proposes an orderly process that spans from problem definition to the interpretation of results, prioritizing the usefulness of the findings for those who participate and make decisions within the study context. The implementation of these phases ensures methodological rigor consistent with the complexity of the phenomenon analyzed, and systematically organizes the documentary review, methodological design, data collection, analysis, and interpretation of findings, while maintaining an ethical, participatory, and context-sensitive perspective.

RESULTS

This section presents the main findings of the research, integrating quantitative data and in-depth interview narratives to provide a comprehensive view of managerial competencies in NGOs. The results are organized according to the study's objectives and linked to the theoretical framework for a deeper discussion. The empirical basis of this study was built through a mixed-method approach, which

included nine in-depth interviews with executives and 81 surveys administered to staff from five NGOs operating under the Colombian Institute of Family Welfare (ICBF) in Cali and Bogotá. The surveyed sample was predominantly female (71 women, 11 men) and had high representation in operational and administrative roles.

The quantitative results revealed noteworthy perceptions regarding management and leadership. The categories *Change Management* (average 3.87) and *Managerial Competencies for Change* (average 3.67) received the highest ratings, suggesting that these organizations are managing to adapt to transformations. However, the categories *Innovation* (average 3.53) and *Training* (average 3.63) scored slightly lower. This indicates a potential gap: while NGOs are capable of handling change, they struggle to translate it into creative or disruptive solutions, partly due to the lack of continuous training. Analysis by sociodemographic variables revealed significant trends: individuals with technical training had the most positive perceptions, whereas those with master's degrees exhibited a more critical outlook, particularly regarding innovation. This may reflect a contrast between an operational perspective and a more critical structural vision. The 36–45 age group gave the highest ratings in most categories, suggesting that the combination of experience and adaptability is a key factor in perceptions of organizational effectiveness. Notable variations were observed among the foundations, pointing to organizational culture, leadership styles, and access to resources as determining factors in performance.

The qualitative analysis, aimed at identifying the factors influencing change management, highlighted the high dependency on ICBF guidelines. Executives reported that contractual changes, budget instability, and regulatory uncertainty are external barriers that compromise planning and team motivation (E02, Bogotá). Internally, cultural resistance was identified among long-standing staff, a phenomenon that, according to Lewin's theory, requires the "unfreezing" of established structures in order to advance (Sandoval, 2016).

In this context, soft skills such as adaptability and emotional intelligence emerge as essential. Leaders have had to act as emotional mediators for their teams, managing uncertainty and fatigue, underscoring the importance of leadership capacity in addressing both tangible and symbolic barriers, as proposed by Kotter (1996). The findings show that managerial competencies extend beyond the technical domain, valuing situational and emotional leadership grounded in experience, intuition, and contextual awareness. One executive noted: *I have had to accompany my team through difficult moments, being more than a boss, being a guide* (E01, Cali). This perspective aligns with Goleman (2006), who emphasizes the crucial role of empathy and self-regulation in crisis environments. Decision-making is often carried out without complete information, a process Schön (1992) describes as reflection-in-action, in which leaders adjust their responses in real time.

Regarding innovation, an uneven use of technological tools was observed. While some NGOs have successfully integrated platforms such as Office 365, SharePoint, and Excel macros, underutilization remains common. As one executive stated: *We have SharePoint, but very few use it because there has been no formal training* (E06, Cali). These findings suggest that digital transformation requires not only technology but also a cultural adoption strategy and pedagogical leadership that promotes meaningful use (Carreras et al., 2022). A crucial finding is that many innovations were not planned but emerged as creative responses to unexpected crises. This demonstrates that executives have turned problems into opportunities for structural improvement and have fostered organizational learning. The final testimonies point toward a leadership model based on mutual care, humility, and horizontal communication, viewing management as an ethical and transformative practice.

The methodological triangulation, contrasting qualitative interview results with quantitative survey data, enabled a robust and nuanced understanding of managerial competencies in ICBF-affiliated NGOs. From this analysis, several main conclusions and key recommendations emerge. A consistent finding

across both data sources is that executives and staff perceive that their organizations possess adequate capacity to manage change. The highest survey score in this category (3.87/5) is reinforced by qualitative accounts of rapid adaptations to crises. However, a tension is evident: although NGOs change, they do not always innovate. The lowest ratings in innovation (3.53) and training (3.63) suggest that, while resilient, these organizations have not yet institutionalized innovation processes or a culture of continuous learning. This misalignment is consistent with the theoretical framework, in which changes occur reactively, without a clear systematization of organizational learning (Argyris & Schön, 2001).

The research confirms that key managerial competencies in this sector go beyond technical skills and are centered on soft skills. NGO executives act as emotional mediators, supporting their teams and guiding them through uncertainty. This is reflected in the high score for the category *Managerial Competencies for Change* (3.67) and validated in the interviews, where leadership is described as both strategic and emotionally intelligent. This supports the perspectives of authors such as Goleman (2006) and Mintzberg (2010), who highlight the importance of empathy, self-awareness, and the ability to create meaning in complex contexts. While NGOs are adopting digital tools creatively, the results indicate that their use is fragmented and not systemic. Both surveys and interviews agree that the lack of formal training and a cultural adoption plan limits the potential of technology. Innovation is not hindered by a lack of resources but by the absence of conditions for appropriation. The underuse of tools such as SharePoint demonstrates that leadership must also be pedagogical, facilitating learning and integrating technologies into workflows.

Based on these findings, the following recommendations are proposed to strengthen managerial and organizational capacities in the sector:

1. Implement executive training programs emphasizing emotional leadership skills, strategic communication, and crisis team management.
2. Develop training strategies that integrate the use of technological tools with the actual needs of operational staff, fostering the appropriation of new tools beyond traditional management indicators.
3. Include soft metrics (e.g., employee well-being, organizational climate) to monitor the internal health of the organization.
4. Promote collaboration spaces among NGOs to share best practices, change management strategies, and innovations, particularly those that emerge as responses to crises.

DISCUSSION

The findings of this study demonstrate that change management in NGOs operating under the ICBF is not a linear process but rather a socially situated practice, deeply influenced by both external and internal factors. Unlike traditional managerial perspectives that focus on rigid planning, our research highlights that strategic leadership in this context demands a strong capacity to interpret, mediate, and transform institutional structures in response to uncertainty (Mintzberg & Quinn, as cited in Rivas, 2009). Innovation, rather than being the outcome of a formal strategy, often emerges spontaneously as a response to crises, aligning with Senge's (1990) concept of adaptive learning. This reinforces the view that resilience in complex social organizations depends not solely on resources or pre-established plans, but on the ability of leaders to foster dynamic, context-sensitive responses that can be rapidly operationalized in the face of change.

Furthermore, this study reveals the tension between institutional perceptions and lived experiences. While quantitative data suggest an openness to change, qualitative testimonies uncover resistance among staff, driven by emotional and workload fatigue. This tension reflects the complexity of organizational transformation, where structural readiness may coexist with human barriers that hinder implementation.

Addressing this gap requires reframing change management as a multidimensional process that integrates operational adjustments with emotional and cultural dimensions, recognizing that trust, shared meaning, and well-being are critical to sustaining transformation. The prominence of soft skill, adaptability, emotional intelligence, and self-care, among executives confirms that effective leadership in the third sector is, above all, human and transformative (Goleman, 2006). These findings invite a rethinking of leadership models in NGOs, moving away from exclusively technical or administrative approaches toward integrative frameworks that position leaders as both strategic decision-makers and emotional stewards of organizational life.

CONCLUSION

In conclusion, this study positions NGO executives as change managers with an ethical, emotional, and transformative approach. Their role transcends the mere application of procedures, becoming a catalyst for collective transformations. The leadership model observed combines data-driven rigor with an ethical commitment capable of mobilizing teams through mutual care and humility. This approach is essential for developing organizations that are more resilient and adaptive to environmental complexity.

From these findings, the following recommendations emerge:

1. Develop training programs emphasizing emotional intelligence, self-care, and trust-building, core elements for leadership that motivates and supports teams during crises.

2. Design technological adoption strategies that go beyond providing tools, incorporating systematic training plans and pedagogical leadership to ensure effective integration of technology into organizational culture.

3. Influence sustainability and well-being policies by advocating, particularly before entities such as the ICBF, for regulatory and budgetary frameworks that provide greater stability, allowing NGOs to focus on innovation and development.

4. Integrate mental health components into team management as a key dimension of organizational sustainability.

Finally, this research does not merely close a cycle of análisis, it opens a horizon of new questions. The ability of NGOs to transform crises into opportunities for collective learning suggests that their lessons could be applied in other contexts, such as formal education, to build more inclusive, resilient, and human-centered models.

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IMPACT-ORIENTED ANALYSIS OF AEROSPACE-GRADE ISOGRID PANELS WITH VARYING RIB THICKNESSES

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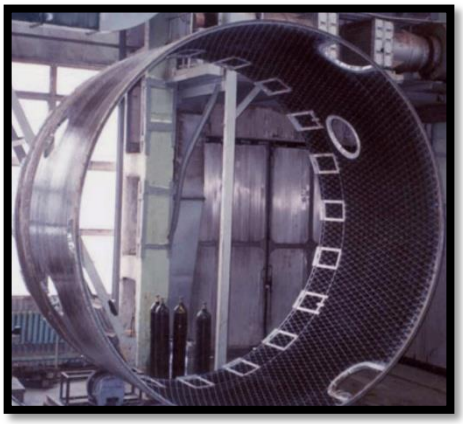


Fig. 1: Implementation of Isogrid Configuration in the Proton-M

ABSTRACT

This study presents an impact-focused numerical investigation of aerospace-grade isogrid panel structures manufactured from aluminum alloy and high-strength steel, examining the structural responses of configurations with varying rib thicknesses. Rather than aiming to identify an optimal configuration, the study seeks to evaluate and compare the mechanical behavior of panels under dynamic loading conditions for predefined rib geometries. This approach is particularly relevant for aerospace and defense applications, where weight-efficiency and impact resistance are critical considerations.

In the initial phase, mesh convergence analyses were conducted to ensure computational accuracy, followed by comparative static simulations of flat and isogrid panels. The results showed that increased rib thickness generally reduces stress concentrations but may negatively affect overall efficiency due to the added mass. Each material type demonstrated distinct performance trends, depending on its rib configuration, with notable variations in load distribution and deformation characteristics.

In the subsequent phase, dynamic impact simulations were performed using an impact velocity of 15 m/s, corresponding to the medium-speed collision range commonly cited in the literature. The findings revealed that isogrid structures consistently outperformed flat panels in terms of energy dissipation, deformation control, and structural resilience. The analysis also highlighted material-specific advantages, indicating that different rib thicknesses can significantly influence the impact response depending on the base material's mechanical properties.

In conclusion, this study underscores the importance of rib geometry in shaping the structural behavior of isogrid panels under impact loads. By systematically comparing various rib thicknesses, it contributes valuable insights into the design considerations for lightweight yet robust structures in advanced engineering applications, particularly in environments subject to high mechanical demands.

Keywords: Aerospace Structures, Isogrid Panels, Rib Thickness, Dynamic Impact Response, Energy Absorption

1. INTRODUCTION

Isogrid structures, characterized by exceptional specific strength, high stiffness-to-weight ratios, and superior resistance to impact and vibratory loading, have emerged as an advanced structural configuration for engineering applications requiring both lightweight design and elevated mechanical performance. Incorporating helical and circumferential stiffening ribs, these structures not only provide substantial axial load-carrying capacity but also significantly enhance global stability through improved

flexural rigidity. As documented in the literature, the integration of three distinct isogrid structural components into Russia's Proton-M launch vehicle, along with the execution of more than 300 successful missions, attests to the operational reliability of this structural architecture in demanding aerospace environments.

Through their triangular lattice topology, isogrid panels effectively redistribute transient loads—*such as those generated by high-velocity impacts*—across a broader structural domain, thereby mitigating localized deformation and preserving overall integrity. This advantageous behavior is strongly governed by mass-dependent design parameters, most notably rib thickness. Consequently, achieving an optimal trade-off between impact tolerance and structural mass constitutes a critical design objective. When such parameters are judiciously selected, isogrid configurations offer not only superior mechanical robustness but also substantial weight efficiency, yielding markedly high structural performance indices[1]. Existing research has predominantly examined the mechanical behavior of isogrid configurations under static loading conditions while their response to dynamic excitations particularly the influence of rib thickness remains insufficiently explored. Furthermore previous investigations have often been constrained to constant geometrical parameters and single-material systems, thereby limiting the comprehensive assessment of material–geometry interaction effects.

To address these research gaps, this investigation undertakes mesh independence analyses for multiple rib thickness configurations using two high-performance engineering alloys extensively applied in aerospace structures: *Al6061-T6* and *AISI 4340 steel*. For each material, the optimal geometrical parameters are established after which the dynamic impact responses of isogrid panels are numerically evaluated in direct comparison with flat plates. This systematic approach facilitates a rigorous assessment of their energy dissipation capacity, deformation control efficiency, and overall structural performance, thereby providing scientifically substantiated guidelines for their optimal integration into aerospace and other high-demand engineering applications.

2. MATERIALS AND METHODS

Two high-performance engineering materials were employed to investigate the mechanical behavior of isogrid structures the Al6061-T6 aluminum alloy and the AISI 4340 low-alloy steel. Both materials are widely utilized in defense, aerospace, and space systems, offering high engineering efficiency in terms of strength and stiffness[2]. The Al6061-T6 alloy, with a density of approximately 2.70 g/cm³, exhibits a tensile strength of 276 MPa and a yield strength of 241 MPa, delivering a high specific strength. A fracture elongation of up to 10% and a hardness of approximately 95 HB, combined with excellent machinability and moderate corrosion resistance make it suitable for a wide range of applications including aircraft fuselages, landing gear, rocket components, and unmanned aerial vehicle (UAV) structures [3].

AISI 4340 steel has a density of approximately 7.85 g/cm³ and can achieve a tensile strength of up to 1,800 MPa and a yield strength of 1,500 MPa after heat treatment [4]. With a high modulus of elasticity *(205 GPa)* and shear modulus *(80 GPa)*, it demonstrates outstanding resistance to impact loading, making it well-suited for use in flight control systems, helicopter rotor shafts, and components requiring high toughness. The distinct densities and deformation characteristics of these two materials allow for a comprehensive evaluation of how isogrid structures can be optimized with respect to key engineering criteria such as weight reduction, stiffness and impact resistance [5]. In this context, the high torsional and bending rigidity inherent to the isogrid geometry when combined with appropriate material selection, becomes a decisive factor in determining the overall mechanical performance of the system. Particularly under impact loading the compatibility between material properties and isogrid design directly affects structural integrity and the efficiency of energy dissipation[6]. Therefore the scope of

this study extends beyond a simple material comparison to include an in-depth assessment of the isogrid configuration's contribution to structural efficiency.

2.1 Mesh Optimization

The mesh optimization study aimed to determine mesh sizes that balance solution accuracy and computational efficiency in the finite element analysis of both flat panels and isogrid panels with varying rib thicknesses. For both panel types, the overall dimensions were set to 400 mm × 400 mm × 15 mm, with the isogrid geometry machined into the panel surface to a depth of 5 mm. Separate mesh density analyses were conducted for these structurally distinct configurations, and the influence of mesh size on analysis outputs was systematically evaluated. The results revealed that reducing the mesh size led to notable improvements in deformation and stress predictions up to a certain threshold, beyond which the performance gains be came marginal. Based on the independent evaluations conducted for flat panels and isogrid panels with different rib thicknesses, mesh sizes approaching mesh independence and ensuring solution stability were identified. These optimum mesh sizes are presented in Table 1.

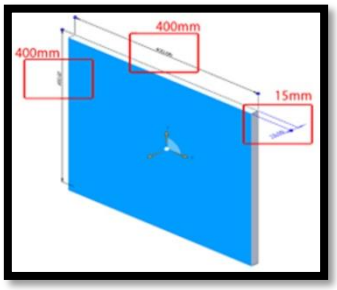


Fig. 2: Dimensions of the Flat

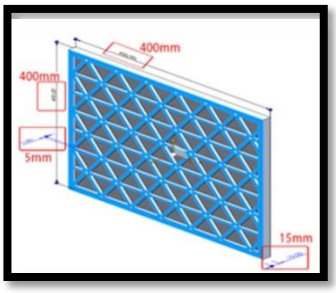


Fig. 3: Dimensions of the

Table 1: Wall Thickness, Mesh Size, Node Count, and Total Deformation Values for Different Plate Types

Plate Type	Rib Thickness (mm)	Mesh Size (mm)	Node	Total Deformation (mm)
Flat Plate	–	2.0	1,410,417	0.14146
Isogrid Plate	2	1.5	1,460,000	7.994
Isogrid Plate	4	1.5	1,497,000	6.4198
Isogrid Plate	6	1.5	1,501,000	5.3649
Isogrid Plate	8	1.5	1,571,000	4.3587
Isogrid Plate	10	1.5	1,581,000	3.6584

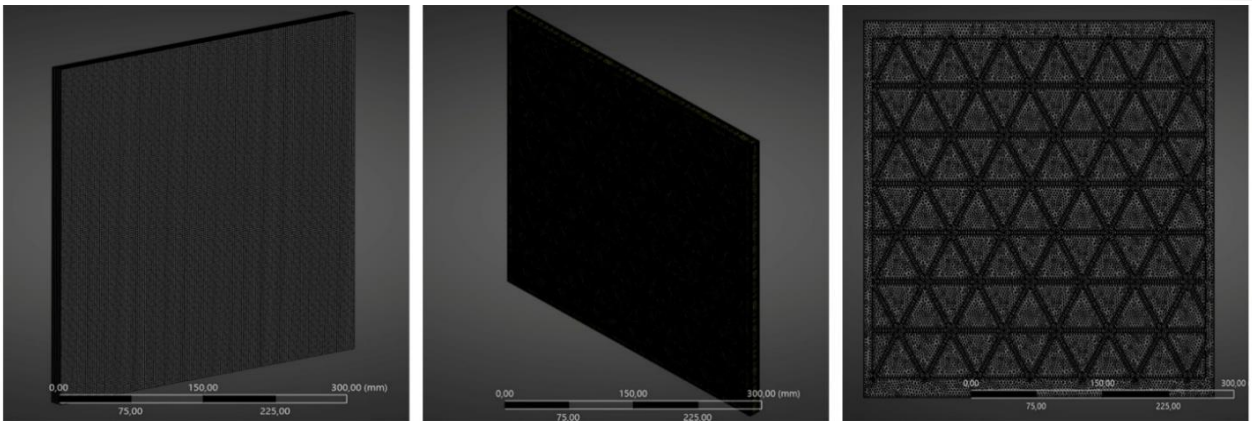


Fig. 4: Mesh Patterns of the Flat Plate, 2 mm-Wall Isogrid Plate, and 4 mm-Wall Isogrid Plate (from left to right)

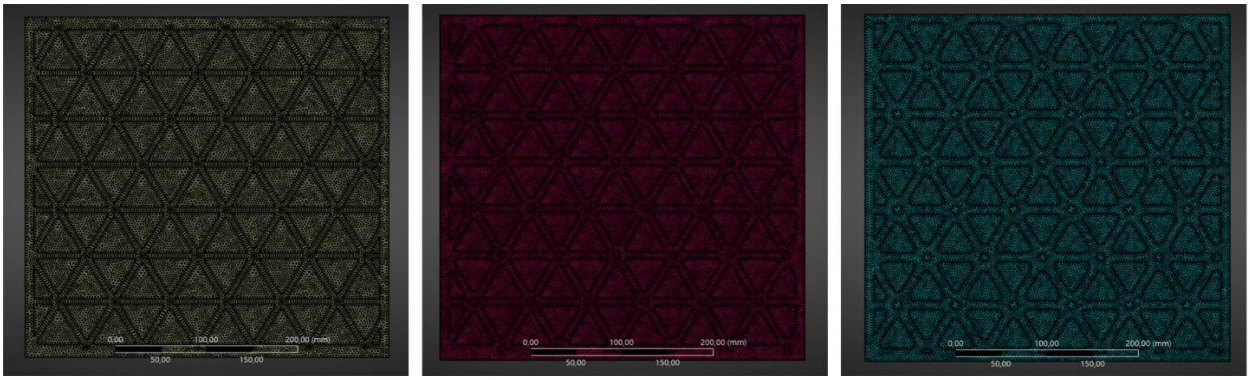


Fig. 5: Mesh Patterns of the 6 mm-Wall, 8 mm-Wall, and 10 mm-Wall Isogrid Plates (from left to right)

Beyond improving the accuracy of static analyses the mesh optimization process provided a robust computational basis for ensuring the reliability and stability of subsequent dynamic impact simulations.

2.2 Identification of the Optimal Rib Thickness

In this part of study the structural performance of isogrid configurations with varying rib thicknesses was evaluated for two high-performance engineering alloys: Al6061-T6 aluminum alloy and AISI 4340 low-alloy steel. Static analyses were conducted under identical loading and boundary conditions, applying a compressive force of *150,000 N*. The resulting von Mises stress values and structural masses were comparatively assessed. While the stress values provide insight into the structural resistance and load transfer capacity, the mass parameter plays a particularly critical role in engineering applications where weight reduction is a primary design objective [7].

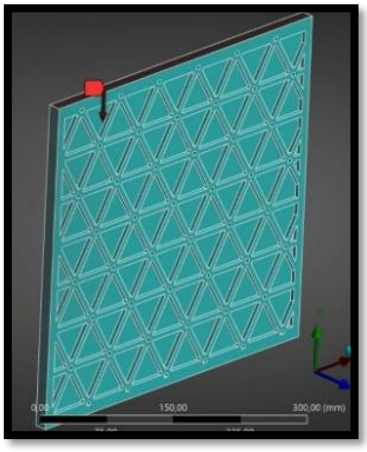


Fig. 6: Applied Load of 150,000 N on the Upper

For the Al6061-T6 alloy, the analyses revealed that increasing rib thickness enhanced stiffness but also led to a substantial rise in mass. In thin-rib configurations, localized stress concentrations and stiffness reductions were observed. Accordingly, a rib thickness of 6 mm was identified as the most suitable option, offering an optimal balance between stress distribution efficiency and lightweight structural design.

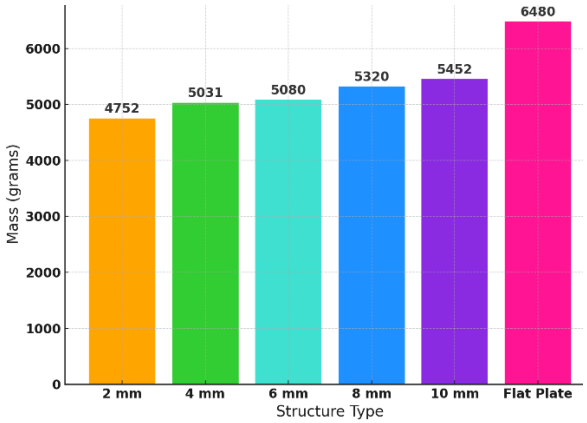


Fig. 7: Structure-Based Mass Values for Al6061-T6

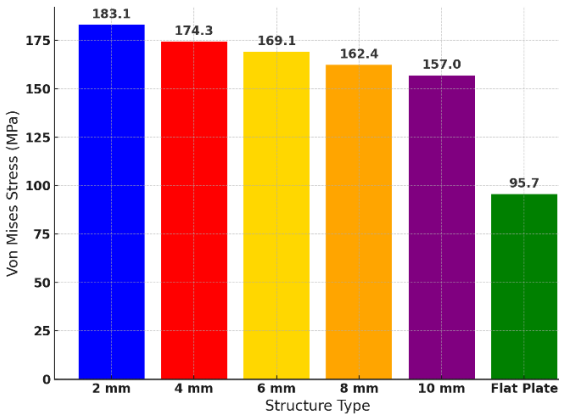


Fig. 8: Von Mises Stress Distribution for Al6061-T6

For the AISI 4340 steel, similar analyses indicated that increasing rib thickness enhanced structural strength; however, due to the material's higher density, the resulting mass increase was more pronounced. In this context, a rib thickness of 8 mm was identified as offering the most balanced outcome between stress control and weight efficiency. The findings for both materials demonstrate that rib thickness is a critical design parameter not only for ensuring mechanical safety but also for achieving structural efficiency. Therefore, the optimum rib thickness must be determined individually, taking into account the specific material properties and operational conditions.

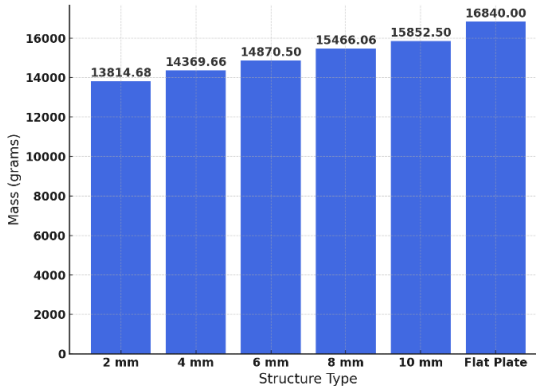


Fig. 9: Structure-Based Mass Values for AISI 4340 steel

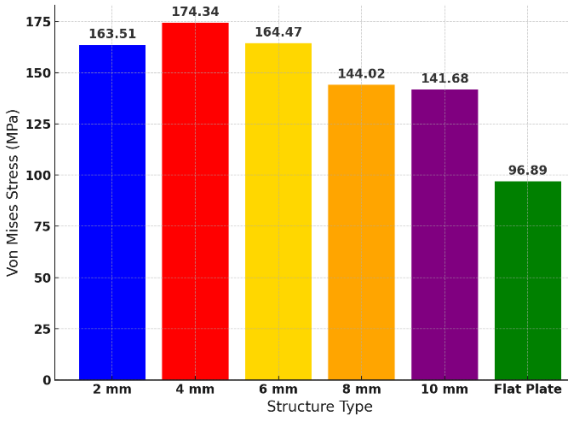


Fig. 10: Von Mises Stress Distribution for AISI 4340 steel

In conclusion, the conducted analyses provided reliable data on the performance of isogrid structures under dynamic impact conditions, thereby establishing a guiding foundation for their application in engineering practice.

2.3. Impact Loading Scenario, Boundary Conditions, and Modeling Specifications

For a fixed impact scenario, the impactor was modeled as a flat-ended cylinder with a diameter of 20 mm and a height of 20 mm, designed to induce widespread deformation while preventing penetration. An initial velocity of 15 m/s was assigned, which is classified in the literature as a medium-velocity impact regime and is of critical importance for the propagation of internal stress waves within the structure [8]. The target panel was constrained only along its bottom edge, allowing upward deformation to develop freely. To preserve the physical realism of the

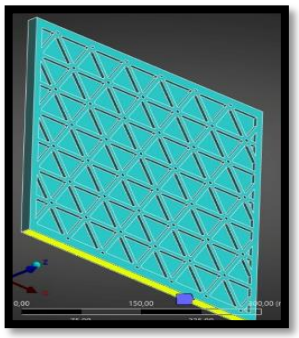


Fig. 11: Fixed Support on the Lower Edge

impact conditions, the contact between surfaces was defined as frictionless. The simulations evaluated outputs including total deformation, equivalent stress distribution, directional velocity components, and energy dissipation.

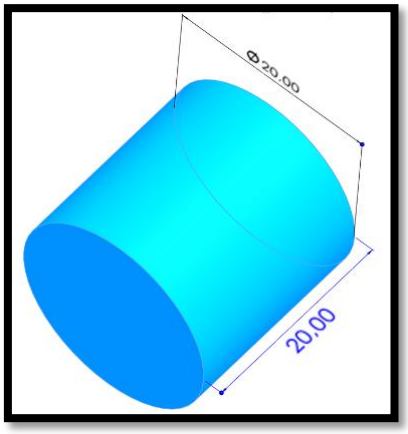


Fig. 12: Geometry of the

For both materials, elastic properties *(Al6061-T6: ρ = 2,703 kg/m³, E = 6.89 × 10⁴ MPa, v = 0.33; 4340 steel: ρ = 7,830 kg/m³, E = 2 × 10¹¹ Pa, v = 0.29)* were defined, along with the Johnson–Cook plasticity and damage models. The Johnson–Cook plasticity model comprises five parameters: initial yield stress (A), hardening modulus (B), hardening exponent (n), strain rate sensitivity coefficient (C), and thermal softening exponent (m). In this context, the parameters for Al6061-T6 were defined as *A = 3.24 × 10⁸ Pa, B = 1.14 × 10⁸ Pa, n = 0.42, C = 0.002,* and *m = 1.34;* for 4340 steel, the corresponding values were *A = 7.92 × 10⁸ Pa, B = 5.10 × 10⁸ Pa, n = 0.26, C = 0.014,* and *m = 1.03*.

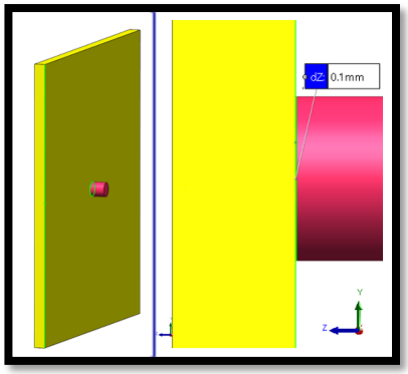


Fig. 13: The Impactor and the Target Structure

To capture the progression of damage associated with plastic deformation, the Johnson–Cook damage model was also employed. The constants D_1–D_5 in this model have distinct physical meanings: D_1 represents the initiation of damage under a triaxial stress state, D_2 quantifies the magnitude of the triaxiality effect, D_3 is the exponent describing the curvature of this effect, D_4 defines the sensitivity to strain rate, and D_5 characterizes the influence of normalized temperature on damage evolution.

In the numerical solution, the total simulation time was set to *0.2 s*, with a minimum time step of *1 × 10⁻⁹ s*, and the time step safety factor was defined as 0.9. Density update was activated, and to prevent violations of energy conservation, the maximum energy error tolerance was limited to *0.1%*. Automatic mass scaling was disabled to preserve physical accuracy. The results demonstrated that, under impact loading, isogrid structures exhibit superior energy distribution and deformation resistance compared to flat panels.

3. ANALYSIS OF DYNAMIC STRUCTURAL RESPONSE UNDER IMPACT LOADING

When numerically investigating the structural responses of components subjected to sudden, high-energy impacts, it is of critical importance to physically and accurately model short-duration, high strain-rate impact scenarios, particularly those encountered in defense, aerospace, and security systems. Accordingly, the ANSYS Explicit Dynamics solver was employed in the analyses to effectively capture nonlinear and time-dependent behaviors [8].

The impact scenario was defined using a flat-ended cylindrical impactor with an initial velocity of *15 m/s*. This velocity falls within the "medium-velocity impact" classification in the existing literature and is capable of producing significant stress accumulation and material-dependent plastic deformation in structures. The flat impact surface was selected to promote the distribution of impact energy over a wider area, thereby minimizing localized penetration effects. The target structure was fixed only along its bottom edge, leaving the upper portion free to allow natural deformation development. The simulations were conducted with automatic time-step control to accurately capture the rapid wave propagation occurring at the moment of impact, and the total simulation time was set to *0.2 s*. Contact behavior was modeled as frictionless to allow unrestricted sliding and separation between surfaces, thereby ensuring a realistic representation of the impact interaction. A track-based contact detection method was employed, and the penalty method was used to resolve contact forces. Additionally, an

inflation mesh was applied to the contact region of the target structure *(first layer thickness of 0.3 mm, five inflation layers, and a growth rate of 1.2*) to enable accurate computation of stress concentrations and micro-deformations in the vicinity of the contact interface.

Material behavior was defined using the Johnson–Cook model, enabling the consideration of high strain-rate effects in both elastic and potential plastic regions [7]. For Al6061-T6 aluminum alloy and AISI 4340 steel, density, elastic modulus, Poisson's ratio, yield stress, hardening coefficients, strain rate sensitivity, and thermal softening parameters were assigned according to values reported in the literature [9], [10]. Furthermore, to capture potential structural damage associated with the progression of plastic deformation, the Johnson–Cook damage model was implemented, with the D_1–D_5 damage constants defined for each material.

This comprehensive analytical approach ensured that the impact process was modeled in accordance with physical reality, thereby enabling a reliable assessment of the structures' deformation capacity, energy absorption potential, and stiffness levels.

3.1. Evaluation of the Dynamic Response of Al6061-T6 Aluminum Alloy

Within the scope of the dynamic analyses, the structural responses of flat and isogrid configurations manufactured from Al6061-T6 material were comparatively evaluated under an impact load applied at a velocity of *15 m/s*. The numerical assessment was based on key criteria such as total deformation, von Mises stress, and energy components.

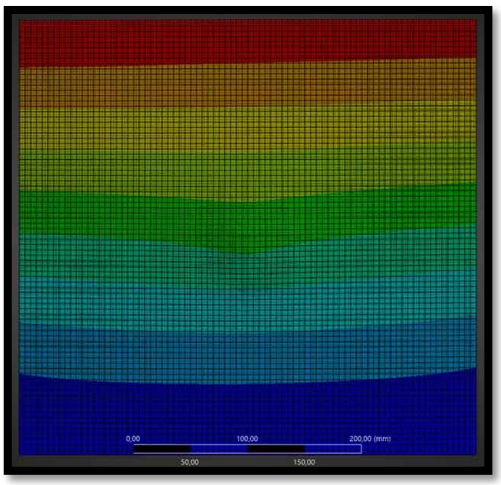


Fig. 14: Total Deformation of the Al6061 Flat Plate

For the flat plate configuration, the maximum displacement was determined to be *0.849 mm*, with deformation concentrated at the center of the impact zone, while remaining at significantly lower levels in the bottom-supported region. The maximum von Mises stress in this configuration was measured at *29.89 MPa*, indicating that the elastic behavior limits were not exceeded.

Analysis of the energy components revealed that the system possessed a total energy of *2,809.8 mJ*, of which *52%* was distributed as kinetic energy and *48%* as internal energy, while the contact energy was recorded as *1,100.2 mJ*. The hourglass energy remained at only *1.4%* of the total energy, and no plastic deformation was observed. In the analyses conducted on the isogrid configuration with a rib thickness of 6 mm, the maximum deformation reached *1.4614 mm*.

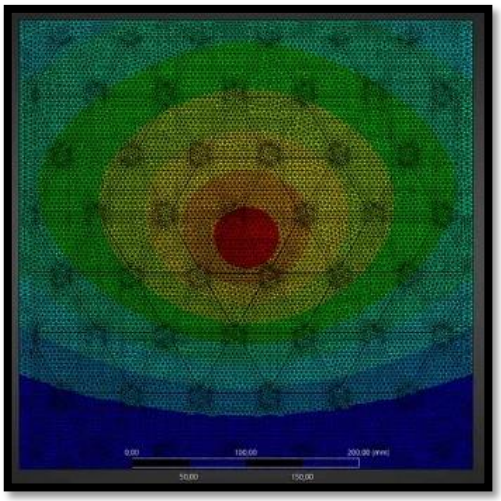


Fig. 15: Total Deformation of the Al6061 6 mm Isogrid Plate

It was observed that the deformation was concentrated at the point of impact and was more systematically distributed to the surrounding regions through the isogrid cells. The maximum von Mises stress measured in the structure was *49.955 MPa*, confirming that this value remained within the elastic limits of the material. The total system energy was determined to be *6,721.8 mJ*, and no plastic deformation was observed. Based on these evaluations, it was determined that the isogrid structure exhibited greater deformation compared to the flat plate, while effectively absorbing impact energy by distributing it over a larger volume, thereby delivering stable performance in terms of structural response.

Table 2: Energy Components of the Al6061-T6 Material under 15 m/s Impact Analysis

Energy Component	Flat Plate (mJ)	Isogrid Plate (6 mm) (mJ)	Description
Total Energy	2,809.8	6.721.8	Total energy calculated for the entire system
Kinetic Energy	1,470.5	3,618.8	Energy transferred to the structure during the initial impact
Internal Energy	1,339.3	3,103	Energy stored through internal stresses
Contact Energy	1,100.2	2,797.2	Energy interaction occurring at the contact interface during impact
Hourglass Energy	38.95	93.165	Energy arising from numerical diffusion

The concentration of stress in the cell centers, in particular, demonstrates that the isogrid configuration is capable of maintaining its stiffness under dynamic loading while efficiently transmitting loads and forces. Both configurations remained within their elastic limits and did not experience any permanent deformation.

3.2. Evaluation of the Dynamic Response of AISI 4340 Low-Alloy Steel Panels

In the numerical analyses, the behavior of flat and isogrid configurations manufactured from 4340 low-alloy steel was comparatively evaluated under an impact load applied at a velocity of *15 m/s*. Both configurations were examined in terms of total deformation, von Mises stress, and energy components in accordance with the defined evaluation criteria.

In the flat plate configuration, the maximum total deformation was measured at *0.637 mm*, with deformation concentrated in the upper free region and remaining at significantly lower levels in the bottom-fixed areas. This behavior indicates that the high stiffness of 4340 steel enables the impact to be absorbed within the elastic limits. The maximum von Mises stress was recorded as *21.75 MPa*, remaining well below the material's yield strength. According to the energy analysis results, the total system energy was observed to be *1,492.4 mJ*. No permanent deformation occurred, and the structure exhibited fully elastic behavior throughout the impact even.

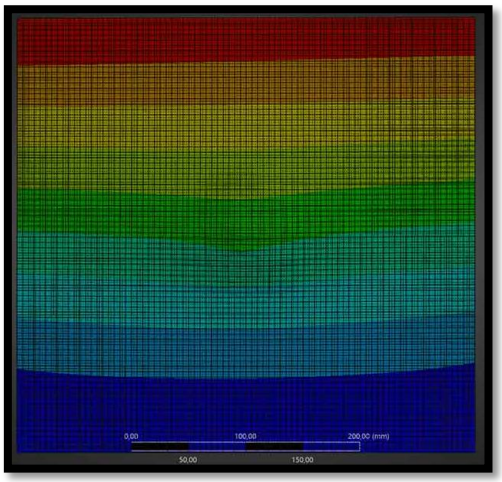


Fig. 16: Total Deformation of the 4340 Steel Flat Plate

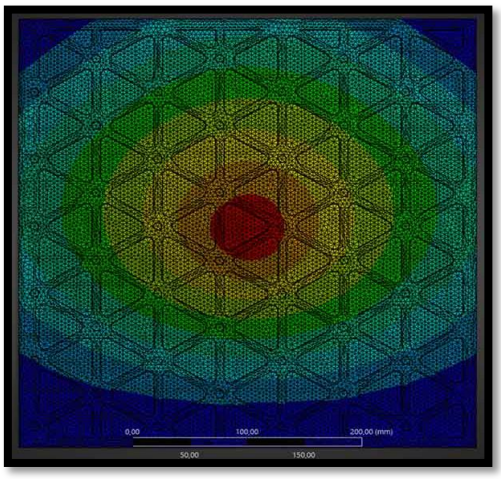


Fig. 17: Total Deformation of the 4340 Steel 8 mm Isogrid Plate

In the analysis conducted for the isogrid configuration with a rib thickness of 8 mm, the maximum deformation was measured at *1.7749 mm*, with deformation concentrated at the center and systematically distributed throughout the cellular structure. In the lower regions,

deformation was constrained by the fixed boundary, while in the upper regions, it was freely distributed. This highlights the potential of the isogrid geometry to dissipate impact effects in a controlled manner.

The maximum von Mises stress was recorded at *59.289 MPa*, remaining below the elastic limit. Stress contours were distributed homogeneously, becoming more pronounced at the cell centers and connection regions. The total system energy was determined to be *9,326.8 mJ*. No plastic deformation energy was generated, and the structure remained entirely within the elastic range.

Table 3: Energy Components of the 4340 Steel Material under 15 m/s Impact Analysis

Energy Component	Flat Plate (mJ)	Isogrid Plate (8 mm) (mJ)	Description
Total Energy	*1,492.4*	*9,326.8*	Total energy calculated for the entire system
Kinetic Energy	*746.6*	*5,065.8*	Energy transferred to the structure during the initial impact
Internal Energy	*745.8*	*4,261.1*	Energy stored through internal stresses
Contact Energy	*557.6*	*3,964.9*	Energy interaction occurring at the contact interface during impact
Hourglass Energy	*20.67*	*128.88*	Energy arising from numerical diffusion

Based on these evaluations, the 4340 steel flat plate successfully withstood the impact loads with high stiffness and low deformation levels, while the isogrid configuration demonstrated effective performance in terms of deformation and energy absorption by distributing the impact energy over a larger area. Both structures remained within their elastic limits, maintaining their structural integrity and exhibiting a safe deformation profile.

4. COMPARATIVE PERFORMANCE ANALYSIS BY MATERIAL

4.1. Structural Investigation of an Al6061-T6 Aluminum Alloy Configuration

Within the scope of the numerical analyses, a flat plate made of Al6061-T6 material and an isogrid structure with a rib thickness of 6 mm were evaluated under the same impact scenario *(15 m/s)*, and a comparative investigation was conducted between the two configurations in terms of mechanical performance and mass efficiency.

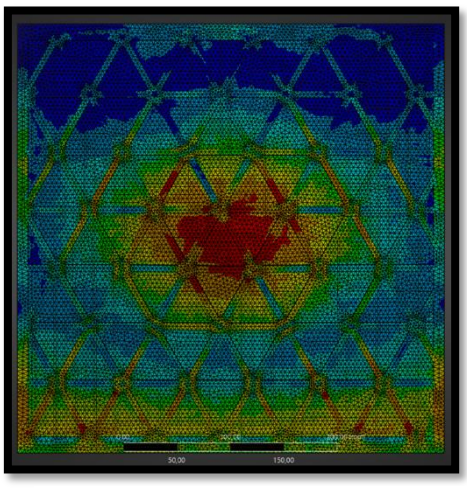


Fig. 18: Von Mises Stress Response of the Al6061 6 mm Isogrid Plate

An examination of the total deformation results revealed that the flat plate exhibited a maximum displacement of *0.849 mm*, indicating a more limited deformation response to the impact. This deformation was localized at the upper free edge of the structure and remained minimal in the bottom-supported region. However with a mass of *6,480 g*, this configuration is significantly heavier than the isogrid model. The isogrid structure, in contrast, weighed *5,080 g*, making it approximately *21%* lighter than the flat plate. Nevertheless, the impact produced a maximum deformation of *1.461 mm*. This increased deformation is attributed to the capability of the isogrid geometry to distribute impact energy

radially from the central region to its surroundings, with the deformation contours spreading across the structure in a disciplined and uniform manner.

In terms of stress distribution, the flat plate exhibited a maximum von Mises stress of *29.897 MPa*, with the stress concentrated in a limited region around the impact zone. The stress contours, particularly concentrated along the central axis, indicate that the flat plate absorbs energy within a small volume and has limited capacity for stress propagation. In the isogrid configuration, however, the maximum von Mises stress reached *49.955 MPa*, representing a higher stress magnitude. Nevertheless, this stress was distributed over a larger area throughout the cellular structure, with a regular stress pattern particularly evident at the junctions between ribs. This configuration redirects load transfer along multiple paths, thereby reducing localized stress concentrations and dissipating impact energy in a controlled manner.

The findings obtained from the analysis of the energy components further support these evaluations. In the flat plate, the total system energy was *2,809.8 mJ*, of which *1,470.5 mJ* was distributed as kinetic energy and *1,339.3 mJ* as internal energy. Additionally, a contact energy of *1,100.2 mJ* was recorded in the regions where the impact occurred, while the hourglass energy remained at a low level of *1.38%*, confirming the stability of the numerical solution. This configuration remained within the elastic limits and dissipated the energy internally without undergoing plastic deformation.

For the isogrid structure, the total energy was determined to be *6,721.8 mJ*. All energy components exhibited a notable increase compared to the flat plate, indicating that the isogrid configuration absorbed a higher amount of energy by distributing the impact load over a larger surface area. Although neither configuration exhibited plastic deformation, the isogrid geometry demonstrated a superior energy dissipation capacity while remaining within the elastic range.

Overall, the isogrid structure demonstrated superior performance in terms of mechanical strength, deformation control, and energy dissipation. This configuration stands out as a strong candidate for applications in areas such as ballistic impact, aerospace, and defense industries, where both structural durability and weight optimization are critical design requirements.

4.2. Structural Investigation of an AISI 4340 Low-Alloy Steel Configuration

Under the impact scenario with an applied velocity of *15 m/s*, a flat plate manufactured from 4340 low-alloy steel and an isogrid structure with a rib thickness of 8 mm were comparatively evaluated in terms of mechanical and dynamic performance.

In terms of maximum deformation, the flat plate exhibited a displacement of *0.637 mm*. The deformation was localized in the upper free region, while remaining minimal along the lower, fixed edges. This behavior indicates that, due to its rigid structure, the flat plate dissipated the impact energy within a smaller volume, thereby making it more susceptible to localized stress concentrations.

The isogrid structure, on the other hand, experienced a maximum deformation of *1.775 mm*, indicating a greater degree of shape change. However, this deformation was isotropically distributed from the central region toward the periphery, with the isogrid lattice geometry enabling the impact energy to be dispersed over a much larger area in a controlled manner. This distribution demonstrates the structure's capability to spread the impact effect volumetrically rather than localizing it, thereby providing a more stable deformation profile.

Considering the masses of both configurations, the flat plate weighed *18,840 g*, whereas the isogrid structure weighed *15,466 g*. Despite being approximately 18% lighter, the isogrid structure exhibited greater deformation under impact, demonstrating a more effective performance in directing and dissipating the impact energy. This indicates that the isogrid configuration offers an optimized solution by simultaneously achieving mass reduction and maintaining the capability to discipline high deformation energy.

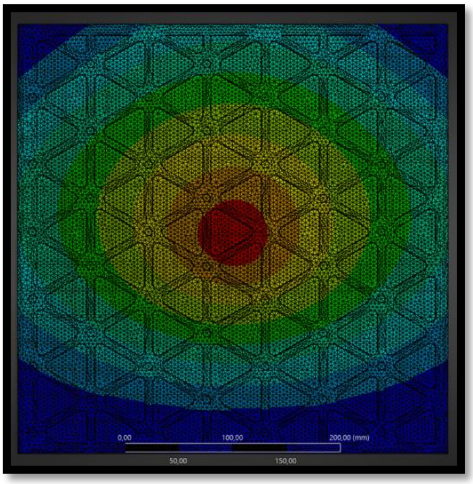


Fig. 19: Von Mises Stress Response of the 4340 Steel 8 mm Isogrid Plate

In terms of stress distribution, the flat plate exhibited a maximum von Mises equivalent stress of *21.75 MPa*. This stress was confined to a limited area along the axis where the impact was concentrated, with the contours appearing pronounced and clustered in narrow regions. The rigid nature of the structure reduced the extent of deformation; however, this also resulted in the concentration of energy within a smaller volume. In the isogrid structure, the maximum von Mises stress was measured at *59.29 MPa*, a considerably higher value compared to the flat plate. However, the stress was evenly distributed throughout the structure along the triangular load-bearing elements, exhibiting a smooth and gradual distribution profile, particularly at the junctions between the ribs.

In terms of energy dissipation behavior, the total system energy for the flat plate was recorded at *1,492.4 mJ*. In contrast, the isogrid structure reached a total energy level of *9,326.8 mJ*, corresponding to more than a sixfold increase in energy absorption. In the isogrid configuration, this energy was distributed in a balanced manner among kinetic *(5,065.8 mJ)*, internal *(4,261.1 mJ)*, and contact *(3,964.9 mJ)* components. This balanced distribution demonstrates the structure's capability to direct energy in a way that preserves structural integrity rather than localizing it upon impact. In both models, the hourglass energy values remained at approximately 1.38%, indicating high solution stability, while the absence of plastic deformation energy confirmed that the systems remained within their elastic limits.

In conclusion, the isogrid structure manufactured from 4340 steel was not only lighter than the flat plate but also exhibited a higher energy absorption capacity, offering a more balanced and safe behavior profile under impact in terms of deformation propagation and stress distribution.

5. CONCLUSIONS

In this study, the static and dynamic performances of isogrid structures with varying rib thicknesses were systematically evaluated using the finite element method. At the outset, a mesh optimization was carried out for both flat and isogrid panels, aiming to enhance numerical accuracy while reducing computational cost.

Within the scope of the static analyses, the effects of different rib thicknesses (2 mm, 4 mm, 6 mm, 8 mm, and 10 mm) on the mechanical performance of each material were comparatively examined. The findings revealed that a rib thickness of 6 mm for Al6061-T6 aluminum alloy and 8 mm for AISI 4340 steel offered the optimum performance in terms of stiffness and mass. These thickness values not only provided a more balanced deformation distribution but also reduced the structural mass, thereby improving structural efficiency for engineering applications. The dynamic analysis results demonstrated that, compared to flat plates, isogrid structures dissipated impact energy over a wider surface area, thereby reducing the potential for localized damage. The 6 mm Al6061-T6 isogrid configuration, noted for its light weight, delivered a well-balanced deformation profile by effectively managing impact energy without compromising stiffness. Similarly, the 8 mm AISI 4340 steel isogrid structure absorbed

impact energy more consistently, facilitating its distribution over a broader area and enhancing its energy dissipation capacity. The analysis of energy components indicated that, in both configurations, the majority of the energy was absorbed through elastic deformation, ensuring the preservation of structural integrity. These characteristics position isogrid structures as a strong alternative for applications requiring high impact absorption, such as aerospace, defense, and automotive industries.

In conclusion, rib thickness optimization for isogrid structures has been shown to be a critical design parameter, not only in terms of static stiffness and mass efficiency but also for the effective management of impact effects. However, it should be noted that the optimum thickness may vary depending on factors such as material selection, manufacturing technique, structural boundary conditions, and intended application scenarios.

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THE ROLE OF MULCH APPLICATIONS IN WEED MANAGEMENT: EFFECTS OF THICKNESS, TYPE, AND TIMING

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ABSTRACT

Weeds are one of the most significant factors causing yield and quality losses in agricultural production. While currently widely used chemical control methods provide effective short-term results, they pose risks to environmental contamination, soil health, and human health in the long term. In this context, the need for environmentally friendly, economical, and sustainable weed management strategies is increasing. Mulching practices are attracting attention as one of the most prominent cultural control methods for this purpose. However, mulch applications vary in terms of mulch thickness, type of mulch material used (organic or inorganic), and application time on weed germination and growth. Therefore, this study evaluated the effects of mulch thickness, type (organic/inorganic), and application time on weed germination and growth based on literature findings. The type of mulch used plays a significant role. Organic mulches such as straw, wood chips, compost, and crop residues are biodegradable and can improve soil health over time. However, their effectiveness may vary depending on decomposition rates, material density, and local climatic conditions. Inorganic mulches, including plastic films and landscape fabrics, provide more uniform and long-lasting weed suppression but can lead to environmental waste issues. Mulch effectiveness is greatly influenced by the thickness of the applied material; thicker layers generally provide better weed control, particularly by limiting light intensity and inhibiting weed emergence. Timing is also important. Most studies agree that early application (preferably before weeds emerge) maximizes the benefits of mulching by preventing initial weed establishment. Late applications are generally less effective in controlling weeds that have already emerged but can still suppress further growth. This review highlights that an integrated approach, including selecting the appropriate mulch type, applying the optimal thickness, and correctly timing the application, can increase mulching effectiveness in weed management.

Keywords: Inorganic mulch, Cultural control, Mulching, Organic mulch, Sustainable agriculture, Weed control

GLOBAL TRENDS OF SUSTAINABLE FINANCING AND GEORGIAN REALITY

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ABSTRACT

During the last decade, the Government of Georgia has been implementing a number of Sustainable Development Goals (SDGs) measures, thereby contributing to the country's sustainable development. Upon request of the Paris Agreement, Georgia has already made a Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC), namely - to reduce greenhouse gas emissions and processes that negatively affect the environment.

The international obligations undertaken by our country are compatible with the policy of Georgia and the "Georgia 2024" strategy of socio-economic development of Georgia. The mentioned strategy provides a clearer vision of how to achieve a long-term, sustainable and inclusive economic growth. It is based on three main principles:

- ✓ Fast and effective economic growth;
- ✓ Inclusive economic growth;
- ✓ Rational use of natural resources is essential for environmental safety and sustainability.

To address the above-mentioned challenge, the National Bank of Georgia periodically plans and implements reforms which provide support for the mobilization of financial resources for green, social and inclusive economic growth, however, to achieve sustainable financing efficiency in Georgia we still need to hold different kinds of events.

For instance: the policy of low-cost loans should be developed, the policy of agro loans needs to be changed, mechanisms must be created for studying the effectiveness of environmental, social, and governance (ESG) risk management by financial institutions, it is necessary to speed up the development process of social entrepreneurship and the development of the methodology of comparative analysis of the effectiveness of social enterprises, as well as the process of functioning of electric municipal transport and others.

Key words: Georgia, sustainable financing, green taxonomy, green economy, inclusive business, social entrepreneurship, social taxonomy.

NAVIGATING THE LABYRINTH OF PATRONAGE: DEMOCRATIZATION CHALLENGES IN ALBANIA'S POLITICAL LANDSCAPE

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ABSTRACT

This article delves into the intricate dynamics of democratization in Albania, a key case study within the broader context of the Western Balkans. It critically examines how the entrenched system of patronage politics influences the democratization process, challenging conventional models of political development. By categorizing Albanian party systems based on their competitiveness and consolidation, the study unveils how these systems, regardless of being dominant or plural, primarily function as expansive patronage networks. This patronage framework, deeply embedded in the political fabric, effectively inverts the standard paradigm of accountability between political parties and the electorate. The article argues that this inversion poses significant obstacles to the democratization trajectory, necessitating a critical reevaluation of party politics in Albania. Through a comprehensive analysis of Albania's political landscape, the study seeks to unravel the complexities of patronage politics and its implications for democratic consolidation, offering insights that contribute to the broader discourse on democratization in post-socialist states.

Keywords: political parties, party system, democratization, Albania, patronage

I. Introduction

Post-communist Albania's journey toward democratic consolidation has been fraught with the persistence of informal patron-client networks that pervade its politics. Three decades after the fall of one-party rule, observers note that Albania's multiparty system still operates under the heavy influence of *patronage* – the exchange of public jobs, contracts, and favors for political loyalty (European Commission, 2023; Xhaferaj, 2013; Sqapi & Mile, 2022; Sqapi, 2022). This phenomenon has deeply politicized state institutions, undermining meritocracy and the rule of law. In Albania's transition period since 1991, "informal practices and clientelist networks of political parties within state structures" have flourished, producing an *extreme politicization* of public institutions (Sqapi & Mile, 2022; Kajsiu, 2005; Xhaferaj, 2013). Such patronage-based governance not only erodes governmental integrity but also poses a serious challenge to democratization by entrenching the power of incumbents and weakening checks and balances.

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This article examines the labyrinthine system of patronage in Albania and its implications for democratization. We begin by clarifying the concept of patronage in political context and how it manifests in practice. We then explore methods for measuring patronage and review evidence of its prevalence in Albania's public sector and elections. Next, we analyze key factors that sustain these patronage networks – including historical legacies, systemic corruption and state capture, and deficits in internal party democracy. In particular, we highlight how weak intra-party democracy in Albania's major political parties has allowed a small elite to control resources and appointments, further reinforcing patron-client relationships. We also consider the role of external pressures and reform efforts, such as European Union (EU) integration conditions, aimed at curbing patronage, and why these efforts have met limited success. Through academic literature and recent reports, the article sheds light on why patronage remains entrenched in Albania's political landscape and what that means for the country's democratic future. The analysis underscores that without addressing the patronage "labyrinth" – by enforcing meritocracy, strengthening party democracy, and curbing corruption – Albania's democratic institutions will continue to face severe challenges in credibility and effectiveness.

II. Understanding Patronage in Politics

In political science, *patronage* refers to the practice of distributing state resources or benefits in exchange for political support. Typically, a political leader or party (the *patron*) offers jobs, public contracts, favors, or other tangible benefits to individuals or groups (the *clients*) in return for their loyalty – usually manifested as votes, campaign assistance, or other forms of support.

The concept of patronage has long been studied as a defining feature of non-meritocratic politics. Max Weber (1978) framed patronage as the antithesis of rational-legal bureaucracy, where officials should be recruited based on impersonal rules and qualifications. In patronage systems, positions are allocated according to loyalty to the ruler or party rather than competence, a legacy of patrimonialism. Eisenstadt and Roniger (1984) emphasized patronage as part of enduring patron–client relationships: reciprocal yet asymmetrical ties where patrons provide protection or material benefits, and clients reciprocate with loyalty. Such ties are embedded in hierarchical structures and have a strong political dimension in states where institutions are weak. James Scott (1972) offered a widely cited definition: "The patron-client relationship may be defined as a special case of dyadic ties involving a largely instrumental friendship in which an individual of higher socio-economic status (patron) uses his own influence and resources to provide protection or benefits for a person of lower status (client), who reciprocates by offering general support and assistance to the patron" (p. 92). This conception highlights the exchange, inequality, and personalism that underpin patronage. Other scholars define patronage more explicitly as the partisan distribution of state resources. Baracskay (2009) describes it as the appointment of individuals to government posts on the basis of partisan loyalty – encapsulated in the phrase "to the victor belong the spoils."

In modern democracies, patronage persists mainly in the form of *party patronage*. Kopecký, Mair, and Spirova (2012) define it as *"the power of a party to appoint people to positions in public and semi-public life."* Patronage allows parties both to ensure policy control by placing loyalists in key posts and to reward supporters. While many democracies tolerate limited patronage in high-level appointments, pervasive patronage undermines bureaucratic impartiality and meritocracy (Grzymała-Busse, 2007). Patronage is closely related to clientelism but distinct in scope. Clientelism often refers to vote-buying and direct exchange of favors at election time, whereas patronage refers to broader, institutionalized distribution of jobs and contracts (Kitschelt & Wilkinson, 2007). In practice, however, the concepts overlap significantly – patronage appointments strengthen clientelist networks, and clientelist electoral strategies rely on promises of patronage. Political patronage is not unique to Albania; it is found in many

democracies, especially emerging ones, where institutions are weaker. It serves as a tool for parties to consolidate power by embedding loyalists throughout the state's administrative apparatus.

In post-communist countries, patronage has often become the backbone of state capture. O'Dwyer (2006) conceptualizes this as "party colonization" of the state, where ruling elites staff ministries and agencies with loyalists. Similarly, Grzymała-Busse (2007) demonstrates how post-communist parties exploit state resources to consolidate power, blurring the lines between public office and party organization.

In the Western Balkans, analysts describe governance as *neopatrimonial* – combining formal democratic institutions with pervasive informal patron-client networks (Volintiru, 2015). Here, patronage goes beyond jobs to include public contracts, privatization deals, and legislative favors for political financiers. Reports emphasize that "powerful patronage networks have infiltrated and consolidated their control of state institutions" in Albania and its neighbors (Institute for Democracy and Mediation [IDM], 2023).

Some scholars distinguish between *programmatic* politics, where policies and public goods are allocated impartially, and *patronage-based* politics, where distribution depends on political loyalty (Kitschelt & Wilkinson, 2007). In theory, limited forms of patronage (often called "political appointments") are present even in established democracies – for instance, when an incoming government appoints its affiliates to senior civil service roles or advisory positions. Such appointments can be benign if the individuals are qualified, the number of positions is limited, and the rule of law is respected. However, in Albania, patronage tends to be pervasive and often crosses into nepotism and cronyism, undermining bureaucratic impartiality. Positions at all levels of the public administration, from high-ranking officials to entry-level employees, have been treated as rewards to be doled out to party supporters. This entrenched system leads to a *"politicization" of the civil service*, where public servants feel beholden to the party that hired them rather than to the public interest (Sqapi & Mile, 2022). The benign end of the patronage spectrum is thus far overshadowed by corrupt practices in which hiring and procurement are based on partisan loyalty or personal connections, not on qualifications or competitive bidding.

Patronage networks can significantly distort governance and democratic accountability. When jobs and resources are exchanged for loyalty, public officials are incentivized to serve their patron's political agenda rather than deliver public services neutrally (Grzymała-Busse, 2007; Kopecký et al., 2012). This often results in inefficiency, as unqualified personnel fill roles, and in corruption, as rules are bent to favor allies (Scott, 1972; Transparency International, 2024). Moreover, citizens may come to perceive public services and welfare not as rights, but as favors contingent on political alignment, thereby weakening the social contract (Eisenstadt & Roniger, 1984; Mungiu-Pippidi, 2006). In Albania's case, widespread patronage has corroded public trust. For example, surveys and reports indicate that Albanians commonly view the bureaucracy as sluggish and favor-based, where "personal favours are often prioritized over regular state functioning" in sectors like education, healthcare, and public employment (Rosa Luxemburg Stiftung, 2021; IDM, 2023). Such perceptions align with Albania's consistently poor rankings on corruption and governance indices, such as the Corruption Perceptions Index and the Worldwide Governance Indicators (Transparency International, 2024; World Bank, 2023). In sum, patronage undermines meritocracy and fuels a vicious cycle: it skews resource allocation to entrench the ruling party's power, which in turn weakens institutional checks and enables further patronage and corruption (O'Dwyer, 2006; Volintiru, 2015). Breaking out of this cycle is a central challenge for democratization.

III. Measuring Patronage and Its Prevalence in Albania

Because patronage networks are often informal and concealed, measuring their scope and impact poses significant methodological challenges. Nevertheless, researchers and analysts have developed several strategies to assess the prevalence of patronage, particularly in transitional democracies such as Albania.

One of the most direct approaches involves analyzing public sector appointment data. Increases in public sector employment during election years or shifts in civil service staff following changes in government often serve as indicators of strategic hiring practices intended to reward loyalty rather than merit (Grzymała-Busse, 2007; O'Dwyer, 2006). In Albania, official statistics offer compelling evidence of such patterns. For example, during the 2021 parliamentary elections, public sector employment reached a record high of over 185,000 employees, marking a 4% increase within the year (Politiko.al, 2021). A similar pattern emerged in the final quarter of 2024, preceding the 2025 elections, with approximately 3,900 individuals added to the public payroll—a 2.1% increase compared to the previous quarter (Politiko.al, 2024). This temporal clustering suggests that state jobs were used as tools of electoral mobilization. Investigative journalism and civil society reports further support these claims, frequently documenting appointments of individuals with direct political affiliations or personal ties to high-ranking officials, rather than independent technocrats (IDM, 2023; Vurmo et al., 2021). Such evidence is gathered through cross-referencing public records, civil society monitoring, and media disclosures, which often reveal that ministries and state agencies are staffed by individuals linked to ruling party networks.

Another method for detecting patronage involves correlating government distributive decisions with electoral patterns. When regions or groups that show strong support for the ruling party receive disproportionate public investments, jobs, or benefits, this may signal clientelistic exchange (Kopecký et al., 2012; Lami & Imami, 2022). In Albania, this dynamic has been observed in the form of pre-election property legalization initiatives that disproportionately benefit potential swing voters. One study found that the legalization of informal properties significantly accelerated during election periods, especially in areas considered politically competitive, implying a strategic "vote-for-benefit" exchange (Lami & Imami, 2022).

Network analysis offers another useful tool in mapping out political patronage. Scholars employ this method to identify clusters of civil servants connected through kinship or clientelist ties to political elites (Scott, 1972; Eisenstadt & Roniger, 1984). In Albania, such analyses have highlighted the presence of so-called "party families," in which groups of officials within specific ministries or local governments share personal or familial links to prominent politicians. The media has consistently reported cases of nepotism where relatives of ministers and MPs secure key appointments or lucrative state contracts, reinforcing the notion of a politicized and kinship-driven bureaucracy (BIRN, 2022; IDM, 2023).

Political rhetoric also offers qualitative insights into patronage practices. Content analysis of party manifestos and campaign speeches reveals implicit or explicit promises of state resources in exchange for political support. In the 2023 local elections, for instance, the ruling Socialist Party reportedly warned that municipalities governed by the opposition might not receive equal financial support, effectively tying public welfare to partisan allegiance (European Commission, 2023). Such threats reinforce a perception that state benefits are contingent on electoral behavior rather than distributed equitably.

Investigative journalism and civil society reports have also been instrumental in uncovering patronage practices beyond public employment. Reports by organizations such as BIRN, Transparency International Albania, and IDM have revealed instances of state capture in Albania, whereby public procurement processes, regulatory decisions, and even legislation are tailored to benefit individuals or businesses with close ties to political elites (Vurmo et al., 2021; IDM, 2023). These cases illustrate that patronage extends beyond hiring to include the allocation of state contracts and regulatory privileges.

International institutions have consistently highlighted the persistence of political patronage in Albania. The European Commission's 2023 progress report criticized the lack of consistency in applying merit-based civil service recruitment, particularly at senior levels. It specifically noted that recent reorganizations of the Prime Minister's Office, including the creation of new executive agencies under direct control, raise concerns about bypassing standard procedures and concentrating patronage power at the executive center (European Commission, 2023). Moreover, the appointment processes for independent institutions such as the Ombudsperson and the Commissioner for Protection from Discrimination were heavily politicized and delayed, undermining institutional independence.

Further evidence comes from election monitoring bodies. During the May 14, 2023, local elections, OSCE/ODIHR and EU observers reported widespread misuse of public resources and the strategic deployment of patronage networks. These included last-minute bonus payments to pensioners, selective public sector wage increases, and veiled threats by officials suggesting that future funding allocations would depend on electoral outcomes (OSCE/ODIHR, 2023). Such practices, though framed as policy, clearly functioned as tools of electoral patronage. A particularly revealing case involved the Socialist Party's use of so-called "patronazhistët" (patronage operatives), who maintained detailed voter profiles and engaged in voter surveillance. This practice, first exposed in 2021 through a massive data leak, resurfaced in 2023 and was condemned by observers as a distortion of democratic norms (UET, 2023).

The 2023 National Integrity System Assessment by Transparency International and IDM further confirmed the systemic nature of political patronage in Albania. The report found the public sector to be the weakest pillar of governance, plagued by vague standards, weak enforcement mechanisms, and deep political interference in recruitment and promotion processes (IDM, 2023). It also identified multiple cases of grand corruption, where laws or regulations were custom-made to benefit particular companies or individuals linked to the ruling elite.

Quantitatively, Albania's standing on global governance indices reflects the entrenched nature of patronage and related corruption. Transparency International's Corruption Perceptions Index (CPI) for 2023 gave Albania a score of 37 out of 100, ranking it 98th out of 180 countries, one of the lowest rankings in Europe (Transparency International, 2024). Although the country improved slightly from its 2022 ranking of 110th, it still lags behind regional peers. The CPI, which gauges perceived corruption in public administration and political processes, indirectly reflects the impact of patronage, particularly when political loyalty determines access to jobs and contracts. Regional surveys such as the Balkan Barometer likewise indicate that a majority of Albanians believe that personal or party connections are essential for securing public employment or winning tenders.

In summary, a convergence of evidence from public employment data, electoral trends, investigative journalism, and international assessments indicates that political patronage is a systemic feature of Albania's governance. Public institutions are routinely used to reward partisan loyalty, bypassing meritocratic procedures and undermining democratic accountability. Understanding this entrenched dynamic is crucial for addressing the structural challenges of democratization in Albania.

IV. Factors Sustaining Patronage Networks in Albania

Historical Legacies and Path Dependency

One explanatory lens is the concept of path dependency—the idea that historical legacies and institutional trajectories constrain present choices and behavior. Albania's contemporary patronage practices are widely viewed as the continuation of both its communist past and the turbulent post-communist transition. Under the communist regime (1944–1991), the ruling Party of Labour established a totalitarian system where all employment, advancement, and benefits were contingent on political

loyalty. Scholars describe this as a form of "state socialism with patronage logics," where political reliability, not competence, was the core criterion for accessing state resources (Ekiert & Hanson, 2003; Ganev, 2007).

This created what Grzymała-Busse (2007) has termed a "patronage state," albeit under ideological disguise, where citizens internalized the expectation that the Party controlled access to all opportunities. Even after communism's collapse, many of the same elites and informal networks persisted. As Elbasani (2009) notes, Albania's transition did not entail a wholesale institutional rupture; rather, many former communist elites repurposed their influence in the nascent democratic order. The result, according to Elbasani (2009), was a "continuity of informality," where informal political exchanges shaped the functioning of democratic institutions.

The chaotic 1990s, marked by economic collapse and political instability—including the 1997 pyramid crisis—further entrenched patronage. With weak formal institutions and constant shifts in power, political competition became a zero-sum game. Each new administration purged the civil service and filled it with loyalists, establishing a practice of "rotation-based politicization" (Manning, 2007). In such a context, citizens came to view political loyalty as essential for survival and access to public services.

Path dependency theory explains why, once such systems are in place, actors rationally adapt to them. Even when suboptimal collectively, these patterns persist because no single actor wants to unilaterally disarm (Pierson, 2000). By the 2000s, both the Socialist and Democratic parties had institutionalized patronage: they campaigned on promises—implicit or explicit—of jobs and benefits, and once in power, fulfilled them to consolidate support (Elbasani & Vurmo, 2012).

Cultural legacies also reinforce these trends. Albanian political culture has long been shaped by hierarchical and personalist structures—from Ottoman-era patron-client ties to the patriarchal family model and the cult of personality under Enver Hoxha (Mertus, 1999; Gashi, 2016). These experiences foster a political environment where loyalty to a leader is normalized, and where seeking favors from party officials is viewed as a legitimate strategy. According to Krasniqi and Gashi (2018), such norms sustain a "paternalistic perception of the state," in which governance is understood more as personal benefaction than as rule-based service delivery.

Thus, the persistence of patronage in Albania is not simply a matter of political expediency—it reflects a deeply rooted institutional memory. The combination of path dependence, informal continuity, and cultural acceptance makes reform difficult and often superficial.

Corruption and State Capture

A second major factor sustaining patronage is systemic corruption and the phenomenon of state capture. Patronage can be viewed as a specific mechanism within broader corruption: the abuse of public office for private or partisan gain (Johnston, 2005). In Albania, the two are interlinked and mutually reinforcing. Transparency International (2024) consistently identifies Albania as one of the most corrupt countries in Europe, with widespread perceptions of political and bureaucratic corruption. According to the European Commission's 2023 Albania Report, "corruption remains prevalent in many areas and continues to be a serious concern" (European Commission, 2023, p. 12). Weak enforcement mechanisms and politicized oversight bodies create an environment where patronage networks operate with impunity.

One critical area is public procurement, which constitutes around 7–10% of Albania's GDP (Open Procurement Albania, 2023). Ideally governed by competitive bidding, this process is frequently manipulated to favor firms connected to the ruling elite. As reported in the *National Integrity System Assessment* (IDM & Transparency International Albania, 2023), many tenders are awarded through non-

competitive procedures, or structured in ways that benefit pre-selected firms—often donors or affiliates of the governing party. Public companies and state-owned enterprises serve as patronage reservoirs, offering board seats and contracts to politically connected individuals. Despite accumulating financial losses, these entities are maintained for their political utility (IDM, 2023).

Closely tied to this is state capture, defined as the ability of private interests to subvert public institutions and shape laws, policies, and regulations to their advantage (Hellman et al., 2000). Albania has been repeatedly cited as a case of state capture in the Western Balkans (Freedom House, 2023; European Commission, 2023). The 2023 report *Deconstructing State Capture in Albania* documents how legislation, such as the Strategic Investment Law, was crafted to benefit specific oligarchic actors—allowing them access to public land and investment incentives outside competitive procedures (IDM, 2023).

These patronage arrangements extend to the judiciary. Although Albania launched a comprehensive justice reform in 2016, including the vetting of judges and the establishment of the Special Anti-Corruption Structure (SPAK), the impact has been mixed. SPAK has prosecuted several high-profile cases, but overall impunity for elite corruption remains (European Commission, 2023). The passage of a controversial amnesty law in late 2023, which pardoned dozens of convicted officials, was widely seen as a blow to judicial independence and an indicator that political elites can shield their networks from accountability (Rosa Luxemburg Stiftung, 2024). Patronage also permeates the electoral process. Clientelism during elections—vote buying, misuse of administrative resources, and employment of "patronazhistë" (party operatives maintaining voter databases)—is well documented. The OSCE/ODIHR report on the 2023 local elections noted "credible allegations of pressure on public employees" and the use of public resources for campaign purposes (OSCE/ODIHR, 2023). These tactics are not incidental, but structural: they ensure the reproduction of patronage by winning elections and maintaining control over the distribution of state benefits.

Thus, Albania's high levels of corruption and patterns of state capture create a permissive environment for patronage to thrive. Without effective constraints—either from legal institutions, civil society, or independent media—political actors have little incentive to dismantle these systems. Breaking this cycle would require not only technocratic reforms but also political will and sustained external pressure, particularly from EU accession conditionality (Elbasani & Vurmo, 2012; Kopecký et al., 2016).

Weak Internal Party Democracy (IPD) and Centralized Power

A critical but often overlooked driver of patronage is the internal structure of political parties. In Albania, major parties suffer from weak internal party democracy (IPD), meaning there are few effective institutional checks on leaders' authority, and decision-making remains highly centralized. This internal autocracy allows party leaders to deploy party and state resources to consolidate power without accountability to rank-and-file members or dissenting voices (Xhaferaj, 2022). IPD refers to the mechanisms by which parties select their leadership and candidates, make policy decisions, and involve their members. Strong IPD features transparent internal elections, competitive candidate nomination, inclusive policy deliberation, and decentralization of authority to local branches (Xhaferaj, 2022). However, Albania's main parties score poorly on these metrics. Xhaferaj's study demonstrates low levels of inclusiveness and decentralization in the Socialist Party, Democratic Party, and Socialist Movement for Integration (Xhaferaj, 2022; Xhaferaj, 2023). Echoing this, Krasniqi (2017) and collaborators describe a structure in which a limited elite—often the party chairman alone—makes key decisions, marginalizing local party units (Krasniqi & Gjoni, 2017).

The consequences of this centralization are serious: party leaders function as patrons at the top of a hierarchical pyramid, controlling electoral candidate lists, the allocation of public offices when in power,

and the distribution of party resources and favors. Analysts at the Albanian Institute for Political Studies describe an elite composed of "untouchable leaders" who dominate the party system and decision-making in Albania (Krasniqi & Gjoni, 2017). This creates incentives for loyalty over merit among aspirants, reinforcing patronage as the dominant mode of political advancement.

The closed-list proportional representation system adopted in 2008 further entrenched these dynamics. Under this system, only party leadership determines candidate order on electoral lists, making individual politicians reliant entirely on leadership favor for parliamentary seats. Research indicates that following this reform, party programs declined in importance while "linkage strategies" emphasized leader-focused appeals and clientelist mobilization (Xhaferaj, 2022). As a result, local popular figures are frequently sidelined in favor of loyalists or those with financial resources. Once elected, MPs have very limited autonomy and are typically expected to support the party leader's patronage networks. MPs who deviate risk removal from the list, reinforcing discipline and discouraging dissent.

This nepotistic logic spills over into public administration. After an election, incoming ministers—often chosen for loyalty—replace bureaucrats with party loyalists, using statutory exceptions, temporary appointments, or new agencies to circumvent merit-based recruitment rules (European Commission, 2023). Because internal party democracy is weak, there is no internal party pushback against this practice. This creates a cyclical pattern: top-level patronage enables pervasive politicization of the state, which in turn reinforces centralized control by party leaders. Once officials ascend through patronage networks, they become part of the system. For example, a mayor or minister who attained office thanks to the party leader and a mobilized base often feels compelled to distribute jobs or resources to supporters to maintain loyalty. In Albanian political culture, there is an informal understanding—"to the victor belong the spoils"—that sustains patronage across electoral cycles. Civil service reforms have repeatedly failed to break this cycle.

Strengthening intra-party democracy could serve as a meaningful antidote to this system. If grassroots members had genuine input in selecting candidates or party leadership, they might reward those with merit and integrity rather than loyal obedience to the boss. However, in practice, internal dissent is often suppressed. Following the 2021 political crisis, a faction within the Democratic Party demanding internal reforms was expelled, and the party split, rather than opening up (Krasniqi & Gjoni, 2017). The Socialist Party occasionally voices the need for broader participation, but leadership remains centralized (Krasniqi & Gjoni, 2017). As Krasniqi and Gjoni (2017) conclude, much of Albania's intra-party democracy is merely formalistic—statutes may exist on paper, but in reality they are orchestrated by party elites and not enacted openly. International organizations have repeatedly recommended stronger internal democracy as a component of democratic consolidation, but progress remains limited.

V. Reform Efforts and External Pressures: Can the Cycle Be Broken?

Albania's persistent patronage and clientelism have not gone unnoticed by the international community, and there have been ongoing reform efforts aimed at dismantling this entrenched system. The European Union, as Albania's desired destination for membership, continues to exert significant pressure on the country to strengthen the rule of law, depoliticize state institutions, and enforce merit-based governance. Over the past decade, EU conditionality has made public administration reform a cornerstone of the accession process. Technical assistance has been provided for strengthening civil service laws, introducing transparent recruitment mechanisms, implementing e-recruitment portals, digitizing services to curb petty corruption, and establishing oversight bodies such as the Department of Public Administration (DoPA) to monitor hiring (Xhaferaj & Skara, 2023; OECD, 2024).

On paper, Albania has adopted an improved Civil Service Law and accompanying digital tools. However, the 2023 European Commission Report emphasizes that despite these legal frameworks,

"concerns remain about attempted political interference and shortcomings in merit-based appointments" (European Commission, 2023). The EU has repeatedly cautioned that reforms must go beyond mere formal compliance and foster genuine changes in political culture (European Western Balkans, 2024).

Judicial reform has been another focal point. Since 2016, Albania has undertaken broad restructuring of its justice system, including vetting judges and prosecutors and establishing SPAK, an anti-corruption prosecutor's office (Verfassungsblog, 2025). Although these reforms initially benefited from public support and international backing, recent developments have eroded progress. Critics point to a late-2023 amnesty law that pardoned multiple convicted officials—undermining the reform momentum and showcasing how patronage networks retaliate when threatened (Rosa Luxemburg Stiftung, 2024).

Efforts to reform electoral legislation have similarly stalled. Despite repeated urging from the OSCE and EU to address vote buying and misuse of administrative resources, an ad hoc parliamentary committee formed in 2022 had "not produced any results" as of late 2023, raising doubts about the ruling party's willingness to forgo its political advantages (European Commission, 2023).

Civil society and independent media in Albania have played a vital role in exposing patronage. Organizations such as IDM, BIRN, and the Albanian Helsinki Committee have monitored irregularities in recruitment, procurement, and political financing, while investigative media have uncovered scandals ranging from the 2021 "patronazhistët" database leak to cases of nepotism involving relatives of public officials. Nevertheless, these efforts often encounter structural limitations: media ownership concentration and political-business entanglements result in self-censorship or intimidation of journalists (Rosa Luxemburg Stiftung, 2024).

Political will remains sparse. Dismantling patronage requires elites to surrender a system that benefits them—a classic collective-action problem. With the Socialist Party dominating government since 2013 and the opposition fragmented, the incentive to reform remains low. Analysts warn of democratic erosion and tendencies toward competitive authoritarianism, especially as Prime Minister Edi Rama secured a historic fourth term in 2025 amid concerns of power centralization (The Guardian, 2025; Reuters, 2025).

Yet, there are hints of societal fatigue with corruption. Surveys and protests—against concession contracts or the demolition of the National Theatre—reflect a growing public appetite for accountability. Meanwhile, the EU's leverage endures: with accession negotiations underway, the EU has made clear that "progress in the Fundamentals cluster will determine the overall pace of negotiations," specifically tying Albania's success to its performance in judiciary, public administration, and procurement reforms (AP, 2025).

One potentially transformative reform is professionalizing the public service. Proposals include establishing tenure protections, competitive salaries to reduce patronage incentives, and independent oversight. Although the government has launched an online hiring portal via the DoPA and permitted third-party monitoring of senior appointments, these reforms often remain limited in scope, with senior-level appointments still bypassing merit-based protocols (European Commission, 2023).

Moreover, improving party finance transparency is critical. Patronage networks thrive in ambiguity. Albania has taken initial steps—such as restricting corporate donations and introducing spending limits—but enforcement remains weak. A 2023 regional study, *Bringing the Receipts*, highlighted that while Albania has made some progress in online reporting, it still lags in full political finance transparency (Transparency International, 2023). Empowering institutions like the electoral commission's finance unit and anti-corruption agencies to investigate illicit enrichment could gradually erode the financial foundations of patronage.

VI. Conclusion

Albania's political landscape vividly illustrates the challenges of democratization when confronted with deeply ingrained patronage systems. The "labyrinth of patronage" – an intricate web of favors, loyalties, and informal exchanges – has ensnared Albania's institutions, shaping a reality where political power too often rests on the ability to dispense jobs and perks rather than on policy performance or democratic legitimacy. This article has explored how patronage operates in Albania, how it can be measured and evidenced, and what underlying factors enable its persistence. The findings paint a sobering picture: despite significant reforms on paper and the façade of competitive elections, old patterns of clientelism and political control of state resources continue to undermine the development of a meritocratic, accountable government.

The concept of patronage in Albania is not merely an abstract idea but a daily experience – from the public servant who knows their tenure is tied to election results, to the businessman who nurtures political friendships to win contracts, to the citizen who senses that access to services depends on whom they know. This reality corrodes public trust and impedes the emergence of a political culture based on programmatic competition and equal citizenship. Instead, it perpetuates a vicious cycle of state capture, where governance is looped into serving the interests of those at the top of the party hierarchy and their network. The rampant corruption, as evidenced by international indices and reports, is both a symptom and a facilitator of this cycle.

Crucially, the role of internal party democracy emerged as a linchpin in our analysis. Albanian parties' oligarchical structures have funneled power into the hands of a few, enabling them to use patronage unchecked as a political strategy. Strengthening democracy within parties – through transparent candidate selection, internal checks on leaders, and member empowerment – could, in time, translate to less patronage in the state. As Michels' "iron law of oligarchy" reminds us, without conscious efforts to democratize, any organization (parties included) tends toward rule by a few (Xhaferaj, 2022). Albania's experience affirms this, but also suggests that the law is not immutable: improved statutes, pressure from party bases, and generational change could chip away at internal autocracy.

From an academic perspective, Albania serves as a case study in the difficulties of dismantling patron-client systems in new democracies. It confirms theories that *institutions and informal norms inherited from the past can tenaciously survive regime change*, shaping the behavior of political actors long after democratization. It also illustrates the interplay between formal external incentives (like EU accession conditions) and domestic informal politics – a dance in which progress is made haltingly and often superficially when deeper power structures are threatened.

What can be done to navigate out of this labyrinth? The analysis suggests a multipronged approach: enforcing existing laws (civil service protections, procurement rules) without political bias, enhancing transparency (e.g., open data on government hiring and spending for public scrutiny), empowering independent watchdog institutions (ombudsman, anti-corruption agencies) so they are not patronage pawns, and fostering a culture of accountability starting from within political parties. International actors can continue to support these aims, but ultimately the commitment must come from Albania's own leadership and society to say "enough" to the patronage status quo. Encouragingly, there are signs – however modest – of growing public impatience with corrupt patronage politics, and pockets of the administration that strive for professionalism.

In closing, Albania's democratization journey demonstrates that formal democratic frameworks alone cannot guarantee true democratic governance when informal patronage networks undercut the rule of law. The challenge of navigating this labyrinth is formidable, but not insurmountable. Each step that increases the costs of patronage or the benefits of clean politics will help. By shedding light on the

mechanisms of patronage and their consequences, this article contributes to understanding the depth of the problem – a necessary starting point for any meaningful reform. Albania's experience is a cautionary tale to other young democracies: without vigilance and continuous effort to promote internal party democracy and curb corruption, the shadows of patronage can long darken the prospects of democratic consolidation.

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COMPLETING THE LEGISLATION ON INVESTMENT FORMS IN PRIVATE HIGHER EDUCATION INSTITUTIONS IN VIETNAM TODAY

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ABSTRACT

This article analyzes the current inadequacies in the legislation on investment forms in private higher education institutions in Vietnam and proposes solutions to complete the existing legal framework. In the context where private higher education is increasingly asserting its essential role, attracting and effectively managing private capital is of paramount importance. The study indicates that current legal provisions lack transparency and are overlapping, making it difficult for investors to determine the appropriate investment form, transparentize capital sources, and protect their rights. This not only impedes capital mobilization but also negatively affects the financial and academic governance of these institutions. Therefore, the article emphasizes the necessity of perfecting legislation on investment forms to create a robust and transparent legal environment. The objective is to promote the sustainable development of the private higher education system, enhance human resource quality, and strengthen the competitive position of Vietnamese education on the international stage.

Keywords: legislation; investment; educational institution; private higher education

1. INTRODUCTION

In the context of extensive international integration and the robust development of the market economy, private higher education in Vietnam is increasingly asserting its crucial role in providing high-quality human resources, diversifying educational choices, and reducing the burden on the state budget. The number of private higher education institutions is continuously increasing, leading to a demand for abundant and stable investment capital. However, one of the biggest current challenges is that the legal system concerning investment forms in these institutions still contains inadequacies, failing to genuinely create a favorable environment for attracting and effectively managing private capital. Current regulations are often overlapping and unclear, leading to difficulties in determining the appropriate investment form, transparentizing capital sources, and protecting the legitimate rights of investors. This not only hinders capital mobilization but also affects the financial and academic governance capacity of the institutions. Furthermore, these legal limitations can diminish the attractiveness of the private higher education sector for potential investors, especially foreign investors, who could bring significant financial resources and advanced management experience.

Therefore, completing the legislation on investment forms in private higher education institutions is an urgent and strategically significant requirement. This aims not only to establish a robust and transparent legal corridor but also to serve as a strong impetus for the sustainable development of the private higher education system, contributing to enhancing the quality of human resources and the competitive position of Vietnamese education.

This article will delve into analyzing the existing inadequacies in the legislation on investment forms in private higher education institutions in Vietnam and propose specific solutions to complete this legal framework, aiming for an effective and sustainable investment environment for education.

2. RESEARCH CONTENT

2.1. Concept of Legislation on Investment Forms in Private Higher Education Institutions

According to Vietnam's Investment Law 2020, there are five prescribed investment forms: Investment for establishing an economic organization; Investment by contributing capital, purchasing shares, purchasing capital contributions; Executing investment projects; Investment in the form of BCC contracts; Other new investment forms and types of economic organizations as stipulated by the Government.

Investment forms in private higher education institutions encompass capital investment activities based on general, mandatory principles, applied consistently across different stages. Specific investment activities include:

Initial investment: Constructing physical facilities to meet the minimum requirements of a higher education institution.

Continued investment: Upgrading physical facilities to meet increasingly higher standards.

Training investment: Enhancing the quality of lecturers and staff to meet international standards and practical needs.

Curriculum development investment: Responding to market demands and changes in the education sector.

Research and development (R&D) investment: Creating innovative and advanced solutions in education and related fields. These investment forms are aimed not only at improving educational quality but also at enabling investors to achieve greater profits and economic value compared to the capital and resources expended.

Globally, some studies have addressed investment forms in private higher education, approaching them from the perspective of investment objectives, categorized into two main types: "for-profit" and "non-profit."

In the article "Nonprofit - The American Model and International Resonance in Higher Education" by Kevin Kinser and Daniel C. Levy (2005) (Kinser, K., & Levy, D. C. 2005), from the Program for Research on Private Higher Education, Education Management, and Policy Studies at the University at Albany, Washington State, USA, the authors pointed out that:

Non-profit higher education model: Many countries do not permit the establishment of for-profit higher education institutions, such as Poland, Portugal, Russia, Tanzania, and Uruguay. Additionally, some countries question whether for-profit organizations can be legally recognized.

Limitations on the for-profit model: Some countries, such as Chile, only permit for-profit investment in non-higher education sectors.

Current international data on for-profit higher education remains sparse, unreliable, and inconsistent. However, in many countries, the development of private higher education has been very strong, even without a clear legal corridor.

To form the concept of "legislation on investment forms in private higher education institutions," the following elements are essential:

Mandatory general rules of conduct: Specific regulations on investment activities that private investors must comply with.

Correlation with social ethics: In Vietnam, these legal rules are often linked to social ethics, particularly the feudal-influenced concept of respecting teachers and valuing education.

Independent legal system: An independent legal system built upon the view of legal positivism proposed by Professor Hart. According to this, law is a system of social rules established by the state, entirely independent of moral or religious standards. This view is clearly expressed in the study "Positivism and the Separation of Law and Morals" (2017) (Hart, H. L. A. 2005) published in the Harvard Law Review.

Professor Hart emphasized that a legal rule is not considered illegal merely because it violates moral standards. Similarly, a morally compliant rule does not automatically become law unless explicitly stipulated. However, he also acknowledged that moral principles can be integrated into the legal system when they are institutionalized through legal provisions. This view is supplemented by Jeremy Bentham (Rodrigues Simao, J. (2014, December 24)), who asserted that an effective analysis of law requires separating moral judgments until the nature of the legal rule is clearly defined.

Legal positivism emphasizes the independence of law from morality and religion and asserts that only clearly stipulated moral principles have legal validity. This view helps clarify the boundary between law and morality, providing a prerequisite for objective analysis and application of law.

Legislation on investment forms in private higher education institutions is a new concept, but in reality, it has existed for a long time due to social demand. However, this concept currently borrows general legal principles on investment forms in other types of commercial businesses and has not yet been shaped into an independent entity. It exists as a dependent entity, relying on other general legal principles for regulation.

For the legislation on investment forms in private higher education institutions to become an independent entity and contain rules of conduct regulating investment activities in private higher education institutions, its concept must be clarified. This must be a collection of general principles for each distinct component, but when combined, it has specific regulatory characteristics within a certain scope. The constituent components include: "investment," "investment form," and "private higher education institution." Of which:

"Investment" and "investment form" are concepts implicitly recognized for constructing legal rules.

"Private higher education institution" is understood in two senses: higher education and privately funded.

However, in the public's perception, education carries a noble ethical meaning, that of respecting teachers and valuing education. Therefore, it cannot be regarded as a regular business, where students are customers and teachers are sellers. Although the investment is private, the essence of education must still be oriented towards contributing to the cause of education, rather than having a commercial service orientation.

Legislation on investment forms in private higher education institutions is, first and foremost, a set of general, binding rules of conduct within the scope of private higher education investment activities that private investors must comply with. However, are these rules of conduct influenced by ethical rules, such as respecting teachers and valuing education, in the context of Vietnamese society still deeply affected by feudal ideology?

Legislation on investment forms in private higher education institutions needs to be clearly defined as an independent entity with specific rules of conduct. The construction of this legal framework must balance the specifics of private investment with the noble meaning of education, while separating itself from non-legal ethical influences, consistent with the spirit of legal positivism.

Analyzing the concept of legislation on investment forms in private higher education institutions, we can divide it into components: "investment," "investment form," and "investment form in private higher education institutions." The social realities related to investors' demand for investment in higher education to gain profits demonstrate the business demand in the education sector. Simultaneously,

learners' demand for training quality, training fields, and learning conditions reflects the market demand for the education sector. This is the supply-demand of the educational service business market – a special type of service with mandatory rules to comply with.

From the above analysis, it can be seen that the concept of legislation on investment forms in private higher education institutions is a system of rules of conduct and legal provisions related to investment activities in private higher education institutions. This system is built upon the specific socio-economic characteristics of each country, is mandatory, and is clearly defined in form. It expresses the national government's orientation for higher education development, within the framework of general investment regulations, consistent with economic development and social needs.

Specifically for Vietnam, in addition to the above characteristics, the concept of legislation on investment forms in private higher education institutions must also embody ethical elements, especially the element of respecting teachers and valuing education in Vietnamese society. Safety and social responsibility are also encompassed, along with general mandatory rules of conduct.

2.2. Characteristics of Legislation on Investment Forms in Private Higher Education Institutions

Legislation on investment forms in private higher education institutions is a system of rules and regulations issued by state management agencies to orient, regulate, and manage investment activities. These rules ensure transparency, efficiency, and protect the rights of participating investors, while contributing to the development of private higher education in line with the nation's overall development orientation.

Legislation on investment forms in private higher education institutions has distinct characteristics, specifically as follows:

Mandatory nature: Legislation on investment forms in private higher education is a system of mandatory rules, requiring all investing entities to comply. Accordingly, investors have the obligation to demonstrate and fully meet the conditions regarding capital sources and other mandatory conditions from the initial investment stage, to ensure stable and sustainable training operations throughout the operation of the educational institution.

Strict formality: The system of legal norms concerning investment forms in private higher education is built with the aim of ensuring high certainty, demonstrated through clear and specific legal normative documents. Regulations on investment forms, capital sources, investment rates, financial management, capital management, rights and obligations regarding invested capital, along with related procedures, are all specifically regulated and enforced through state management mechanisms. Any violation of these regulations will be handled by legal measures.

Universality: Legislation on investment forms in private higher education is designed to ensure fairness, transparency, and consistency in the investment and operation processes of private higher education institutions. Thanks to a stringent regulatory system, investors must demonstrate accountability throughout their operations to protect the legitimate rights and interests of relevant parties, enhance the stability of the investment environment, and ensure national interests in the education sector.

In the book "Private Investment in Private Education: Higher Education in Kenya" (Moses, W. N., Eldah, N. O., & Damiano, K. M. 2005) by Moses W. Ngware, Eldah N. Onsomu, and Damiano K. Manda (Kenya Institute for Public Policy Research and Analysis, 2005), the authors surveyed 137 private universities in Kenya and pointed out several barriers to investment in private education, such as: Investment incentive schemes that are not truly attractive, difficulties in accessing credit, inadequate infrastructure for development, unclear legal regulations on establishing educational institutions.

These barriers share many similarities with the situation in Vietnam in 2018. Based on their analysis, the book emphasizes the importance of establishing a legal framework, especially concerning the role

of public-private partnerships and the investment registration process. "To increase private sector investment in higher education, it is necessary to review the legal mechanism on investment forms and regulations to clarify the role of public-private partnerships in education development and make the investment registration process more efficient."

From these proposals, it can be concluded that one of the basic characteristics of investment form legislation is its strict and mandatory nature, manifested through the issuance of specific regulations that investors must comply with. However, it should be noted that these studies primarily focus on identifying existing inadequacies rather than delving into analyzing specific legal solutions.

Globally, the number of in-depth studies on legislation regulating investment forms in private higher education remains limited. The main reason stems from the differences among countries in political systems, educational philosophies, and specific characteristics of each country's educational system. This requires that research on legislation on investment forms in private higher education needs an appropriate approach, taking into account the specific factors of each country to ensure feasibility and effectiveness in practical application.

From the results of theoretical and practical research, the overall characteristics of legislation regulating investment forms in private higher education institutions can be summarized as follows:

Firstly, a clear legal framework: The legal system for investment forms in private higher education institutions is established by competent state agencies to create a stable, transparent legal corridor, thereby guiding and supporting investment activities in this field.

Secondly, alignment with national orientation: Legal provisions on investment forms in private higher education institutions reflect the state's educational development strategies and policies, ensuring synchronization with long-term goals in improving educational quality, expanding learning opportunities, and developing human resources.

Thirdly, systematization of investment principles and models: The legal system specifically regulates investment methods, criteria for investors, capital requirements, rights and obligations of relevant parties, thereby ensuring transparency and feasibility in the implementation of investment activities, systematized into specific legal models that help organizations and individuals easily invest in private higher education institutions.

2.3. Nature and Significance of Legislation on Investment Forms in Private Higher Education Institutions

According to the research by Professor Hart and Green L in their study on "The Concept of Law" (Hart, H. L. A., & Green, L. 2012) published by Oxford University (2012), "What is the nature of law? Its most striking general characteristic is that law is no longer optional, but obligatory. Non-compliance with law does not merely lead to a lack of choice, but also causes certain legal consequences." [page 6].

Derived from this concept, legislation on investment forms in private higher education institutions is defined as a system of highly generalized, mandatory legal rules aimed at regulating investment activities in private higher education institutions. The essence of this legal system is the combination of socially accepted and mandatory rules.

Legislation on investment forms in private higher education institutions is highly specific, as this field requires particular rules of conduct, and also includes regulations on supervision mechanisms, preferential policies, and protective measures to support investment activities.

Despite its mandatory nature, legislation on investment forms in private higher education contributes to important values, including ensuring a healthy, transparent investment environment, protecting the legitimate rights of investors, and enhancing fairness in educational investment activities.

As a result, the law contributes to creating a stable investment environment in private higher education institutions, encouraging development, and minimizing legal risks and disputes. This is particularly significant in promoting the socialization of education, attracting resources from private investors, reducing the burden on the Government, meeting the diverse needs of learners, and enhancing educational quality.

Dưới đây là bản dịch sang tiếng Anh, sử dụng thuật ngữ pháp lý chuyên ngành chính xác:

2.4. Classification of Investment Forms in Private Higher Education Institutions

Investment forms in private higher education institutions vary, including direct investment, indirect investment, and operation under for-profit and non-profit governance models. The selection and application of these investment forms depend on the historical context, socio-economic conditions, and legal policy of each country. The table below classifies investment forms and analyzes the characteristics of each type of investment form in different economic contexts across various countries.

From a business investment perspective, there are various investment forms, such as: Stock investment, where investors purchase shares to become shareholders of an enterprise. Bond investment, executed by lending capital to governments or enterprises to receive periodic interest. Capital contribution to investment funds, allowing capital allocation into various sectors to optimize profits. Real estate investment, focusing on owning, exploiting, or transferring real estate assets for profit.

These investment forms have existed and developed in many countries worldwide, subject to different regulatory mechanisms. To ensure effective and sustainable business investment operations, the development and improvement of management tools, especially the legal framework governing the economy, play a crucial role.

In a study by Tran Thai Duong (2002) on "Economic Functions of the State in Ancient and Medieval Times" (Trần Thái Dương 2002), conducted by the Institute of Legislative Studies under the National Assembly Standing Committee, the author pointed out that even in ancient Rome, the state established legal norms to manage economic activities. Specifically, the Twelve Tables of ancient Rome are considered a foundational legal model for managing commercial activities and property ownership. Similarly, in ancient India, the Code of Manu – in addition to its religious content – also included provisions to protect the property rights of the autocratic monarchy and the upper classes in society.

Depending on the specific legal environment, government management orientation, and economic development, each country will have its own regulations regarding investment activities. Therefore, building a suitable legal system is an essential condition to ensure the healthy and stable development of the economy.

For private higher education, in many countries, the development of private higher education has achieved remarkable successes without a clear legal framework, and sometimes for-profit higher education is neither legal nor entirely illegal (Levy, 2002) (Kinser, K., & Levy, D. C. 2005) (page 3). Investment forms in private higher education institutions have not been clearly classified in any research work, nor is there a specific legal framework, even though higher education continues to develop globally with various methods suited to each country's cultural, historical, and economic development context.

The reality in private universities in other countries and Vietnam shows that these investment forms still exist, even though the legal system governing these activities is vague and rudimentary.

Each country has its own regulations regarding for-profit and non-profit educational institutions. In a study on private higher education by Kevin Kinser and Daniel C. Levy (Kinser, K., & Levy, D. C. 2005) (page 5) from the University at Albany – State University of New York (2005), the authors noted:

"Education policy and management research have addressed the lack of a policy framework, leading to ambiguous distinctions."

Even in the United States, the functional difference between a for-profit and a non-profit organization is not always clear (page 5, 2005). This study also notes that "Researchers have largely overlooked for-profit higher education. Current literature in this area is limited, though rapidly growing, especially in the United States, while information in other countries is very scarce" (page 2, 2005).

2.5. Current Legal Status of Investment Forms in Private Higher Education Institutions

Through numerous amendments and the promulgation of new legal documents replacing those no longer suitable for the actual development of higher education, the current legal system for managing investment activities in the education sector has somewhat addressed inadequacies to better align with reality. Below are the positive aspects and remaining shortcomings that need further adjustment.

Investment Law No. 61/2020/QH14 (National Assembly 2020), effective from January 1, 2021, pursuant to the Investment Law (Article 21 on Investment Forms), Vietnam permits five different investment forms, including:

(1) Establishing an economic organization such as a limited liability company (LLC), joint-stock company (JSC), partnership (GP), private enterprise (PE), or cooperative; or participating with 100% private capital or as a joint venture with domestic partners; or

(2) Investing by contributing capital, purchasing shares, purchasing capital contributions of economic organizations; or contributing capital to economic organizations; purchasing shares or capital contributions of economic organizations already established in Vietnam; receiving transfer of shares or capital contributions from other investors;

(3) Implementing investment projects under: BCC contracts (Business Cooperation Contracts): Business cooperation contracts between domestic and foreign investors; BOT contracts (Build-Operate-Transfer); BTO contracts (Build-Transfer-Operate); BT contracts (Build-Transfer); Investing in the form of PPP (Public-Private Partnership);

(4) Establishing an enterprise between domestic and foreign investors to implement projects in Vietnam;

(5) Other investment forms permitted by the Government, appropriate for each period and socio-economic development policy.

From the above regulations, the first option is for investors to choose the investment form of establishing an economic organization to establish a higher education institution. In the case of domestic investors, the Enterprise Law is applied to select the type of economic organization to be established, such as an LLC or a JSC. In the case of foreign investors, investment procedures must be complied with before applying the Enterprise Law to select the type of economic organization to be established. With the investment form of establishing an economic organization to choose a company type that can be a JSC or an LLC, this type of company is subject to the regulation of the Enterprise Law. Therefore, investors have legal frameworks as a basis for conducting their investment activities, such as applying regulations on establishing a general meeting of shareholders or a board of directors, and regulations on majority and minority voting ratios. This is a new step forward in the education legal system regulating the establishment of private higher education institutions. With this investment form, investors will not encounter any difficulties during the investment process.

Although the investment form has not been specifically and clearly regulated by law, it has somewhat resolved some of the difficulties currently faced by private universities. The law has abandoned the borrowing of concepts from joint-stock companies and has made a strong shift in allowing investors to choose the investment form of establishing an economic organization to be subject to the Enterprise

Law. There are no longer any difficulties in operations when applying this investment form. The regulation on this investment form of establishing an economic organization has created an initial legal basis for the investment, establishment, and development of private higher education institutions, specifically:

Both Vietnamese and foreign investors are subjects of the investment form of private higher education institutions. Any university established, regardless of domestic or foreign investment capital, is a private university. (Clause 2, Article 7) "Private higher education institutions are invested by domestic or foreign investors, ensuring operational conditions."

Investors are correctly referred to as investors (Article 16). The borrowed concept of a General Meeting of Shareholders no longer exists.

The investment form in private higher education institutions is defined as requiring investors to establish an economic organization, for the economic organization to then establish a private higher education institution. (Article 16) "Invest in establishing an economic organization as prescribed by the Investment Law, Enterprise Law for the economic organization to establish a private higher education institution as prescribed by this Law;"

The rights of investors are returned to the investors, meaning investors will decide to approve the chairperson of the school council, the rector, and the composition of the school council – the body representing the investors in managing academic matters. (Article 17) "The school council of a private university includes investor representatives, internal and external members of the university elected and decided by the investor meeting according to their capital contribution ratio." With such content, some shortcomings regarding investment forms have been addressed.

Besides the investment form where investors first establish an economic organization and then establish a private higher education institution, there are still some shortcomings regarding the content of direct investment forms, such as:

The Law permits the form of direct investment in private higher education institutions. "Directly invest in establishing a private higher education institution as prescribed by this Law. In this case, the organizational and operational regulations of the higher education institution must specify the investor meeting and the operational methods of the investors; the choice of applying relevant provisions of law on limited liability companies or social funds to resolve issues in the higher education institution not yet regulated by this Law; the responsibilities and powers of investors and the supervisory board in accordance with the regulations on the chosen limited liability company or social fund." Choosing the investment form where the investor directly invests in establishing a private higher education institution, along with the condition that the organizational and operational regulations of the higher education institution must specify the investor meeting and the operational methods of the investors; the type of operation; the responsibilities and powers of investors and the supervisory board in accordance with the regulations on the chosen limited liability company or social fund. In this option, all procedures for investment, capital contribution, majority voting ratios, and operational methods are agreed upon by the investors themselves and enshrined in the company's charter, with no and cannot be any regulation by any law because these investors are not subject to the Investment Law or the Enterprise Law. Therefore, investors who do not establish an economic organization can only apply the provisions of an LLC or social fund in their capital investment activities as stipulated in the 2018 Higher Education Law. Especially, the investment capital invested by these investors in private higher education institutions is not confirmed by the investment licensing authority or any competent authority. Instead, investors only record the capital contribution by a capital contribution minutes. Other procedures, such as the company issuing a certificate of invested capital after receiving a business registration certificate and/or a member register, are also not applicable.

With this type of direct investment, when investors choose to apply legal provisions and record them in the school's organizational and operational regulations (Clause 3, Article 16), risks can always arise in disputes between investors because the applicable law is chosen, not a mandatory legal framework. This investment form reveals a loophole: the lack of a legal mechanism to recognize investment capital, which means that capital contributions from investors are not managed by state agencies through a legal document. In the case of investment through an economic organization, the investment capital is determined and recorded in the business registration certificate or investment certificate.

With the investment form of directly establishing a private higher education institution, there is no mandatory requirement for private investors to prove sufficient capital contribution and have the capital recorded in the business registration certificate or investment project certificate by the competent authority for review and approval; only:

"Commitment letter for school construction capital contribution from individuals and organizations and consent from the legal representative establishing the school; List of shareholders committing to contribute capital; Capital contribution agreement minutes." (Clause 3, Article 88, Decree 46). "Bank confirmations of current funds managed by the project management board, legal documents proving asset ownership accompanied by asset valuation documents if contributing capital with assets or asset ownership rights; documents related to the capital already invested in construction and equipment procurement for the school (with confirmation from the competent financial authority on the capital invested in school construction and bank confirmation of capital contribution in the project management board's account)." (Clause 3, Article 88, Decree 46).

Due to the lack of regulations on legal mechanisms to verify capital sources, the capital of private investors in private higher education institutions under the direct investment form is not managed by any state management agency. The education management agency only manages academic matters. The business investment management agency manages investment activities by approving new, supplementary, or amended business registration certificates and investment certificates when there are changes in investment capital, project scale, project duration, but cannot manage the investment activities of private investors in the direct form because investors do not establish an enterprise. This is a loophole in state management of private investment in education, leading to many disputes among investors in practice, which most significantly affects students.

Vietnam does not yet have a separate law on private higher education. Regulations on investment subjects and investment capital – the core elements of investment forms and investment capital management – are scattered across several documents. The current development of legal regulations on investment in higher education has only reached the scope of legalizing reality. Practical difficulties have not been adequately considered, and impact assessments have not been conducted to develop legal regulations. The current law does not contain specific provisions on permitted and prohibited investment methods that investors must comply with to guide the development of private higher education.

From another overall perspective on investment in education with domestic and foreign investment capital. For foreign investment to establish a private higher education institution, foreign investors do not have the right to choose the investment form of establishing a higher education institution without establishing an economic organization, unlike Vietnamese investors. According to the Investment Law, foreign investors must have an economic organization to implement an investment project (Article 22, Investment Law). Before that, they must apply for an investment registration certificate for investing in a private university. After receiving approval from the Prime Minister for the investment registration policy and then receiving the investment registration certificate from the local licensing authority, the investor must establish an economic organization for the economic organization to implement the private university project. Thus, foreign investors who wish to establish a higher education institution

must establish an economic organization and are not allowed to choose the direct investment form of establishing a private higher education institution.

With the regulation on the investment form of establishing an economic organization, the economic organization will be subject to the Enterprise Law and the Investment Law, so all procedures, rights, and voting ratios are regulated by these laws.

The form of direct investment in establishing private higher education institutions is a form that Vietnamese investors have been and are still implementing since the early years (1993) when the Government allowed the establishment of private higher education institutions. With this form, some schools have encountered difficulties in capital investment operations, such as borrowing operating capital, increasing or withdrawing capital being decided by the investors themselves or by applying the Enterprise Law. As a result, disagreements have arisen among investors due to the lack of a governing law, unlike the form of establishing an economic organization.

2.6. Recommendations for Improving Legislation on Investment Forms in Private Higher Education Institutions in Vietnam

Regarding investment forms, it is necessary to conduct qualitative and quantitative impact analyses to determine the optimal economic organization model, which may include joint-stock companies, limited liability companies, or a combination of both.

First, define the type of economic organization model for the owner of private universities. In the context of the growing development of private universities, defining the economic organization model of the owner plays a crucial role in ensuring effective governance and sustainable development. Accordingly, the owners of private universities can be organized under various enterprise forms, including joint-stock companies, limited liability companies, or other types of enterprises as stipulated by the Enterprise Law. Each type of enterprise organization will have specific regulations on organizational structure, rights and obligations of founding members, investors, as well as operational methods.

Clearly regulating the types of investment and accompanying legal procedures will help ensure that private universities operate correctly, according to legal principles, while creating transparency and fairness in management. In particular, the economic organization model of the owner must meet the requirements for effective governance, including mechanisms for financial control, oversight of training activities, and protection of learners' rights.

Second, investment capital must be confirmed by legal documents as a condition for permitting investment. Determining and recognizing investment capital for private educational institutions is an important factor in the process of establishing and developing private universities, aiming to ensure transparency, accountability, and the rights of relevant parties, especially learners. To achieve this, the law stipulates that the investment capital of private educational institutions must be confirmed through specific legal documents, including the Investment Registration Certificate and the Business Registration Certificate.

Specifically, the Investment Registration Certificate will be the legal proof certifying the amount of capital that the investor commits to contribute to the educational institution. This certificate not only reflects the investment capital but also clearly defines the purpose, scope of operation, and duration of investment, thereby ensuring transparency in capital utilization and investment activities.

The Business Registration Certificate will be the document confirming the establishment and legal operation of the organization owning the private university, thereby verifying that the investing organization has completed legal procedures in accordance with enterprise law. This certificate will provide information on the organizational structure, rights and obligations of investors, as well as information related to management and operation.

Furthermore, investors must bear legal responsibility for the invested capital, including financial responsibility and responsibility towards learners. This means that investors must ensure that their investments are used for the correct purpose, serving educational activities, and must ensure the quality of training and protect the rights of learners. In case of incidents or violations during capital utilization, investors will be held legally accountable and liable for compensating damages related to learners' rights.

Therefore, confirming investment capital through legal documents such as the Investment Registration Certificate and the Business Registration Certificate is not only a condition for investment permission but also a tool to enhance transparency, protect learners' rights, and ensure the sustainability of private educational institutions.

3. CONCLUSION

Improving legislation on investment forms in private higher education institutions is an important task to guide and promote the development of this system in Vietnam. A comprehensive legal framework helps enhance transparency in management, improve the effectiveness of academic governance, and attract private investment, fostering educational innovation. In the context where private higher education institutions are increasingly important, the legal framework needs to clearly and strictly regulate the process from establishing an economic organization to defining investment capital for education. This ensures financial transparency and creates a solid foundation for the development of universities. Investors must register capital sources with competent authorities for screening and to ensure financial capacity, then establish and operate educational institutions, ensuring operations are legal and effective.

A comprehensive legal framework will create a favorable environment for the development of private higher education and Vietnam's economy. Policies encouraging private investment in private education need to ensure investor benefits, improve educational quality, and enhance the competitive position of Vietnamese higher education institutions. The improvement of legislation on investment forms is a prerequisite for the robust development of private education, contributing to the socio-economic development of the country.

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COMPLETING THE LEGAL FRAMEWORK FOR INVESTMENT CAPITAL GOVERNANCE IN PRIVATE HIGHER EDUCATION INSTITUTIONS IN VIETNAM TODAY

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ABSTRACT

This article focuses on analyzing the challenges and shortcomings in the legal framework concerning investment capital governance in private higher education institutions in Vietnam. The study highlights that current regulations lack transparency and synchronicity, leading to difficulties in financial management, capital allocation, and utilization. This not only impedes oversight but also poses potential risks, affecting the quality of education and the reputation of these institutions, while also diminishing investor incentives. Therefore, the article emphasizes the necessity of completing the legal framework for investment capital governance to establish a solid, clear, and transparent legal foundation. The objective is to promote effective capital mobilization and utilization, enhance academic governance capacity, and contribute to the sustainable development of private higher education in Vietnam.

Keywords: legal framework; governance; investment capital; education; private higher education.

1. INTRODUCTION

In the context of deep international integration and robust market economic development, private higher education in Vietnam is increasingly asserting its pivotal role. To fulfill this role, private universities require substantial investment capital from various sources. However, attracting and, especially, effectively governing these capital sources still encounter numerous legal obstacles. The reality shows that the current legal framework for investment capital governance in private higher education institutions remains highly restrictive. The regulations are not truly clear and lack synchronicity, leading to a lack of transparency in financial management, capital allocation, and utilization. This not only creates difficulties for state management agencies in control and oversight but also harbors potential risks concerning capital preservation and development, directly impacting the quality of education and the reputation of these institutions. Furthermore, these legal shortcomings can reduce the motivation of private investors, both domestic and foreign, due to the absence of a sufficiently robust legal framework to ensure the transparency, efficiency, and security of their investments.

Therefore, completing the legal framework for investment capital governance in private higher education institutions is an urgent and strategic task. A solid, clear, and transparent legal framework will not only facilitate more effective capital mobilization and utilization but also enhance academic governance capacity and training quality. This will significantly contribute to the sustainable development of private higher education, improve the competitiveness of the national human resources, and contribute to the overall development of the country.

2. RESEARCH CONTENT

2.1. Concept of Law on Investment Capital Governance in Private Higher Education Institutions

The law on investment capital governance in private higher education institutions is a system of principles and legal regulations aimed at governing activities related to three main elements: "investment capital," "investment capital governance," and "private higher education institutions." Although these

elements have clear distinctions in content and scope, when combined, they form a specific legal framework. This legal framework plays a role in regulating and managing the use of investment capital in private higher education institutions, thereby ensuring the sustainable and effective development of these educational organizations. Basic analyses of investment capital governance and the law on investment capital governance will provide the theoretical foundation for constructing the concept of the law on investment capital governance in private higher education institutions.

Investment capital governance, in the context of corporate governance, serves as a crucial element in the governance triangle comprising: corporate governance, business governance, and academic governance. Investment capital governance is the process of defining investment strategies, overseeing investment activities, evaluating and managing risks, and making decisions regarding specific investment items. The subjects of investment capital governance can be owners or authorized individuals, operating under government management and oversight, to ensure transparency and accuracy in managing investor assets.

According to Chhotray, V. and Stoker (2009), governance is understood as a collective decision-making process in an environment involving multiple actors where no formal control system exists. Meanwhile, management focuses on organizing and implementing plans and policies to achieve stated objectives.

Furthermore, Yusoff Wan Fauziah Wan and Idris Adamu Alhaji (2012) argue that governance is the process by which shareholders influence management to act in their best interests, aiming to ensure the efficient functioning of the capital market.

Sir Adrian Cadbury (Knight of the United Kingdom) wrote (Clarke, T. 2004): “Forms of corporate governance are shaped nationally by their economic, political, and legal foundations, by their sources of finance, as well as by the history and culture of the countries concerned” (Page 1, 2005).

In the project "Researching the theoretical and practical basis for amending and supplementing the Higher Education Law 2012" (Research Group of Hanoi Law University and Vietnam National University, Hanoi (n.d.), led by Assoc. Prof. Dr. Vu Thi Lan Anh), the concept of governance is clarified with the view that governance includes defining strategies, macroscopic objectives, plans, policies, and implementation solutions. Conversely, management is understood as the process of organizing and implementing the plans, policies, and solutions defined in governance, aiming to achieve the stated objectives (Page 18, 2020).

From the above perspectives, investment capital governance in private higher education institutions not only involves strategic decision-making regarding investment but also must comply with government legal regulations. The subjects of investment capital governance can be owners or authorized persons according to the chosen investment forms. The goal is to ensure transparency and accuracy in managing investor assets, thereby helping to effectively operate investment capital sources.

The law on investment capital governance in private higher education institutions is not only a part of corporate governance but also has the specific characteristics of the education sector. Concepts of governance and management in enterprises, although long applied in higher education institutions in countries like the US and UK, are still new concepts in Vietnam. Although Vietnam has committed that education is a service under WTO regulations, the management and investment in private higher education still need to comply with domestic investment law.

Investment capital governance is part of corporate governance. The concepts of governance and management are familiar terms in the business environment, but they are still relatively new in private higher education institutions in Vietnam. More than 20 years ago, European universities underwent profound changes to adapt to the development of the economy. The management methods of universities in the US and UK began to apply governance techniques similar to those in businesses. This trend is

mentioned in an article by Mora.J.C (2001) titled "Governance and Management in the New University: Management and Higher Education" (Mora, J. G. 2001), in which he pointed out that "the trend towards increasing application of business management techniques is being applied in universities" [Page 12, 2001]. He also emphasized: "It is an undeniable fact that the country leading in university governance and management reform will also lead in science and technology" [Page 13, 2001].

Originating from the concept of corporate governance, research by Carnegie, G.D. and Tuck, J., 2010, on university governance introduced the governance triangle model, including "academic governance, business governance, and corporate governance." In the article "Understanding the ABC of University Governance" (Carnegie, G. D., & Tuck, J. 2010), the authors affirm: "University governance is complex and contentious. ... The synthetic emphasis on the three main components of governance: academic governance, business governance, and corporate governance. ... Placing academic governance first in the ABC of university governance reminds us all of the vital role and importance of academia" (Page 10, 2010). The operation of a university is always composed of these three pillars; therefore, investment capital governance must be placed under corporate governance, separate from the academic governance structure.

Essentially, investment capital governance in private higher education institutions is inherently investment capital governance within corporate governance. Therefore, the law on investment capital governance in private higher education institutions in Vietnam shares common characteristics with the legal framework for investment capital governance in general, while also incorporating specific regulations and principles of the private higher education model – a conditional service type according to Vietnam's investment law. However, as of 2023, the legal framework for investment capital governance in private higher education institutions has not been fully completed. Investing in private higher education institutions is considered an investment in the educational service sector, according to Vietnam's commitments within the WTO framework, where education is considered a service. Under the Investment Law 2020 (National Assembly 2020), higher education in Vietnam is a conditional service when investing.

From the studies of international scholars and the practical situation in Vietnam, it can be seen that the concept of the law on investment capital governance in private higher education institutions will be influenced by the political, social, and cultural values of each country, as well as the form of investment chosen by the investor.

In summary, the concept of the law on investment capital governance in private higher education institutions can be understood as a system of principles and legal regulations specifically designed to suit the distinct characteristics and requirements of the private higher education sector. This legal system is not only mandatory in its enforcement but also ensures transparency and accuracy in its application. Consequently, this legal system will help private higher education institutions strictly comply with investment capital governance regulations, while aiming to achieve university governance objectives effectively and rationally. These legal regulations also play a crucial role in implementing government strategies and policies, contributing to the sustainable development of the higher education system, and meeting economic and social development requirements in each specific period.

2.2. Characteristics of Investment Capital Governance Law in Private Higher Education Institutions

The law on investment capital governance is an important tool that helps the government control and guide investment in specific sectors to achieve socio-economic development goals. In the context of private higher education, the law on investment capital governance not only includes general regulations on capital injection, capital withdrawal, capital account management, and capital utilization within the legal framework, but also reflects specific characteristics related to the ownership of investment assets,

a matter that varies significantly between countries based on their economic peculiarities and legal environments. Therefore, analyzing and comparing the characteristics of investment capital governance law in private higher education institutions under different economic contexts not only helps clarify global legal trends but also provides an important theoretical basis for perfecting the concept of the law on investment capital governance in private higher education institutions, specifically:

According to Spring Su, in the article "Policy Environment of Private Higher Education in China: A Discussion Based on Property Rights" (Su, S. (2012)), the law on investment capital governance in China (under Article 32 of the Law on Promoting Private Education 2002) only permits exclusive use rights to assets and land, but does not allow permanent ownership or transfer of assets. This reflects the lack of regulations related to transfer rights and property ownership, preventing private investors from using educational institution assets (such as buildings, libraries) as collateral for bank loans to supplement investment capital. Studies indicate that the disparity between policy and practice in capital governance, asset management, and finances of private investors is an issue that needs improvement.

Similarly, Daniel C. Levy's research on "Public Policy Towards Private Higher Education" (Levy, D. C. 2011) shows that in Latin America, the law often stipulates similar treatment between the private and public sectors, although this similarity cannot be guaranteed in practice, especially in financial and governance matters [page 384, 2011]. This also shows the differences between countries in managing investment capital and private higher education systems.

In the context of private higher education in the United States, a country with a long history of developing a private education system, Professor William Zumeta from the University of Washington, Seattle (USA), in his article "State Policy and Private Higher Education in the United States: Understanding Differences in Comparative Context" (Zumeta, W. 2011), stated: "The United States is a federal country where private higher education is the responsibility of individual states. Each state has a different approach to public policy applied to private higher education" (page 125, 2011). In the context of the free market economy of the United States, public policy towards private higher education does not focus on regulations on investment capital governance for private investors. Instead, US policy focuses on promoting the growth of private investor capital through grants for students attending private universities. This policy not only supports students but also promotes research at private institutions. "Market mechanisms are applied, allowing students to receive grants and use them at any accredited public or private institution, including for-profit organizations." The ability of students to use government grants at private institutions is quite unique in the world. These policies supporting students and research build important foundations for competitive incentives in the US education system and contribute to facilitating the success of private organizations (page 426, 2011).

From the above studies, it can be seen that the law on investment capital governance in private higher education institutions will have different characteristics based on the economic and political context and the development orientation of each country.

With different economic contexts, laws are built and approached in different ways. Spring Su's research points out that the Chinese economy, although developing towards a market economy, is still regulated by the government through policies. Private education, despite being private investment, due to the specific nature of the education sector, requires government regulation. Therefore, the Chinese government has built a policy framework that does not completely grant investment capital governance rights to private investors. This regulation reflects the difficulty in state management in the early stages of developing private higher education in China, which is similar to the situation in many other countries, including Vietnam.

Similarly, Daniel C.'s research shows that in Latin America, education policy is applied generally to both public and private education systems, although the investment capital sources for these two sectors

are different. This is also a characteristic that Vietnam has experienced before, when a common policy framework was applied to both public and private education.

For Vietnam, a developing country transitioning from a state-subsidized economy to a market economy, with its own characteristics according to the state's development orientation, the law on investment capital governance in private higher education has specific characteristics, including:

Legal Basis for Investment Capital Governance: The law on investment capital governance is built based on the investment capital structure chosen by the investor. The investment capital governance by the investor includes deciding long-term and short-term development policies and plans, approving development plans for higher education institutions, including the development of facilities, improving faculty quality, and investing in human resource development.

Capital Development and Preservation: Specific regulations on capital development and preservation to achieve the goals of training development and improving the quality of higher education, especially when the capital source is not state-owned.

Linkage with Other Legal Regulations: These regulations are closely linked with other legal regulations (investment, enterprise) to form a unified legal system in state management of investment and utilization of investment capital sources for private higher education institutions.

Investment Capital Governance as a Corporate Function: Investment capital governance in private higher education is not only a financial management tool but also a function of corporate governance, belonging to the university governance legal system, including elements of academic governance, business management, and corporate governance (ABC – Academic Governance, Business Management, Corporate Governance).

Principles of Capital Governance: The law regulates the principles and system of capital governance, defining the responsibilities of investors and the methods of organizing capital management to be transparent and efficient, in accordance with the permitted investment forms.

Protection of Stakeholder Rights: Possesses a protective nature of the state towards investment activities, ensuring fairness and the rights of stakeholders in the operation of private universities.

These characteristics show that, although the law on investment capital governance in private higher education in Vietnam is developing in line with market economies, it is still subject to strict government regulation and oversight to ensure the sustainable development of the private higher education system in the current economic transition.

2.3. Significance of Investment Capital Governance Legislation in Private Higher Education Institutions

Legislation governing investment capital in private higher education institutions plays a crucial role in the establishment and sustainable development of these institutions. This legal framework is not merely a financial management tool but also reflects the nation's policy orientation, ensuring a balance between stakeholder interests and educational quality. The legislation on investment capital governance in private higher education contributes the following:

It institutionalizes the state's policies and guidelines for the development of private higher education. The law helps to concretize government policies, thereby establishing the state's authority over private higher education institutions while ensuring alignment with national educational development goals. It creates a transparent and effective legal framework for financial management. Investment capital governance legislation establishes a clear legal system, ensuring transparency and efficiency in the utilization and allocation of capital, while protecting the interests of investors and the educational quality of private higher education institutions, in line with national development orientations and societal

needs. It further ensures transparency and public disclosure in the management of investor capital, fostering a healthy competitive environment and sustainable development. It embodies the will and protects the interests of the higher education system in general and private higher education institutions in particular. It provides reassurance for investors as their rights are protected through regulations on investment capital governance.

2.4. Content of Investment Capital Governance Legislation in Private Higher Education Institutions

Differences in the socio-economic contexts across countries have led to diverse approaches concerning the content of investment capital governance legislation in private higher education institutions. Over various development stages, the legal framework governing investment capital has undergone significant adjustments to ensure its suitability with practical realities and to meet management requirements.

Firstly, the investor is identified as the subject of capital governance in private higher education institutions, where the governance activity is characterized by corporate governance.

According to research by Prof. Dr. Sc. Nguyen Van Chon and Nguyen Hong Hai in their book "Fundamental Theories of Business Administration" (Nguyen Van Chon and Nguyen Hong Hai 2008), the governing subject is characterized by ownership of business assets, freedom and proactiveness in business operations as stipulated by law, and responsibility for business outcomes. This demonstrates that investment capital governance is not only crucial to the operational mechanism of private higher education institutions but also determines the operational efficiency of participating investors.

In a prominent study by Dr. Do Thi Thanh Van, "Financial Policies Promoting Socialization of Higher Education in Vietnam, 2014-2020" (Do Thi Thanh Van 2018), the author highlighted limitations in legal regulations concerning investment capital governance. Specifically, the current legal system lacks comprehensive regulations on the financial management mechanism for non-public higher education institutions, thereby creating barriers to attracting investment capital.

Concurrently, this study emphasized the necessity of transparentizing undivided assets in private higher education institutions and proposed increasing the annual profit distribution to contributing investors. However, during this period, investors' rights to capital management were still constrained by legal provisions, leading to limited control and flexible use of capital.

Additionally, the article "Private University Governance Model" by (Ha Thuy 2011) in Dai Bieu Nhan Dan newspaper, also pointed out several inadequacies in legal regulations concerning equity capital. Unclear regulations on assets and ownership rights in private higher education institutions have led to the overt trading of universities, directly affecting state management and training quality. The lack of stringent control mechanisms has given rise to numerous legal risks, necessitating the urgent completion of the legal system in this field.

Over various development stages, the legal documents related to finance, assets, and investment capital governance in private higher education institutions have been adjusted to address emerging practical inadequacies. However, to date, no comprehensive and systematic study has thoroughly resolved the issues related to investment capital governance in this field, posing an urgent requirement for further refinement and supplementation of the legal framework to suit the current context.

Based on practical requirements and the goal of sustainable development of higher education in Vietnam, the content of investment capital governance legislation in private higher education institutions needs to be developed focusing on the following fundamental principles:

Principle of Asset Ownership: The law must clearly define ownership rights over invested capital, and stipulate that this capital must be attested by official legal documents to ensure transparency in the

investment process and protect investors' rights. This will clarify the scope of assets owned by the investor and the common undivided assets over which the investor has only the right of disposition but not the right of sale or transfer. Concurrently, the mechanism for capital transfer and any restrictions on transfer must be rigorously regulated to protect stability and ensure the long-term development objectives of the educational institution.

Preservation of Financial Norms: The law must set forth financial principles for mandatory investments to ensure training quality. These principles will help investors determine appropriate investment levels and provide a basis for effective, purposeful, and legally compliant investment capital governance, contributing to the long-term financial stability of the educational institution.

Orientation Towards Sustainable Development: Legal provisions on investment capital governance must be consistent and synchronized with the overall development orientation of the private higher education system in Vietnam, ensuring feasibility and long-term sustainability, while promoting the comprehensive development of the private higher education sector in the country.

2.5. Current Legal Landscape of Investment Capital Governance in Private Higher Education Institutions

Vietnam has a legal framework regulating investment forms, but it merely names these forms without providing specific regulations. Investment capital governance is a consequence of the investment form; therefore, as long as the investment form is not specifically regulated, investment capital governance remains unaddressed in Vietnam's legal system.

When investors choose to establish an economic organization to form a higher education institution, if they opt for the joint-stock company model, investment capital governance rights will follow the voting methods, capital contribution methods, capital management, and dispute resolution mechanisms applicable to joint-stock companies. If investors choose the limited liability company (LLC) model, investment capital governance rights will follow the voting methods, operations, and management of contributed capital applicable to LLCs as stipulated in the Enterprise Law (2014 and 2020). When the investment form is clearly defined as an economic organization with legal personality and investment capital managed by legal documents as per the Enterprise Law and Investment Law, then investment capital governance, including voting rights, financial rights, and asset rights, will follow the chosen investment form and apply the provisions of relevant specialized laws. This will eliminate existing inadequacies during operations when applying this investment form.

Autonomy over Investment Capital Sources: In addition to regulations on establishing new private higher education institutions, the transformation from "semi-public" to "private" institutions is governed by Circular No. 45/2014/TT-BGDĐT (Ministry of Education and Training 2014), which provides detailed guidance on capital source governance and capital conversion for semi-public universities transitioning to private status, replacing Circular 20/2010/TT-BGDĐT. A positive aspect of Circular 45, following numerous state management regulations on capital governance, is the "Empowerment of investment capital management autonomy for investors" [Article 32, Clause 5]. Granting investment capital management autonomy to investors without any specific regulations on the conditions to be met during the management of this capital ensures that investors are free to manage their investment capital.

From the above content, it is evident that investment capital governance in private higher education institutions will depend on the economic organization form chosen by the investor, such as a joint-stock company or an LLC. Each form has specific regulations on voting rights, capital contribution methods, and capital management according to the Enterprise Law. Investors will also adhere to management and voting mechanisms suitable for the specific characteristics of that type. Both the Enterprise Law and the Investment Law clearly regulate the capital management of economic organizations with legal

personality, ensuring transparency and legality in financial activities, voting rights, and asset management.

Furthermore, the autonomy in investment capital governance has been emphasized through Circular 45/2014/TT-BGDĐT, which has given investors in private universities greater freedom in managing their capital sources. This Circular does not impose legal barriers or complex conditions, facilitating investors in the capital governance process, helping to optimize investment efficiency, and resolving inadequacies in the operations of educational organizations. As a result, investors can be more proactive and flexible in developing and expanding higher education institutions, contributing to enhancing educational quality and sustainable long-term development.

To resolve difficulties in the transformation from "semi-public" to "private," on December 17, 2014, the Ministry of Education and Training issued Circular No. 45/2014/TT-BGDĐT, providing detailed guidance on capital source governance and capital conversion for semi-public universities transitioning to private status, replacing Circular 20/2010/TT-BGDĐT. While the Circular partially addressed the difficulties, some issues persist:

Investor contributions are "preserved at their value at the time of conversion" and "based on the consensus between the Board of Trustees and the contributing organizations and individuals."

The issue of value preservation causes inconsistent disputes between the Board of Trustees and investors, especially the disagreement among the founding members of the institution regarding the value of capital contributions in cash versus contributions in effort and educational experience. The "preservation" of capital contribution value after many years is inconsistent with actual market value.

For direct investment, investors have the right to choose the applicable legal provisions and record them in the institution's organizational and operational regulations (Article 16, Clause 3.b). However, problems still exist:

Risk of disputes among investors due to self-selected, inconsistent applicable laws.

Investment capital is not clearly identified by legal documents, leading to inefficient capital governance.

These inadequacies affect the stability and sustainable development of private higher education institutions. To overcome these limitations, it is necessary to continue improving the legal system, focusing on ensuring transparency, synchronization, and fairness in investment capital governance in private higher education institutions.

2.6. Recommendations for Improving Legislation on Investment Forms and Investment Capital Governance in Private Higher Education Institutions in Vietnam

In a study led by Associate Professor Dr. Tran Quang Quy, "Research Proposing Solutions for Sustainable Development of Non-Public Universities" (Tran Quang Quy 2020), the authors proposed the following solutions to improve the legal framework related to investment and development of private higher education institutions:

Review and adjust policy documents: Conduct a comprehensive assessment of current regulations on investment and finance in private higher education. Eliminate overlaps and conflicts between legal documents to ensure consistency and practical feasibility.

Issue long-term development policies: Develop and announce a strategy for private higher education development for the period 2021-2030, with an orientation to 2050, ensuring synchronization between the higher education development strategy and national socio-economic, scientific, and technological policies.

Complete the legal framework for the organization and governance of private universities: Clearly define the legal status, rights, and obligations of organizations and individuals investing in private higher

education. Specifically regulate the authority of the Board of Trustees, the Chairperson of the Board of Trustees, and the Rector in private universities.

Innovate financial resource allocation mechanisms: Focus on preferential policies for lecturers and administrative staff.

Reform administrative procedures related to investment: Simplify approval processes to ensure a transparent and fair investment environment among investors.

The aforementioned solutions have initially approached governance mechanisms in operating a private university. However, to complete the legal framework related to investment forms and investment capital governance mechanisms, it is necessary to research and identify appropriate legal norms, ensuring efficiency, transparency, and sustainability in the financial management of private higher education institutions.

Regarding investment capital governance: The legal framework needs to be designed to be compatible with legally permissible investment models, ensuring synchronization and consistency among relevant legal provisions. Simultaneously, it should create favorable conditions and encourage the private sector to invest in private higher education.

Clearly define the roles of stakeholders in investment activities: Within the framework of private university governance, clearly defining the roles and authorities of stakeholders is crucial to ensuring effective investment and management. From the legal framework governing investment forms and investment capital governance, it is necessary to clearly delineate the authority between the economic organization (investor) and the Board of Trustees, especially in capital governance and training activities. The relationship between these two bodies can be envisioned as follows:

Economic Organization (Investor): The economic organization acts as the governing body for the invested capital in the educational institution. Accordingly, the investor will exercise rights and obligations related to finance and the development of the institution's physical infrastructure through the economic organization. Specifically, the economic organization is responsible for:

Managing invested capital: The investor, through the economic organization, will supervise and direct investment activities, ensuring that capital is used effectively and for the intended purpose. The economic organization will be responsible for establishing financial regulations, accounting systems, and monitoring compliance with financial standards during the institution's operations.

Approving financial and development plans: The economic organization has the right to approve financial plans, institutional development plans, infrastructure construction projects, and personnel plans proposed by the Board of Trustees. This is a crucial task to ensure the stable and sustainable development of the educational institution.

Managing advertising, enrollment, and financial reporting activities: The investor is responsible for conducting institutional promotion, enrollment, and periodic financial reporting, ensuring transparency and accountability in fundraising and student recruitment.

Board of Trustees: The Board of Trustees is the highest governing body for the institution's training and academic activities. The powers of the Board of Trustees include:

Governing training and academic activities: The Board of Trustees decides on matters related to training programs, opening new fields of study, scientific research, and developing academic policies. This helps ensure the quality of teaching, learning, and research within the institution.

Deciding policies for lecturers and learners: The Board of Trustees has the right to decide on policies for lecturers, learners, and activities to improve teaching quality, as stated in the institution's educational

development strategies. This includes establishing lecturer recruitment policies, compensation regimes, and student support.

Developing academic and scientific research plans: The Board of Trustees must also ensure that scientific research plans, academic development, and the application of science and technology to teaching activities are rigorously implemented, enhancing the institution's reputation and training quality.

3. CONCLUSION

Completing the legal framework for investment capital governance is a key factor in guiding and promoting the development of Vietnam's private higher education system. A robust legal framework not only brings transparency in financial management but also significantly enhances the efficiency of academic governance in institutions. This will strongly attract private investment and encourage innovation and creativity in the education sector.

With the increasingly important role of private higher education institutions in providing high-quality education, establishing clear and stringent procedures for investment capital and governance is extremely necessary. Every aspect, from organizational establishment to capital source identification, must be transparent to ensure effective financial management and build a solid foundation for sustainable development. Registering capital sources and verifying investors' financial capacity are crucial steps to ensure lawful operations and optimize educational effectiveness.

In summary, a comprehensive legal framework not only creates a favorable environment for private higher education but also contributes to fostering Vietnam's sustainable economic development. Policies encouraging private investment in education must balance investors' interests with the goal of enhancing educational quality, helping Vietnamese universities strengthen their competitiveness on the international stage.

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ASSESSMENT OF THE USABILITY LEVEL OF E-GOVERNMENT AND PUBLIC APPLICATIONS

E-DEVLET VE KAMU UYGULAMALARININ KULLANILABİLİRLİK DÜZEYİNİN DEĞERLENDİRİLMESİ

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ABSTRACT

This study aims to provide a comprehensive and in-depth analysis of the usability of e-Government and public service applications in Turkey in the context of the rapidly advancing digital transformation in public administration. As digital public services have become indispensable for effective, transparent, and accessible governance, ensuring their usability, accessibility, and security is critical to strengthening citizen-government interaction and improving overall public service delivery. Accordingly, this research examines the technical infrastructure, interface design, security components, and user experience of e-Government systems with the aim of proposing strategic, user-centred solutions. The theoretical framework of the research draws on Information Systems Success Models, Technology Acceptance Models, and User Experience theories. While the existing literature has explored various factors influencing the adoption of e-Government services, most studies primarily focus on user perceptions, satisfaction levels, and usage statistics. This study distinguishes itself by emphasising behavioural and technical variables such as perceived usability, navigation, accessibility, and digital security from an empirical and systemic perspective. The empirical phase of the study includes a survey involving 255 participants selected using convenience sampling. The collected data were analysed using SPSS and AMOS to test the relationships between concepts such as Information Quality (InfQual), Interface Quality (IntQual), System Quality (SysQual), Accessibility (ACS), Navigation (NVG), Perceived Security (RLB), Attitude (ATT), and Intention to Use (INT). Confirmatory Factor Analysis (CFA) was used to validate the measurement model, and path analysis was conducted to evaluate causal relationships. The results revealed that Perceived Security is the most important determinant of users' attitudes toward e-Government services, while Accessibility and Navigability are the primary determinants of usage intention. These findings indicate that citizens prioritise practical and functional features such as ease of use and data protection over aesthetic or content-focused features when interacting with digital government systems. These include simplifying complex system structures, increasing mobile compatibility, designing interfaces that can be adapted to different ages and levels of digital literacy, increasing transparency in data privacy policies, and encouraging iterative design based

on user feedback. In conclusion, this research makes an important contribution to the development of user-centred and secure digital public services in Turkey. It provides both theoretical knowledge and practical insights for policymakers, designers, and public administrators aiming to enhance the usability and effectiveness of e-government platforms.

Keywords: E-Government, Public Applications, Mobile Applications, Usability

ÖZET

Bu çalışma, Türkiye'de e-Devlet ve kamu hizmeti uygulamalarının kullanılabilirliğini, kamu yönetiminde hızla ilerleyen dijital dönüşüm süreci bağlamında kapsamlı ve derinlemesine incelemeyi amaçlamaktadır. Dijital kamu hizmetlerinin, etkin, şeffaf ve erişilebilir bir yönetimin vazgeçilmez unsurları haline gelmesiyle birlikte; bu hizmetlerin kullanılabilirlik, erişilebilirlik ve güvenlik boyutlarının güçlendirilmesi, vatandaş-devlet etkileşiminin geliştirilmesi ve kamu hizmeti sunumunun iyileştirilmesi açısından kritik bir gereklilik haline gelmiştir. Bu doğrultuda, araştırmada e-Devlet sistemlerinin teknik altyapısı, arayüz tasarımı, güvenlik bileşenleri ve kullanıcı deneyimi incelenmiş; stratejik ve kullanıcı merkezli çözüm önerileri geliştirilmiştir.

Araştırmanın kuramsal çerçevesi; Bilgi Sistemleri Başarı Modelleri, Teknoloji Kabul Modelleri ve Kullanıcı Deneyimi kuramlarına dayanmaktadır. Mevcut literatürde, e-Devlet hizmetlerinin benimsenmesini etkileyen çeşitli faktörler ele alınmakla birlikte, çalışmaların büyük bölümü daha çok kullanıcı algıları, memnuniyet düzeyleri ve kullanım istatistiklerine odaklanmaktadır. Bu çalışma ise, algılanan kullanılabilirlik, gezinme kolaylığı, erişilebilirlik ve dijital güvenlik gibi davranışsal ve teknik değişkenleri, ampirik ve sistematik bir bakış açısıyla ele alarak literatüre farklı bir katkı sunmaktadır.

Çalışmanın ampirik aşaması, kolayda örnekleme yöntemi ile seçilen 255 katılımcıdan elde edilen anket verilerine dayanmaktadır. Toplanan veriler; Bilgi Kalitesi (InfQual), Arayüz Kalitesi (IntQual), Sistem Kalitesi (SysQual), Erişilebilirlik (ACS), Gezinme (NVG), Algılanan Güvenlik (RLB), Tutum (ATT) ve Kullanım Niyeti (INT) gibi kavramlar arasındaki ilişkilerin test edilmesi amacıyla SPSS ve AMOS programları kullanılarak analiz edilmiştir. Ölçüm modelinin geçerliliği Doğrulayıcı Faktör Analizi (CFA) ile sınanmış; nedensel ilişkiler ise yol analizi ile değerlendirilmiştir.

Elde edilen bulgular, Algılanan Güvenliğin kullanıcıların e-Devlet hizmetlerine yönelik tutumlarının en güçlü belirleyicisi olduğunu; Erişilebilirlik ve Gezinilebilirliğin ise kullanım niyetinin temel belirleyicileri olduğunu ortaya koymuştur. Bu sonuçlar, vatandaşların dijital devlet sistemleriyle etkileşimlerinde estetik veya içerik odaklı unsurlardan ziyade, kullanım kolaylığı ve veri güvenliği gibi işlevsel özelliklere öncelik verdiklerini göstermektedir. Bulgular doğrultusunda; sistemlerin karmaşık yapılarının sadeleştirilmesi, mobil uyumluluğun artırılması, farklı yaş ve dijital okuryazarlık düzeylerine uygun arayüzlerin geliştirilmesi, veri gizliliği politikalarında şeffaflığın artırılması ve kullanıcı geri bildirimine dayalı yinelemeli tasarım süreçlerinin teşvik edilmesi önerilmektedir.

Sonuç olarak, bu araştırma Türkiye'de kullanıcı odaklı ve güvenli dijital kamu hizmetlerinin geliştirilmesine önemli bir katkı sunmaktadır. Çalışma, hem kuramsal bilgi üretimine hem de uygulamaya yönelik içgörülere katkı sağlayarak, e-Devlet platformlarının kullanılabilirliğini ve etkinliğini artırmayı hedefleyen politika yapıcılar, tasarımcılar ve kamu yöneticileri için yol gösterici niteliktedir.

Anahtar Kelimeler: e-Devlet, Kamu Uygulamaları, Mobil Uygulamalar, Kullanılabilirlik

GİRİŞ

Son yıllardaki teknolojik gelişmeler, dijital devrim olarak nitelendirilebilecek bir dönüşüm sürecini başlatmış ve bu dönüşüm, yalnızca zaman ve mekân algısını değil, devletlerin kamu hizmeti sunum biçimlerini de yeniden şekillendirmiştir. Bilgi ve iletişim teknolojilerindeki ilerlemeler; sağlık, eğitim, e-ticaret gibi alanlarda olduğu gibi kamu kurumlarında da etkili olmuş, devletin vatandaşlara daha etkin hizmet sunmasına imkân tanımıştır (Naralan, 2009). Kamu yönetiminde gerçekleştirilen yenilikler, kolaylık, hız ve maliyet tasarrufunu hedeflemekte olup, bu hedefler bilgi teknolojileri sayesinde mümkün hale gelmiştir (Eroğlu, 2006). Gelişmiş ülkelerde devlet-vatandaş ilişkilerinin bilgi teknolojileri aracılığıyla yürütülmesi, kamu hizmetlerinde kaliteyi artırmayı temel hedef haline getirmiştir (Kulabaş & Avcı, 2023). Ancak e-devlet uygulamalarının etkili olabilmesi için bu hizmetlerin vatandaş merkezli ve sonuç odaklı tasarlanması gerekmektedir (İnal, Çınar & Çağıltay, 2016).

E-devlet, bilgi ve iletişim teknolojilerini kullanarak hizmet etkinliğini, yönetim verimliliğini, şeffaflığı ve vatandaş katılımını artıran bir reform niteliğindedir (Alkan & Ünver, 2020). Türkiye'de 2006 sonrası hızlanan dijitalleşme, 2008'de e-Devlet Kapısı Projesi'nin hayata geçirilmesiyle ivme kazanmış, vatandaş-devlet etkileşiminde köklü değişimler yaşanmıştır (Çarıkçı, 2010). TÜİK verileri, özellikle 2010 sonrasında bilişim teknolojilerine yapılan yatırımların hizmet çeşitliliğini artırdığını göstermektedir (TÜİK, 2014). Covid-19 salgını ise e-Devlet Kapısı kullanımını daha da yaygınlaştırmıştır. MERNİS, Kimlik Paylaşım Sistemi ve Adres Kayıt Sistemi gibi projeler altyapının güçlendirilmesinde önemli rol oynamış, kalkınma planlarında yer alan politika ve tedbirler ise kullanıcı odaklılık, erişilebilirlik ve yeni teknolojilerin entegrasyonuna vurgu yapmıştır (T.C. Cumhurbaşkanlığı Strateji ve Bütçe Başkanlığı, 2019).

Bu bağlamda, kamu internet sitelerinin kullanılabilirliği kritik öneme sahiptir. Geniş bir kullanıcı kitlesine hitap eden uygulamalarda hem kullanılabilirlik hem de kullanıcı güveni belirleyici faktörlerdir. ISO 9241-11 standardına göre kullanılabilirlik; ürünün belirli bir kullanıcı kitlesi tarafından, belirli hedeflere uygun, etkili ve verimli biçimde kullanılabilme derecesini ifade eder. Düşük kullanılabilirlik, düşük kabul oranı ve hizmetin terk edilmesiyle sonuçlanabilir (Norman, 2013; Kortum & Peres, 2014). Bu nedenle kamu kurumlarının internet sitelerinin kullanıcı dostu hale getirilmesi, kullanıcı memnuniyetini artıracak ve kamu hizmetlerine erişimi kolaylaştıracaktır (Osaimi & AlSumait, 2013)

METOT

Bu çalışmada, e-Devlet uygulamalarının algılanan kullanılabilirliğinin kullanıcı tutumu ve kullanım niyeti üzerindeki etkisi incelenmiştir. Katılımcılar, kolayda örnekleme yöntemiyle ve gönüllülük esasına göre belirlenmiş; temel internet bilgisine ve e-Devlet şifresine sahip 255 kişiden oluşmuştur. Yaş sınırlaması yapılmamıştır.

Veriler SPSS ve AMOS yazılımlarıyla analiz edilmiş, Yapısal Eşitlik Modeli (YEM) kullanılarak hipotezler test edilmiştir. Anket dört bölümden oluşmuştur: demografik bilgiler, algılanan kullanılabilirlik, kullanıcı tutumları ve davranışları, teknolojik kullanım düzeyine göre kullanılabilirlik.

Araştırma bulgularına göre, e-Devlet'in algılanan kullanılabilirliği kullanıcı tutumu ve kullanım niyetini anlamlı şekilde etkilemektedir. Ayrıca dijital okuryazarlık düzeyi, bu algının oluşumunda kritik bir rol oynamaktadır. Çalışma etik kurallara uygun olarak gerçekleştirilmiş ve kamu dijital hizmetlerinin kullanıcı merkezli tasarımı için önemli öneriler sunmuştur.

Aşağıda yer alan Tablo 1 katılımcıların profil detaylarını göstermektedir.

Öğrenim Durumu	Erkek	Kadın	Grand Total
Doktora	1	3	4
İlköğretim		3	3
Lisans	75	103	178
Lise	1	6	7
Ortaöğretim	4	12	16
Önlisans	3	27	30
Yüksek Lisans	5	12	17
Grand Total	**89**	**166**	**255**

Tablo1: Katılımcı profilleri

Araştırma kapsamında yürütülecek anket çalışmaları için üniversitenin İnsan Araştırmaları Etik Kurulu'ndan gerekli izinler alınmıştır. Katılımcı haklarının korunması, kişisel verilerin gizliliği ve etik ilkelere tam uyum sağlanmıştır. Veri toplama süreci, bilgilendirilmiş onam temelinde gönüllülük esasına göre yürütülmüş; katılımcılar özgür iradeleriyle sürece dâhil edilmiştir.

Araştırmanın her aşamasında nesnellik, dürüstlük, akademik şeffaflık ve metodolojik doğruluk ilkeleri gözetilmiş; bilimsel çeşitlilik ve güvenilirlik artırılmaya çalışılmıştır. Kullanılan yöntemler etik standartlara uygun olarak planlanmış ve uygulanmıştır.

Katılımcılardan elde edilen veriler herhangi bir müdahaleye maruz kalmadan, objektif bir yaklaşımla analiz edilmiş ve raporlanmıştır. Veri analizinde kullanılan veriler, uluslararası akademik veriler, uygun olarak belirlenmiş, analizlerde sunulan ve güncellik öğeleri dikkate alınmıştır.

Ayrıca, ürünlerin yapısal özelliklerini desteklemek amacıyla literatür taraması kapsamlı bir şekilde gerçekleştirilmiş, araştırma problemine yönelik mevcut teorik çerçeve ve ampirik bulgular ayrıntılı olarak belirtilmiştir. Böylece, çalışma hem teorik hem de pratik açıdan sağlam bir temel üzerine inşa edilerek literatüre katkı sağlayacağını düşünmekteyiz.

BULGULAR

Geçerlilik ve Güvenirlilik Testleri

Doğrulayıcı Faktör Analizi (CFA), gizil değişkenlerin ölçme güvenilirliği ve geçerliliğini değerlendirmek için kullanılır. Güvenilirlik, ölçümlerin tutarlılığını ifade eder ve Bileşik Güvenilirlik (CR) ile değerlendirilir; CR'nin 0,70'in üzerinde olması beklenir. Geçerlilik ise modelin ölçmek istediği yapıyı ne kadar doğru yansıttığını gösterir ve Ortalama Varyans Çıkarımı (AVE) ile değerlendirilir; AVE'nin 0,50'nin üzerinde olması gerekir. Ayrıca, En Büyük Paylaşılan Varyans (MSV), faktörler arası ilişkiyi ölçer ve AVE'den küçük olmalıdır.

Bu çalışmada, gizli faktörlerin CR değerleri 0,70'in üzerinde, AVE değerleri ise 0,50'nin üzerindedir. MSV değerleri, InfQual, IntQual ve SysQual faktörleri hariç tüm faktörlerde AVE'den düşüktür; bu üç faktörde ise fark ihmal edilebilir düzeydedir. CR ve AVE değerlerinin eşik değerleri sağlaması nedeniyle, yol analizi sürecinde herhangi bir sorun bulunmamaktadır.

	CR	**AVE**	**MSV**	**Max R (H)**	**InfQual**	**IntQual**	**SysQual**	**ACS**	**NVG**	**RLB**	**ATT**	**INT**
InfQual	0,912	0,723	0,877	0,918	**0,850**							
IntQual	0,886	0,723	0,877	0,909	0,936***	**0,851**						
SysQual	0,950	0,791	0,845	0,953	0,919***	0,889***	**0,889**					
ACS	0,947	0,816	0,557	0,949	0,672***	0,746***	0,658***	**0,903**				

NVG	0,945	0,775	0,590	0,958	0,721***	0,768***	0,711***	0,730***	**0,881**			
RLB	0,973	0,876	0,561	0,984	0,584***	0,644***	0,635***	0,576***	0,646***	**0,936**		
ATT	0,951	0,906	0,715	0,951	0,511***	0,567***	0,582***	0,502***	0,559***	0,721***	**0,952**	
INT	0,940	0,761	0,715	0,957	0,642***	0,719***	0,653***	0,647***	0,705***	0,749***	0,846***	**0,872**

Tablo 2- Güvenirlilik ve Geçerlilik Sonuçları

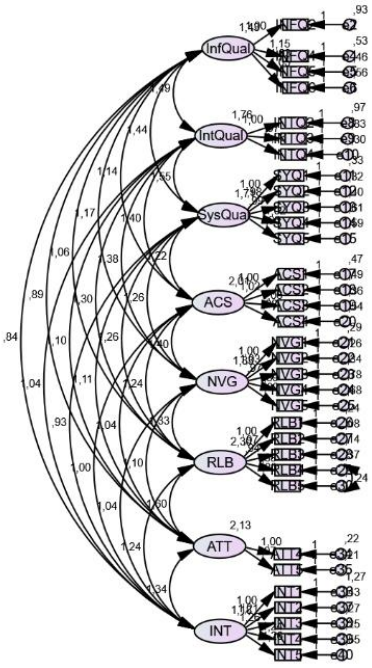
Doğrulayıcı Faktör Analizi (CFA)

Doğrulayıcı Faktör Analizi modeli Şekil 1'de sunulmuştur. Modelin uyum endeksleri incelenerek iyileştirme süreci gerçekleştirilmiş ve bu doğrultuda bazı faktörlerden belirli ölçekler çıkarılmıştır. Yapılan düzenlemeler sonucunda elde edilen nihai model, görselde gösterildiği şekildedir. Ölçeklerin gizli faktörlere olan regresyon ağırlıkları Tablo 3'de detaylı olarak verilmiştir. Analiz sonuçları, görselde yer alan tüm ölçeklerin ağırlıklarının istatistiksel olarak anlamlı olduğunu göstermektedir. Bu bulgular, modelin ölçüm yapısının geçerliliğini ve güvenilirliğini desteklemektedir.

			Ağırlık	S.E.	C.R.	P
INFQ4	<---	InfQual	1,145	,072	15,963	***
INFQ5	<---	InfQual	1,031	,065	15,787	***
INFQ6	<---	InfQual	1,046	,068	15,372	***
INTQ3	<---	IntQual	,970	,065	14,984	***
INTQ4	<---	IntQual	1,033	,057	18,034	***
SYQ2	<---	SysQual	,977	,040	24,712	***
SYQ3	<---	SysQual	,991	,042	23,543	***
SYQ4	<---	SysQual	1,021	,048	21,157	***
SYQ5	<---	SysQual	,958	,047	20,591	***
ACS2	<---	ACS	1,017	,046	22,294	***
ACS3	<---	ACS	1,062	,044	24,290	***
ACS4	<---	ACS	,980	,046	21,424	***
NVG2	<---	NVG	1,031	,036	28,290	***
NVG3	<---	NVG	,973	,038	25,799	***
NVG4	<---	NVG	,895	,048	18,705	***
NVG5	<---	NVG	,817	,044	18,370	***
RLB2	<---	RLB	,966	,023	41,925	***

RLB3	<---	RLB	,938	,025	38,060	***
RLB4	<---	RLB	,880	,031	28,411	***
RLB5	<---	RLB	,800	,034	23,587	***
ATT5	<---	ATT	,968	,032	29,849	***
INT2	<---	INT	1,211	,089	13,568	***
INT3	<---	INT	1,256	,089	14,125	***
INT4	<---	INT	1,236	,087	14,145	***
INT5	<---	INT	1,256	,094	13,344	***
Not: *** p<0.001						

Tablo 3- Ölçeklerin Gizli Faktörlere Olan Regresyon Ağırlıkları



Şekil 1 - Doğrulayıcı Faktör Analizi Modeli

Doğrulayıcı Faktör Analizinde (CFA) model uyum endeksleri, oluşturulan modelin veriye ne derece iyi uyum sağladığını değerlendiren istatistiksel göstergelerdir. Bu endeksler, modelin teorik yapısının gerçek verilerle ne kadar örtüştüğünü belirlemeye yardımcı olur. Bu çalışmada hesaplanan model uyum endeksleri Tablo 4'te sunulmuş olup, model yaygın olarak kabul edilen metrikler için belirlenen kriterleri karşılamaktadır.

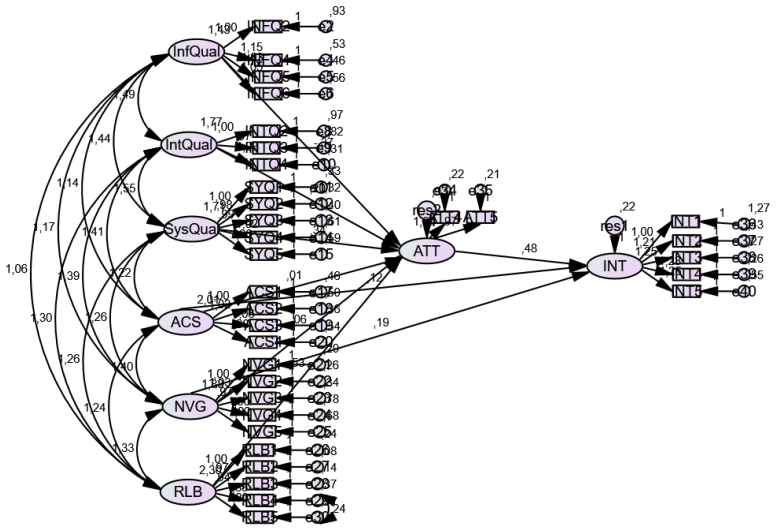
Metrik	Kriter	Değer	Sonuç
cmin/df	< 3 iyi; <5 orta	2,218	Kabul

CFI	> 0,95 çok iyi; 0,90 iyi; 0,80 orta	0,946	Kabul
RMSEA	< 0,05 iyi; 0,05-0,10 orta; >0,10 kötü	0,069	Kabul
TLI	>0,90	0,939	Kabul
TLI	>0,90	0,947	Kabul

Tablo 4- Model Uyum Endeksleri

Yol Analizi (Hipotez Testi)

Yapısal Eşitlik Modelinde (SEM) yol analizi, değişkenler arasındaki nedensel ilişkileri belirlemek ve test etmek için kullanılan güçlü bir analiz yöntemidir. Bu teknik, karmaşık çok değişkenli ilişkileri inceleyerek neden-sonuç bağlamında daha derinlemesine bir anlayış sağlar. Bu çalışmada gerçekleştirilen yol analizi Şekil 2'de sunulmuştur. Modelde, altı bağımsız ve iki bağımlı faktör yer almakta olup, değişkenler arasındaki ilişkiler teorik çerçeve doğrultusunda değerlendirilmiştir.



Şekil 2 - Yol Analizi

Yol analizine ilişkin regresyon ağırlıkları Tablo 5'te sunulmuştur. Bu tablodaki katsayılar, bağımsız değişkenlerdeki bir birimlik artışın bağımlı değişkenler üzerindeki etkisini göstermektedir. Örneğin, regresyon ağırlığı 0,531 olan RLB → ATT ilişkisi, RLB'nin 1 birim artması durumunda ATT'nin 0,531 birim artacağını ifade etmektedir.

			Ağırlık	S.E.	C.R.	P
ATT	<---	InfQual	-,369	,314	-1,174	,240
ATT	<---	IntQual	,199	,268	,741	,459
ATT	<---	SysQual	,339	,176	1,923	,054
ATT	<---	NVG	,061	,092	,666	,506

ATT	<---	RLB	,531	,066	8,004	***
ATT	<---	ACS	,009	,086	,107	,915
INT	<---	ATT	,476	,044	10,765	***
INT	<---	NVG	,191	,045	4,243	***
INT	<---	ACS	,121	,040	3,001	,003
Not: *** p<0.001						

Tablo 5- Yol Analizine İlişkin Regresyon Ağırlıkları

Yol Analizi Modelinde Squared Multiple Correlation (R^2), bir bağımlı değişkenin toplam varyansının bağımsız değişkenler tarafından ne kadar açıklandığını gösteren bir ölçüttür. Bu değer, regresyon analizindeki determinasyon katsayısına (R^2) karşılık gelir ve bağımlı değişkenin model tarafından ne kadar iyi açıklandığını ifade eder. Yol analizine ait determinasyon katsayıları Tablo 6'te sunulmuştur. Bu çalışmada tutum faktörü (ATT) için R^2 değeri 0,563 bulunmuştur, yani modele dahil edilen bağımsız değişkenler ATT'nin varyansının %56,3'ünü açıklamaktadır. Niyet (INT) faktörü için ise R^2 0,811 olup, bu bağımlı değişkenin varyansının %81,1'inin model tarafından açıklandığını göstermektedir. Bu değerler, özellikle INT değişkeni için oldukça yüksek bir açıklayıcılık düzeyi olduğunu göstermektedir.

Faktör	R^2
ATT	0,563
INT	0,811

Tablo 6 - Determinasyon Katsayısı (R^2)

Yol analizi bulguları doğrultusunda, araştırmada test edilen hipotezlerin kabul veya ret durumları Tablo 7'de özetlenmiştir. Analiz sonuçlarına göre, öne sürülen hipotezlerden dördü yüksek düzeyde anlamlı ($p < 0,01$), biri ise $p < 0,10$ seviyesinde sınırda/kısmen anlamlı bulunarak kabul edilmiştir.

H1	E-Devlet ve kamu uygulamalarının sağladığı Bilgi Kalitesi (**InfQual**), bu uygulamalara yönelik Tutumu (**ATT**) anlamlı ve olumlu şekilde etkiler.	Ret
H2	E-Devlet ve kamu uygulamalarının Arayüz Kalitesi (**IntQual**), bu uygulamalara yönelik Tutumu (**ATT**) anlamlı ve olumlu şekilde etkiler.	Ret
H3	E-Devlet ve kamu uygulamalarının Sistem Kullanışlılığı (**SysQual**), bu uygulamalara yönelik Tutumu (**ATT**) anlamlı ve olumlu şekilde etkiler.	Kısmen Kabul
H4	E-Devlet ve kamu uygulamalarında Gezinme Kolaylığı (**NVG**), bu uygulamalara yönelik Tutumu (**ATT**) anlamlı ve olumlu şekilde etkiler.	Ret
H5	E-Devlet ve kamu uygulamalarında Algılanan Güvenlik (**RLB**), bu uygulamalara yönelik Tutumu (**ATT**) anlamlı ve olumlu şekilde etkiler.	Kabul
H6	E-Devlet ve kamu uygulamalarına Erişim Kolaylığı (**ACS**), bu uygulamalara yönelik Tutumu (**ATT**) anlamlı ve olumlu şekilde etkiler.	Ret

H7	E-Devlet ve kamu uygulamalarına yönelik Tutum (**ATT**), bu uygulamaları kullanma Niyetini (**INT**) anlamlı ve olumlu şekilde etkiler.	Kabul
H8	E-Devlet ve kamu uygulamalarında Gezinme Kolaylığı (**NVG**), bu uygulamaları kullanma Niyetini (**INT**) anlamlı ve olumlu şekilde etkiler.	Kabul
H9	E-Devlet ve kamu uygulamalarına Erişim Kolaylığı (**ACS**), bu uygulamaları kullanma Niyetini (**INT**) anlamlı ve olumlu şekilde etkiler.	Kabul

Tablo 7 - Hipotez SonuçlarıBulgular doğrultusunda, kabul edilen ve reddedilen hipotezler değerlendirildiğinde bazı önemli çıkarımlar yapılabilir.

Kabul Edilen Hipotezler:

- **H5 (Algılanan Güvenlik → Tutum) ve H7 (Tutum → Niyet):** E-devlet ve kamu uygulamalarında algılanan güvenlik, kullanıcıların kişisel verilerinin korunacağına dair güven duymasını sağlayarak, tutumlarını anlamlı şekilde etkiler. Bu tutum ise, kullanıcıların sistemi kullanma niyetini güçlü bir biçimde belirler ve teknoloji kabul modelleriyle uyumludur.
- **H8 (Gezinme Kolaylığı → Niyet) ve H9 (Erişim Kolaylığı → Niyet):** Kullanıcıların e-devlet ve kamu uygulamalarını kolayca gezebilmesi ve erişebilmesi, kullanım niyetini doğrudan artıran önemli bir faktördür. Kolay erişim ve gezinebilirlik, kullanıcıların uygulamayı tercih etme ve etkin şekilde kullanma kararlarını doğrudan etkileyebilir.

Kısmen Kabul Edilen Hipotez:

- **H3 (Sistem Kullanışlılığı → Tutum):** Bu hipotezin kısmen kabulü, sistemin kullanılabilirliğinin tutumu etkilediğini, ancak güvenlik ve erişim gibi diğer faktörlerin daha belirleyici olabileceğini göstermektedir.

Reddedilen Hipotezler:

- **H1 ve H2: Bilgi ve arayüz kalitesi,** kullanıcıların tutumunu belirlemede kritik görülmemiştir; kullanıcılar daha çok erişim, güvenlik ve kullanım kolaylığına önem vermektedir.
- **H4 ve H6: Gezinme ve erişim kolaylığı**, tutumu doğrudan etkilemekten ziyade kullanım niyetini etkileyebilir; kullanıcılar bu faktörleri sistemin kullanım kolaylığı olarak değerlendirmiştir.

SONUÇ

Bu çalışma, e-devlet ve kamu uygulamalarının kullanılabilirlik, kullanıcı deneyimi ve güvenlik algısı bağlamında detaylı bir analiz sunmaktadır. Bulgular, e-devlet sistemlerinin etkinliğini artırmada kullanılabilirliğin kritik rol oynadığını ortaya koymaktadır. Kullanıcılar, erişim kolaylığı, gezinme deneyimi ve güvenlik gibi işlevsel özelliklere öncelik verirken; arayüz tasarımı ve bilgi kalitesi, tutumları üzerinde daha sınırlı etki göstermektedir. Bu durum, e-devlet hizmetlerinin geliştirilmesinde önceliğin kullanıcı dostu ve erişilebilir sistem altyapısına verilmesi gerektiğini göstermektedir.

Özellikle algılanan güvenlik, kullanıcıların e-devlet sistemlerine yönelik tutum ve kullanım niyetlerini doğrudan etkileyen en güçlü faktör olarak öne çıkmaktadır. Kişisel verilerin korunması ve işlemlerin güvenli yürütülmesi konusundaki beklentiler, güvenlik önlemlerinin güçlendirilmesi ve şeffaf veri politikalarının önemini vurgulamaktadır.

Uluslararası raporlar da bu bulguları desteklemektedir. E-Government Benchmark 2024 sonuçlarına göre Türkiye, kullanıcı odaklılık ve dijital entegrasyonda güçlü performans sergilerken; şeffaflık ve sınır ötesi hizmetlerde iyileştirmeye ihtiyaç duymaktadır.

Ayrıca Türkiye'de yapılan akademik araştırmalar, e-devlet sistemlerinin geliştirilmesine önemli katkılar sunmaktadır (Parlakkılıç, Şahin & Ünalan). Bu nedenle, bu tür çalışmaların desteklenmesi ve teşvik edilmesi, kullanıcı odaklı stratejilerin oluşturulmasında kritik rol oynamaktadır.

Sonuç olarak, bu çalışma, e-devletin kullanıcı ihtiyaçlarına uygun hale getirilmesi için gelecekteki araştırmalara ışık tutmakta ve dijitalleşme sürecinde karşılaşılan zorlukların aşılmasına yönelik somut politika önerileri sunmaktadır. Bu bulgular doğrultusunda, e-devlet sistemlerinin geliştirilmesine yönelik politika önerileri şu şekilde özetlenebilir:

- ***Erişilebilirlik ve Gezinme Deneyiminin Artırılmalı, Karmaşık Sistem Yapılarının Sadeleştirilmeli:***

E-devlet sistemlerinin kullanıcı dostu olması, erişilebilirlik ve gezinme açısından kritik öneme sahiptir. Kullanıcıların hizmetlere kolay ulaşabilmesi için sade, sezgisel arayüzler ve anlaşılır menü yapıları kullanılmalıdır. Mobil uyumluluk ve farklı cihazlardan erişim kolaylığı da sağlanmalı, karmaşık iş akışları kullanıcı güvenini zedelemeyecek şekilde basitleştirilmelidir..

- ***Güvenlik ve Veri Koruma Mekanizmalarının Güçlendirilerek Kullanıcı Güveni Artırılmalı:***

E-devlet hizmetlerinin benimsenmesinde güvenlik temel faktördür. Kullanıcıların kişisel verilerinin korunması ve şeffaf veri politikalarıyla bilgilendirilmesi güven duygusunu artırır. Güvenlik açıklarının giderilmesi ve güçlü veri koruma mekanizmalarının uygulanması, kullanıcı güvenini sağlamanın ön koşuludur

- ***Akademik Araştırmalar Desteklenmeli, E-devlet Sistemlerinin Geliştirilmesi İçin Bilimsel Analizlerden Yararlanılmalı:***

E-devlet sistemlerinin geliştirilmesinde akademik araştırmalar yol gösterici niteliktedir. Bu araştırmalar, kullanıcı ihtiyaçlarını belirleyerek tasarım ve işlevselliğe katkı sağlar. Akademisyenlerin projelere dahil edilmesi ve bilimsel bulgulara dayalı politika önerilerinin hayata geçirilmesi, sistemlerin daha verimli ve kullanıcı odaklı olmasına yardımcı olur.

- ***Şeffaflık ve Sınır Ötesi Hizmetler Konusunda İyileştirmeler Yapılmalı, Uluslararası Standartlara Uyum Sağlanmalı:***

E-devlet sistemlerinde şeffaflık, kullanıcıların güvenini artırırken; uluslararası standartlara uyum, hizmetlerin kalitesini yükseltir. Ayrıca sınır ötesi hizmetlerin entegrasyonu, Türkiye'nin dijital kamu hizmetlerinde küresel düzeyde rekabet gücünü artıracaktır.

Sonuç olarak, bu çalışma e-devlet hizmetlerinin kullanıcı beklentileri doğrultusunda daha verimli hale getirilmesi için kullanılabilirlik, erişim kolaylığı ve güvenlik unsurlarının öncelikli olarak ele alınması gerektiğini ortaya koymuştur. Elde edilen bulgular, e-devlet sistemlerinin geliştirilmesine yönelik stratejik kararların şekillendirilmesine katkı sağlayabilecek ve gelecekte yapılacak araştırmalara yol gösterici nitelikte olacaktır.

BİLGİ

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OCCURENCE OF *PARASCARIS EQUORUM* OF DOMESTIC MOUNTAIN HORSE IN SERBIA

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ABSTRACT

The domestic mountain horse is an autochthonous breed of horse that originated in the Balkans. Domestic mountain horses kept freely on pastures which are located in nature reserves on Stara planina Nature Park, Zasavica Special Nature Reserve and Krčedinska ada. In order to better understand the biodiversity of its endoparasites we examined 157 animals from this location. Feces were examined using fecal flotation technique, and the determination of parasite eggs was done using morphometric methods. During our examination *Parascaris equorum* we found in 41.33% mainly present in younger categories of horses with a large number of foals. Adult *P. equorum* live in the small intestine, and eggs pass in the feces. A second-stage infective larva develops within each egg; in ideal environmental conditions, this takes approximately three weeks. Infection of the horse is by ingestion of the larvated eggs. The larvae that hatch migrate into the intestinal wall, travel in the portal veins to liver, thence in the vasculature to the heart and then the lungs. Here the larvae break out from the branches of the pulmonary artery into the airways, are coughed up and swallowed. This is a tracheal migration. The pre-patent period is approximately 10 weeks. Clinical symptoms are most pronounced in foals, while in adult horses the infection is mostly subclinical. At the beginning of the disease, short-term diarrhoea appears, then cough and nasal discharge, short-term increase in temperature, and sometimes nervous symptoms. After ten days, the signs of bronchopneumonia disappear. When adult parasites are found in the small intestine, chronic signs of digestive tract disorders appear. Faeces are watery with a hint of mucus, sometimes accompanied by constipation, colic attacks, intestinal flatulence, etc. The coat is bristly, dull and coarse. In foals, pallor of mucous membranes, poor growth or weight loss with an increase in abdominal girth is observed. .

Keywords: *Parascaris equorum*, domestic mountain horse, Serbia

PROPOLİS EKSTRAKTI (APİ10)'NIN AYÇİÇEĞİNDE TOHUM KÖKENLİ *ALTERNARİA ALTERNATA*'NIN KONTROLÜNDE POTANSİYEL KULLANIMI

POTENTIAL USE OF PROPOLIS EXTRACT (APİ10) FOR THE CONTROL OF SEED-BORNE *ALTERNARIA ALTERNATA* IN SUNFLOWER

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ÖZET

Propolis, arılar tarafından bitkisel kaynaklardan üretilen reçinemsi bir madde olup antimikrobiyal ve antioksidan özellikleri sayesinde tarımda fungal hastalıklarla mücadele amacıyla kullanım potansiyeli taşımaktadır. Bu çalışmada, ayçiçeği (*Helianthus annuus*) tohumlarından izole edilen ve fidelerde %30'un üzerinde çökertene neden olan *Alternaria alternata* izolatının gelişiminin propolis ekstraktı ile engelleme olanakları araştırılmıştır. Bu amaçla ilk aşamada propolis ekstraktı %0.300, %0.500, %0.700 ve %0.900 oranlarında patates dekstroz agar (PDA) ortamına eklenmiş, üzerine *A. alternata*'nın agar diski yerleştirilmiş, günlük gelişme hızı takip edilmiş ve 13. gün sonunda koloni çapları ölçülmüştür. İkinci aşamada, koloni gelişimini %70'in üzerinde engelleyen dozlar besi ortamlarına ilave edilerek üzerine patojenle inokule edilmiş ayçiçeği tohumları yerleştirilmiş, patojenin tohum kolonizasyonunu engelleme oranı tespit edilmiştir. Patojen %0.900 oranında propolis ilave edilen besi ortamında gelişme göstermemiş ve gelişimi %100 oranında engellenmiştir. Bu dozu, sırasıyla %77.34 ve %75.06 engelleme oranları ile %0.700 ve %0.500 dozları takip etmiştir. Tohum etrafında en düşük koloni gelişimi yine %0.900 doz ile (0.38 cm) gözlenmiş ve bu doz patojenin koloni gelişimini %75.19 oranında engellemiştir. **Bu çalışma**, propolisin özellikle yüksek konsantrasyonlarda ayçiçeğinde tohum kökenli *A. alternata*'nın gelişimini baskılayarak, tohum sağlığının korunmasında antifungal bir bileşik olarak değerlendirilebileceğini göstermektedir.

Anahtar kelimeler: Propolis ekstraktı, Ayçiçeği, Antifungal etki, *Alternaria alternata*

ABSTRACT

Propolis is a resinous substance produced by bees from plants, and it has the potential to be used in agriculture to control fungal diseases due to its antimicrobial and antioxidant properties. In this study, propolis extract was evaluated for its potential to inhibit the growth of an isolate of *Alternaria alternata*, which was isolated from sunflower (*Helianthus annuus*) seeds and was found to be responsible for more than 30% of seedlings damping-off disease. In the first stage of the experiment, propolis extract was added to potato dextrose agar (PDA) medium at concentrations of 0.300%, 0.500%, 0.700% and 0.900%. An agar disc of *A. alternata* was placed on the medium, and the daily growth rate was recorded. At the completion of the 13th day, the colony diameters were measured. In the second stage, the doses that resulted in the inhibition of colony growth above 70% were added to the media, and sunflower seeds inoculated with the pathogen were placed on the media. The rate of inhibition of seed colonization was then determined. The addition of 0.900% propolis to the medium resulted in the absence of pathogen growth, with the medium itself exhibiting an inhibitory effect of 100% on the pathogen. This was followed by doses of 0.700% and 0.500%, which resulted in inhibition rates of 77.34% and 75.06%,

respectively. The lowest colony growth around the seed was observed at 0.900% dose (0.38 cm) and this dose inhibited the colony growth of the pathogen by 75.19%. This study shows that propolis, especially at high concentrations, can be evaluated as an antifungal compound for the protection of seed health by inhibiting the growth of seed-borne *A. alternata* in sunflower.

Keywords: Propolis extract, Sunflower, Antifungal effect, *Alternaria alternata*.

GİRİŞ

Ayçiçeği (*Helianthus annuus* L.) ülkemizde ekim ve üretimi en çok yapılan önemli yağ bitkilerinden birisidir (Gül ve ark., 2016). Ayçiçeği başta funguslar olmak üzere bakteri ve virüs gibi bitki patojenlerinden etkilenmekte buna bağlı olarak da tohum verimi ve yağ kalitesi üzerinde azalmalar söz konusu olmaktadır (Nahar ve ark., 2005). Ayçiçeğinin en önemli fungal hastalıklarından biri olan mildiyönün yanı sıra, tohum kökenli fungal patojen olan *Alternaria alternata* da, tohum çimlenmesi ve fide gelişimi üzerinde olumsuz etkilere neden olarak verim ve kalite kayıplarına yol açmaktadır (Ghoneem ve ark., 2014; Irshad ve ark., 2017; Arap, 2018). Son yıllarda çevre ve insan sağlığı açısından kimyasallara alternatif sürdürülebilir uygulamalar bitki fungal hastalıkları ile mücadelede araştırma konuları arasında yer almaktadır. Bu bağlamda propolisin antifungal özelliğe sahip olması neticesinde *in vivo* ve *in vitro* denemelerde bitki hastalıklarının önlenmesinde kimyasal alternatifi uygulama olarak kullanılabilirliği birçok çalışmacı tarafından araştırılmıştır. Daha önce yapılan araştırmalar gözden geçirildiğinde çok sayıda çalışmanın *in vitro* koşullarda yürütüldüğü ve farklı bitkilerden izole edilen fungal patojenlerin başta miselial gelişimi olmak üzere (La Torre ve ark., 1990; Yanar ve ark., 2005; Quiroga ve ark., 2006; Özcan, 1999; Özcan ve ark., 2004; Ahmed ve ark., 2008; Meneses ve ark., 2009; Yang ve ark., 2011; Curifuta ve ark., 2012; Haile ve Dekebo, 2013; Mottiuz ve ark., 2015; Abd-El-Kareem ve ark., 2018; Campo ve ark., 2018; Özyiğit ve ark., 2018; Pazin ve ark., 2019; Dudoit ve ark., 2020; Er, 2021; Çakar ve ark., 2022; Davari ve Ezazi, 2022; Urrea ve ark., 2022; Alarjani ve ark., 2023; Ouahab ve ark. 2023; Ebrahim ve ark., 2024; Güller ve ark., 2024; Okçu ve ark., 2024; Okçu ve Özer, 2024; Erdoğan ve Güzel, 2025) konidi çimlenmesini de engelleme (Ghaly ve ark., 1998; Soylu ve ark., 2008; Mottiuz ve ark., 2015) yeteneğine sahip olduğu bildirilmiştir. Gerçekleştirilen çalışmalarda kullanılan fungal patojen türleri arasında *Alternaria alternata, A. brassicicola, A. solani, Aspergillus carbonarius, Aspergillus flavus, A. niger, A. parasiticus, A. nomius, Botrytis cinerea, Botryodiplodia theobromae, Colletotrichum gleosporioides, C. musae, Fulvia fulva, Fusarium asiaticum, F. culmorum, F. equiseti, F. graminearum, F. oxysporum, F. proliferatum, F. redolens, F. solani, F. sporotrichiodes, F. subglutinans, F. verticillioides, Monilia fructigena, Penicillum corylophilum, P. digitatum, P. expansum, P. italicum, P. notatum, Phlyctema vagabunda, Phytophthora. infestans, P. capsici, P. parasitica, Pythium aphonidermatum, P. ultimum, Rhizopus stolonifer, Rhizoctonia solani, Sclerotium rolfsi, Trichoderma reesei, Verticillum* spp. *V. dahliae* yer almaktadır.

In vivo şartlar altında yürütülen çalışmalarda ise propolis ekstraktının çilekte *B. cinerea* (La Torre ve ark., 1990), greyfurtta *P. digitatum* (Soylu ve ark., 2008), hıyarda *Podosphaera fuliginea* (Guginski-Piva ve ark., 2015), mangoda *C. gleosporioides* (Mottiuz ve ark., 2015), ayvada *M. fructigena* (Özyiğit ve ark., 2018), fasulyede *R. solani* ve *S. rolfsii* (Abd-El-Kareem ve ark., 2018), muzda *C. musae* (Dudoit ve ark., 2020), ahududa *A. alternata*, *A. carbonarius, B. cinerea* ve *Penicillum* spp. (Moreno ve ark., 2020), kabakta *A. brassicicola*, yoncada *V. dahliae* (Er, 2021) ve elmada *Phlyctema vagabunda* (Urrea ve ark., 2022) enfeksiyonunu engelleme oranları belirlenmiştir. Gerçekleştirilen bu çalışmada laktik asit bazlı propolis ekstraktının ayçiçeği tohumlarından izole edilen *A. alternata* üzerine etkisi hem *in vitro* şartlar altında incelenmiş, hem de tohum kolonizasyonunu önleme yeteneği yönünden test edilmiştir.

MATERYAL VE YÖNTEM

Materyal

Denemelerde ayçiçeği tohumlarından izole edilen ve %30'un üzerinde fide gelişimini engelleyen *Alternaria alternata* (No: 17) izolatı (Arap, ve ark., 2022), ayçiçeği genotipi olarak ise TTAE-13-19 kullanılmıştır. Propolis ekstraktı olarak Tekirdağ Namık Kemal Üniversitesi Teknopark ürünü ve patenti bulunan Api10 propolis ekstraktı (Patent başvuru numarası 2020/05364; buluş sahibi Prof. Dr. İbrahim PALABIYIK, Tekirdağ Namık Kemal Üniversitesi, Ziraat Fakültesi, Gıda Mühendisliği Bölümü, Tekirdağ/Türkiye) kullanılmıştır.

Yöntem

In vitro denemelerde propolis ekstraktı erlenmayer içerisine 50°C'de Patates Dekstroz Agar (PDA) besi ortamına (100 ml) dört farklı konsantrasyonda (%0,300, %0,500, %0,700, %900) eklenerek 8,5 cm çapında steril petri kaplarına dökülmüştür. Besi yeri katılaştıktan sonra, PDA besi yerinde 25°C'de karanlıkta geliştirilen patojen kültüründen alınan 5 mm çapındaki agar diski petri kabının tam ortasına gelecek şekilde yerleştirilmiştir. Kontrol uygulama ise ekstraktı içermeyen ve sadece patojenin miselial agar diskinin yerleştirildiği petri kaplarından oluşmuştur. Petri kapları 25°C'de karanlıkta inkübe edilmiştir. Denemenin kurulumundan, 13. gün sonuna kadar miselial koloni gelişiminin çapı ölçülmüştür. Miselial gelişimin engellenme oranı (MGI%), MGI= (mc-ma)/mc × 100 formülü ile hesaplanmıştır; burada mc kontroldeki miselial büyüme çapının ortalaması ve ma uygulamadaki miselial büyüme çapıdır (Deans ve Svaboda, 1990). Ayrıca miselial gelişme hızı, propolis ekstraktının %0,300, %0.500, %0.700, %0.900'lük konsantrasyonları içeren petri kaplarında ve kontrolde her iki günde bir ölçülerek büyüme hızı (cm/gün) hesaplanmıştır. Denemeler, dört tekerrürlü (her tekerrürde bir petri kabı) olacak şekilde gerçekleştirilmiştir.

Propolis ekstraktının ayçiçeği tohumunda *A. alternata*'nın gelişimi üzerindeki etkisini belirlemek için misel gelişimini %70 ve üzerindeki oranlarda engelleyen dozlar kullanılmıştır. Yüzey dezenfeksiyonu için, tohumlar %2'lik sodyum hipoklorit (NaOCl) çözeltisine 7da daldırılmış, daha sonra steril saf su ile üç kez durulandıktan sonra steril kurutma kâğıdı üzerinde 30 dakika boyunca kurutulmuştur. Dezenfekte edilen tohumlar %0.1 Tween 20 içeren *A. alternata*'nın konidi süspansiyonu (1×10^5 konidi/ml) içerisine aktarılmış ve 25°C'de bir saat süre ile çalkalanmıştır. Kontrol grubu için sadece patojenin konidi süspansiyonu kullanılmıştır. Patojen ile inokule edilen tohumlar ve kontrol grubundaki tohumlar içinde değişik dozlarda propolis ekstraktı eklenmiş PDA ortamı bulunan petri kaplarına (8.5) cm) yerleştirilmiştir (her petriye 10 tohum). Deneme, her tekrarda bir petri kabı olacak şekilde 5 tekrarlı olarak gerçekleştirilmiştir. Denemenin kurulumundan 7 gün sonra tohum etrafında gelişen *A. alternata*'nın koloni çapı ölçülmüştür.

İstatistik Analizi

Deneme verilerinin dağılımının normalliği ve varyansların homojenliği ilk olarak SPSS, versiyon 23 (IBM SPSS Statistics for Windows, IBM Cora., Armonk, Ny, ABD) kullanılarak sırasıyla Shapiro-Wilk testi ve Levene testi ile belirlenmiş, tüm verilerin ANOVA testinin gerekliliklerini karşıladığı tespit edilmiştir. Uygulamalar arasındaki farklılıklar JMP Version Pro 17 için Windows (Cary, North Carolina, ABD) yazılımı kullanılarak p=0.05 düzeyinde Tukey HSD ile test edilmiştir.

BULGULAR

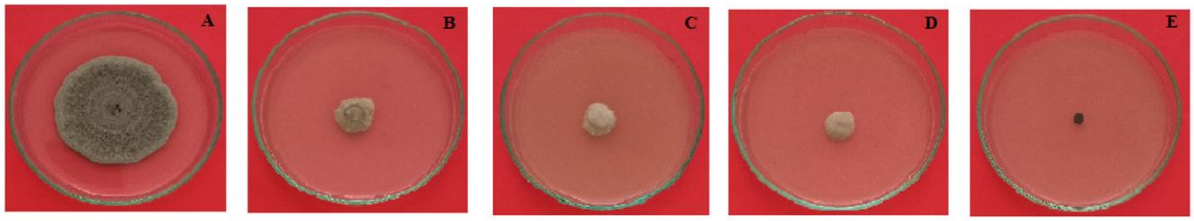
Gerçekleştirilen çalışmada 4 farklı dozda propolis ekstraktı kullanıldığında, *A. alternata*'nın, %0.900 propolis ekstraktı içeren PDA ortamında herhangi bir gelişmenin söz konusu olmadığı ve gelişmenin %100 oranında engellendiği görülmüştür (Tablo 1.). Şekil 1.'de görüldüğü üzere artan dozlarda patojen gelişimi gözlenmesine rağmen bu dozlarda da miselial koloni çapı kontrole kıyasla önemli derecede düşük olmuştur. Uygulamalar arasında %0.900'lük dozdan sonra en düşük koloni çapı (1.24 cm) %0.700

dozunda belirlenmiş, bunu %0.500 (1.36 cm) dozu takip etmiştir. Ekstraktın %0.700 ve %0.500 dozları miselial koloni çapını engellemede sırasıyla %77.34 ve %75.06 oranlarında etkili bulunmuşlardır.

Tablo 1. Propolis ekstraktının farklı dozlarının *Alternaria alternata*'nın miselial koloni çapı üzerine etkisi.

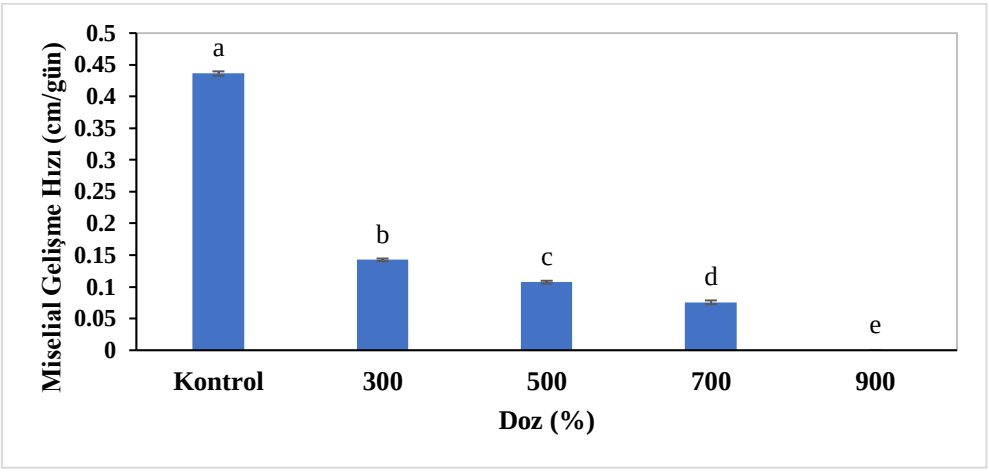
Doz (%)	Miselial Koloni Çapı*	Engelleme oranı* (%)
Kontrol	5.46±0.07 a	-
0.300	1.80±0.03 b	67.05±0.64 d
0.500	1.36±0.03 c	75.06±0.57 c
0.700	1.24±0.01 c	77.34±0.22 b
0.900	0.00±0.00 d	100.00±0.00 a

*Her bir değer 4 tekerrürün ortalamasıdır. Aynı sütunda farklı harflerle gösterilen değerler arasındaki farklılıklar Tukey HSDtestine göre önemlidir. *(Miselial koloni çapı için; $F_{4.15}$=2815.934, P<0.0001. Koloni çapı engelleme oranı için $F_{3.12}$= 994.9565, P<0.0001)*



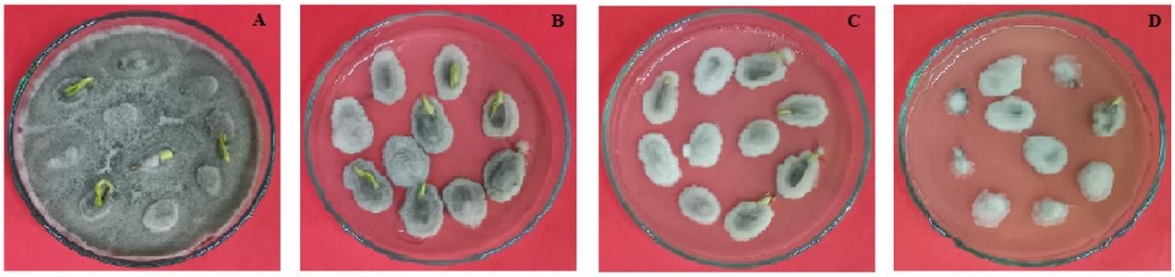
Şekil 1. Propolis ekstraktının artan dozlarında *Alternaria alternata*'nın miselial koloni gelişimi. A: Kontrol, B: %0.300, C: %0.500, D: %0.700, E: %0.900.

Patojenin miselial gelişme hızının değerlendirilmesi sonucunda kontrol petrilerindeki miselial gelişme hızının 0.44 cm/gün olduğu tespit edilmiştir (Şekil 2). Miselial gelişme hızı doz artışına bağlı olarak (%0,300, %0.500, %0.700, %0.900) önemli derecede düştüğü, %0.900 dozunda ise herhangi bir gelişmenin söz konusu olmadığı gözlemlenmemiştir. Propolis ekstraktının %0.500 (0.107 cm/gün) ve %0.700 (0.076 cm/gün) dozlarında da miselial gelişme hızının oldukça düşük olduğu bulunmuştur.



Şekil 2. Farklı dozlardaki propolis ekstraktı uygulamalarında *Alternaria alternata*'nın miselial gelişme hızı. Her bir değer 4 tekrarın ortalamasdır. Barlar üzerinde farklı harflerle gösterilen ortalamalar (±Standard hata) arasındaki farklılıklar Tukey HSD testine göre önemlidir. *$F_{4.15}$=4633.49, P<0.0001.*

A. alternata'nın miselial koloni gelişimini %70'in üzerinde engelleyen propolis ekstraktının 3 dozu PDA besi ortamına ilave edilerek patojen ile inokule edilen ayçiçeği tohumları besi ortamı üzerine yerleştirilmiş ve patojenin ayçiçeği tohumları etrafındaki koloni gelişimi ölçülmüştür (Şekil 3). Dozlar kontrolle mukayese edildiğinde ayçiçeği tohumu etrafındaki patojenin koloni çapının %0.900 dozunda 0.38 cm ile en düşük olduğu tespit edilmiştir (Tablo 2.). Propolisin %900 dozu koloni gelişimini %75.19 oranında azaltmıştır.



Şekil 3. Propolis ekstraktının artan dozlarında (A: Kontrol, B: %0.500, C: %0.700, D: %0.900) *Alternaria alternata*'nın ayçiçeği tohumu etrafındaki miselial gelişimi

Tablo 2. Farklı dozlardaki propolis ekstraktının *Alternaria alternata*'nın ayçiçeği tohumu etrafındaki koloni çapları.

Doz (%)	Koloni Çapı*	Koloni Çapı Engelleme* (%)
Kontrol	1.54±0.02 a	-
0.500	0.78±0.01 b	49.09±0.53 b
0.700	0.70±0.02 b	54.17±1.37 b
0.900	0.38±0.03 c	75.19±2.04 a

*Her bir değer 5 tekerrürün ortalamasıdır. Aynı sütunda farklı harflerle gösterilen değerler arasındaki farklılıklar Tukey HSD testine göre önemlidir. *(Koloni çapı için; $F_{3.16}$=461.5802, P<0.0001. Koloni çapı engelleme oranı için $F_{2.12}$= 90.6464, P<0.0001)*

TARTIŞMA

Gerçekleştirilen çalışmada propolis ekstraktının (Api10) ayçiçeğinde tohum kökenli fungal hastalık etmeni olan *A. alternata*'ya karşı miselial koloni gelişimine, miselial gelişme hızına ve tohum etrafındaki koloni gelişimine etkisi belirlenmiş olup propolis ekstraktının hastalık etmenine karşı kullanım olanakları araştırılmıştır. Propolis ekstraktının ayçiçeğinde *A. alternata* üzerine etkisine yönelik üç adet çalışma ile karşılaşılmış, bu çalışmalarda izolatların kültür kolleksiyonlarından elde edildiği ve *in vitro* koşullarda testlerin gerçekleştirildiği görülmüştür (Özcan, 1999; Curifuta ve ark., 2012; Özcan ve ark., 2004). Bunlardan ilkinde kovanlardan toplanan propolisin %4 konsantrasyonunda kullanılması durumunda petri kaplarına patojenin inokulasyonundan 7 gün sonra patojenin koloni gelişiminin %65.6 oranında engellendiği belirtilmiştir (Özcan, 1999). İkinci çalışmada (Curifuta ve ark., 2012) 6 adet etanolik propolis ekstraktından birinin %2.5 ve %5 konsantrasyonlarında patojenin koloni oluşturamadığı (%100 engelleme), %0.5 ve %1 konsantrasyonlarda ise %45-55 arasında koloni gelişiminde azalma olduğu belirtilmiştir. Üçüncü çalışmada (Özcan ve ark., 2004) ise farklı bölgelerdeki arı kovanlarından toplanan propolisler etanol ile ekstrakte edilerek kullanılmış, koloni gelişimini en yüksek engelleme oranı (%58.6), Alanya'dan elde edilen propolis ekstraktının %5 oranında besi ortamına ilave edilmesi ile elde edilmiştir. Çalışmamızda patojenin %100 oranında engellenmesi

Curifuta ve ark. (2012)'nın bildirdiği dozdan daha düşük dozda (%0.900) gerçekleşmiştir. Yine araştırmamızda test edilen propolis ekstraktının düşük konsantrasyonlarda dahi her üç araştırmacının yüksek dozlarda belirlediği etkililik oranlarından daha yüksek oranda etki gösterdiği (%0.300, %0.500 ve %0.700'de sırasıyla %67.05, %75.06 ve %77.34) tespit edilmiştir.

Çalışmamızda ayrıca propolis ekstraktının farklı dozlarının ayçiçeği tohumlarında *A. alternata*'nın gelişimine etkisi de belirlenmiş. %0.900 konsantrasyonunda tohum etrafındaki gelişimin %50.61 oranında azaldığı bulunmuştur. Farklı propolis ekstraktları farklı bitki türlerinde çeşitli hastalık etmenlerinin oluşturduğu enfeksiyonları önleme yetenekleri açısından karşı test edilmiştir (La Torre ve ark., 1990; Soylu ve ark., 2008; Guginski-Piva ve ark., 2015; Mottiuz ve ark., 2015; Özyiğit ve ark., 2018; Abd-El-Kareem ve ark., 2018; Dudoit ve ark., 2020; Moreno ve ark., 2020; Er, 2021; Urrea ve ark., 2022). Ancak ayçiçeği tohumlarında propolisin *A. alternata* üzerine etkisine yönelik yapılan herhangi bir çalışma ile karşılaşılmamıştır. Bu nedenle elde edilen sonuçlar ayçiçeğinde tohum kökenli hastalık etmeni olan *A. alternata*'nın mücadelesinde kullanılabilirliğini ortaya koymaktadır.

SONUÇ

Çalışmada kullanılan propolis ekstraktının tohumda *A. alternata* gelişimini %100 oranında engellememesi nedeniyle, farklı antifungal özelliklere sahip doğal ekstraktlarla birlikte kullanıldığında etkinliğinin artırılabileceği düşünülmektedir. Sürdürülebilir tarım uygulamaları çerçevesinde, kimyasal pestisitlere çevre dostu alternatiflerin geliştirilmesi, bitki hastalıklarıyla mücadelede büyük önem taşımaktadır. Bu bağlamda elde edilen bulgular, ileride yürütülecek saksı ve arazi denemelerine bilimsel bir temel oluşturacak ve çevreye duyarlı entegre mücadele yaklaşımlarına katkı sunacaktır.

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TRİCHODERMA HARZİANUM'UN FARKLI TUZ KONSANTRASYONLARINDA GELİŞİMİ VE SPORULASYON YETENEĞİ

THE GROWTH AND SPORULATION ABILITY OF *TRICHODERMA HARZIANUM* AT DIFFERENT SALT CONCENTRATIONS

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ÖZET

Toprakta çeşitli sebeplerden dolayı artan tuz konsantrasyonu, bitkilerde ozmotik stres oluşturarak su alımını sınırlandırmakta ve hastalıklara duyarlılığı artırmaktadır. Fungal hastalıkların biyolojik mücadelesinde kullanılan antagonist fungus *Trichoderma harzianum* ise bitkilerin stres koşullarına karşı dayanıklılığını teşvik etme özelliği ile bilinmektedir. Bu nedenle bazı fungal patojenlere karşı antifungal özelliklere sahip olduğu bilinen *T. harzianum* izolatlarının bitkilerin tolere edebileceği tuz konsantrasyonlarına karşı dayanım düzeylerinin belirlenmesi önem taşımaktadır. Bu çalışmada, bazı fungal etmenlerin kontrolünde başarı sağlamış olan *T. harzianum* (TRIC8) izolatı kullanılmıştır. Testlerde bitkilerde stres yaratabilecek tuzluluk koşullarını sağlamak amacıyla, Patates Dekstroz Agar besi ortamına (PDA) 50 mM (düşük-orta tuzluluk), 100 mM (orta-yüksek tuzluluk) ve 150 mM (yüksek tuzluluk) konsantrasyonlarında sodyum klorür (NaCl) eklenmiş ve bu ortamlarda izolatın koloni gelişimi ile sporulasyon düzeyi değerlendirilmiştir. Artan tuz konsantrasyonları koloni gelişimini yalnızca sınırlı düzeyde etkilemiş (%9.18–%17.18 azalma), en düşük koloni çapı 150 mM NaCl'de gözlenmiştir. Sporulasyon ise tuz stresinden daha belirgin şekilde etkilenmiş, ancak bitkiler açısından tolere edilebilir düzey 50 mM NaCl içeren ortamda yalnızca %27.27 oranında azalmıştır. Bu durum, *T. harzianum*'un bu tuz seviyesinde spor oluşturmaya devam edebildiğini ve dolayısıyla biyolojik mücadele potansiyelini koruyabileceğini göstermektedir. Elde edilen bulgular, TRIC8 izolatının yüksek tuz stresine karşı duyarlılık gösterdiğini, ancak düşük ve orta düzey tuzluluk koşullarında koloni gelişimini ve sporulasyon yeteneğini büyük oranda koruyarak biyolojik mücadele potansiyelini sürdürebileceğini ortaya koymuştur.

Anahtar Kelimeler: Tuzluluk, *Trichoderma harzianum*, sporulasyon, koloni gelişimi.

ABSTRACT

Increased salt concentration in the soil due to various reasons creates osmotic stress in plants, limiting water uptake and increasing susceptibility to diseases. *Trichoderma harzianum*, a fungus used in the field of biological control of fungal diseases, has been characterized by its ability to enhance plant resistance to stress conditions. It is therefore important to determine the resistance levels of *T. harzianum* isolates, which are known to have antifungal properties against some fungal pathogens, against salt concentrations that plants can tolerate. In this study, *T. harzianum* (TRIC8) isolate, which has been successful in the control of some fungal agents, was used. In the course of the tests, sodium chloride (NaCl) was added to Potato Dextrose Agar medium (PDA) at concentrations of 50 mM (low-medium salinity), 100 mM (medium-high salinity) and 150 mM (high salinity) in order to provide salinity conditions that may cause stress in plants. The colony growth and sporulation level of the isolate were

then evaluated. Increasing salt concentrations had only a limited effect on colony growth (a reduction of 9.18% -17.18%), with the smallest colony diameter observed at 150 mM NaCl. Sporulation was more significantly affected by salt stress; however, it was only reduced as 27.27% at 50 mM NaCl, which is the tolerable level for plants. This case suggests that *T. harzianum* is able to continue to sporulate at this salt level and thus will retain its biological control potential. The findings revealed that the TRIC8 isolate is sensitive to high salt stress, but it can still maintain its biological control potential under low and medium salinity conditions by maintaining colony growth and sporulation ability to a sufficient level.

Keywords: Salinity, *Trichoderma harzianum*, sporulation, colony growth

GİRİŞ

Toprak tuzluluğu, küresel ölçekte tarımsal üretimi kısıtlayan başlıca abiyotik stres faktörlerinden biri olup, özellikle kurak ve yarı kurak bölgelerde yaygın bir sorundur (Shrivastava ve Kumar, 2015). Toprak tuzluluğunun artışı; yükselen deniz seviyeleri, tuzlu suyla sulama, uzun süreli kuraklık, aşırı ve düzensiz sulama, hatalı tarımsal uygulamalar, aşırı kimyasal gübreleme gibi çeşitli etmenlere bağlı olarak gerçekleşmektedir (Marlet ve ark., 2009; Mbarki ve ark., 2017; Ding ve ark., 2021; Elkelish ve ark., 2020; Taufiq ve ark. 2020). Tuz stresinin yalnızca bitki büyümesi, su alımı ve besin dengesini olumsuz etkilemekle kalmadığı aynı zamanda toprak mikrobiyal popülasyonlarının bileşimi ve aktivitelerini de doğrudan etkilediği bilinmektedir (Li ve ark., 2024). Bu bağlamda, biyolojik mücadele etmeni olarak yaygın şekilde kullanılan *Trichoderma spp.*, özellikle bitki patojenlerine karşı antagonistik etkisi, rizosferi kolonize etme yeteneği ve bitki gelişimini teşvik edici özellikleri ile dikkat çekmektedir (Harman ve ark., 2004; Kashyap ve ark. 2020; Anam ve ark., 2019; Gul Jan ve ark., 2019). *T. harzianum*'un çevresel stres koşullarına, özellikle de yüksek tuz konsantrasyonlarına karşı tolerans düzeyi, biyolojik mücadele uygulamalarının başarısını doğrudan etkilemektedir. Artan tuz dozlarına maruz kalan *Trichoderma* spp.'nin miselial gelişimi ve sporulasyon aktiviteleri hem izolatın genetik yapısına hem de uygulanan tuz düzeyine bağlı olarak farklılık göstermektedir (Kredics ve ark., 2000, 2004; Mohamed ve Haggag, 2006; Yiğit, 2011; Zhang ve ark., 2019; Boamah ve ark., 2021; Abu-Shanab ve ark., 2022). Ayrıca tuz stresi altında yetiştirilen bitkilere *T. harzianum* izolatlarının inokulasyonu sonucunda; bitkilerde IAA üretiminin arttığı, çimlenme yüzdesi, kök ve sürgün uzunluğu, yaş ve kuru ağırlık ile yaprak alanında artışın söz konusu olduğu ve bitki ölümünün minimuma indiği bildirilmekte olup buna bağlı olarak da bitkilerin vejetatif gelişiminde tuzluluk stresin azaldığı belirtilmektedir (Fu ve ark., 2017; Kumar ve ark., 2017; Taufiq ve Yunsnawan, 2020; Boamah ve ark., 2021; Fu ve ark., 2021; Yusnawan ve ark., 2021; Rawat ve ark., 2022; Abdelrhim ve ark., 2024).

Bu çalışmada, farklı NaCl konsantrasyonlarının *Trichoderma harzianum*'un *in vitro* koşullardaki koloni gelişimi üzerindeki etkileri değerlendirilmiş ve söz konusu izolatın tuz stresine karşı tolerans seviyesi belirlenmeye çalışılmıştır. Elde edilen verilerin, tuzlu toprak koşullarında uygulanabilir biyolojik mücadele stratejilerinin geliştirilmesine katkı sağlaması beklenmektedir.

MATERYAL VE YÖNTEM

Materyal

Bu çalışmada kullanılan *Trichoderma harzianum* (TRIC8) (Accession number: MH351669) biyolojik mücadele ajanı Tekirdağ'da soğan ekili alanlardan elde edilmiştir (Özer ark., 2009) ayrıca fungusun çok sayıda fungal etmene karşı antagonistik aktiviteye sahip olduğu da bilinmektedir (Özer ve ark., 2009; Özer ve Arın, 2014; Özdamar ve Özer, 2022; Özer ve ark., 2023).

Yöntem

Tuz toleransı için Patates Dekstroz Agar (PDA) ortamına 0, 50, 100 ve 150 mM NaCl konsantrasyonu olacak şekilde tuz eklendikten sonra 121°C 1 atm basınçta 20 dakika otoklavda steril edilmiş ve ardından

8.5 cm çapındaki petrilere dökülmüştür. Besi yeri katılaştıktan sonra, yedi gün boyunca 25°C'de karanlıkta PDA besi yerinde büyütülen *T. harzianum*'un (TRIC8) kültüründen 5 mm çapında bir agar diski petri kabının ortasına yerleştirilmiştir. Kontrol grubu, herhangi bir tuz konsantrasyonu içermeyen ve yalnızca *T. harzianum*'un agar diskinden oluşan petri kaplarından oluşturulmuştur. Tüm petriler 25°C'de karanlıkta inkübe edilmiştir. Kontrol grubundaki petrilerde *T. harzianum*'un miselyal koloni gelişiminin tamamlanmasının ardından, tüm petrilerde antagonistin miselial koloni çapı ölçülmüştür. Miselial koloni çapının engellenme oranı (MGI%) MGI: [(mc-ma)/mc × 100] olarak hesaplanmıştır; burada mc kontroldeki miselial büyüme çapının ortalaması ve ma uygulamadaki miselial kolani çapıdır (Deans ve Svaboda, 1990). Testler, beş tekrarlı her tekrarda bir petri kabı olacak şekilde tasarlanmıştır.

T. harzianum'un konidi sayımlarında; petri kabında gelişen tüm koloni, 1 cm'lik kareler halinde kesilerek içerisinde 10 ml destile su ve Tween 20 içeren (%0.01) santrifüj tüplerine (50 ml) alınmış daha sonra konidilerin ayrılması için vorteks yardımıyla 2 dakika süre ile çalkalanmış, seyreltme yapılarak mikroskop altında Thoma Lamı kullanılarak sayılmıştır. Konidi yoğunluğu, her kolonide bulunan konidi sayısı olarak hesaplanmıştır. (Silva ve ark, 2013).

İstatistik Analizi

Varyansların homojenliği ve dağılımın normalliği ilk olarak SPSS, versiyon 23 (IBM SPSS Statistics for Windows, IBM Cora., Armonk, Ny, ABD) kullanılarak sırasıyla Levene testi ve Shapiro-Wilk testi ile belirlenmiştir. Tüm deneyler ANOVA testinin varsayımlarını karşılamıştır. Tukey HSD testi, JMP Version Pro 17 için Windows (Cary, North Carolina, ABD) yazılımı kullanılarak p=0.05 düzeyinde muamele ortalamalarını karşılaştırmak için kullanılmıştır.

BULGULAR

Çalışmada, üç farklı tuz dozu kullanılmış olup, *T. harzianum*'un 150 mM dozda en düşük miselial koloni çapına (7.04 cm) sahip olduğu, koloni çapının %17.17 oranında engellendiği belirlenmiştir (Tablo 1.). Tuz dozundaki artışa bağlı olarak koloni çapının kontrole göre azaldığı gözlemlenmiş, ancak engelleme oranları nispeten düşük düzeyde kalmıştır. Uygulanan dozlar arsında en yüksek koloni çapı (7.72 cm) 50 mM dozunda ölçülmüş ve engelleme oranı ise %9.17 olarak hesaplanmıştır. Öte yandan, 100 mM tuz dozunda ise miselial koloni çapı 7.58 cm olarak tespit edilmiş ve %10.82 oranında bir engelleme meydana gelmiştir.

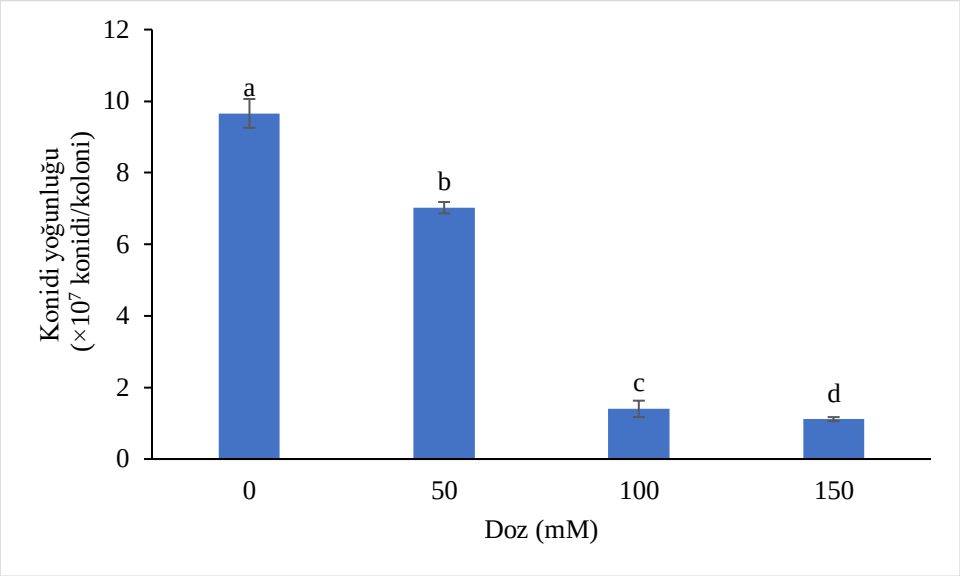
Tablo 1. Farklı tuz dozlarının *Trichoderma harzianum*'un koloni çapı üzerine etkisi

Doz (mM)	Miselial Koloni Çapı*	Koloni Çapı Engelleme* (%)
Kontrol	8.50±0.03 a	-
50	7.72±0.07 b	9.17±0.86 b
100	7.58±0.03 b	10.82±0.44 b
150	7.04±0.05 c	17.17±0.59 a

*Her bir değer 5 tekrarın ortalamasıdır. Aynı sütunda farklı harflerle gösterilen değerler arasındaki farklılıklar Tukey HSD testine göre önemlidir. *(Miselial koloni çapı için; $F_{3.16}$=139.7436, P<0.0001. Koloni çapı engelleme oranı için $F_{2.12}$= 41.1489, P<0.0001)*

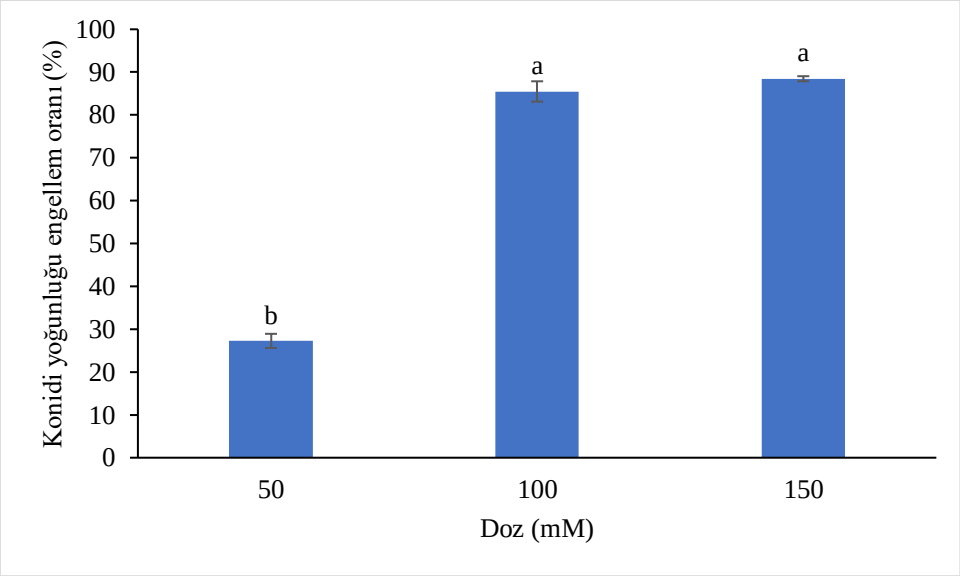
T. harzianum'un kolonideki konidi yoğunluğunun değerlendirildiği deneme sonucuna göre, kontrol petrilerindeki konidi yoğunluğunun 9.7×10^7 (konidi/koloni) olduğu tespit edilmiştir (Şekil 1). Konidi yoğunluğunda, artan tuz dozlarına bağlı olarak (50 mM, 100 mM, 150 mM) azalmalar söz konusu olmuş, ancak biyolojik mücadele ajanının 150 mM (yüksek tuzluluk) dozunda dahi sporulasyon yeteneğini sürdürdüğü (1.1×10^7) belirlenmiştir. Düşük tuz yoğunluğunda (50 mM) ise 7.02×10^7 konidi

yoğunluğuna sahip olduğu tespit edilmiştir. 100 mM dozda ise 1.4×10^7 konidi yoğunluğu ölçülmüştür. Artan tuz dozlarının konidi yoğunluğunu üzerindeki engelleme oranları 50, 100 ve 150 mM'de sırasıyla %27.27, %85.49 ve %88.46 olarak hesaplanmıştır (Şekil 2).



Şekil 1. Artan tuz dozlarının *Trichoderma harzianum*'un sporulasyon yeteneği üzerine etkisi.

Barlar üzerinde farklı harflerle gösterilen ortalamalar Tukey HSD testine göre önemli derecede farklıdır. $F_{3,16}=292.7429$, $P<0.0001$.

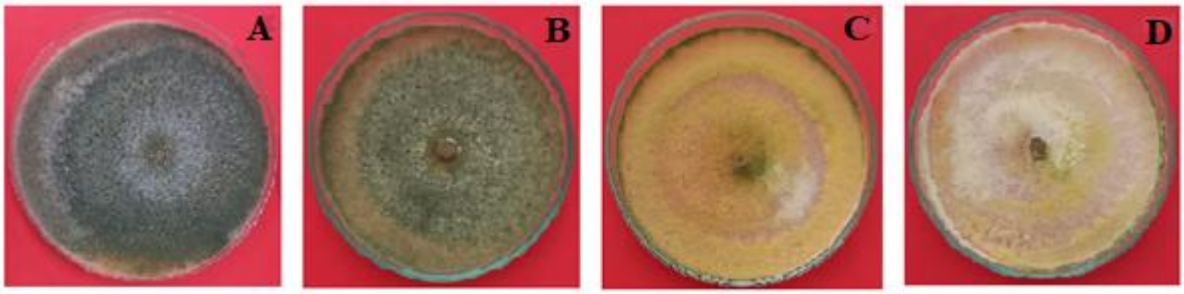


Şekil 2. Farklı tuz dozlarının konidi yoğunluğunu engelleme oranları.

Üzerinde farklı harfler bulunan sütünlar arasındaki farklılıklar Tukey HSD testine göre önemlidir. $F_{2,12}=411.4382$, $P<0.0001$.

Şekil 3'te farklı dozlarda tuz içeren ortamlara *T. harzianum*'un miselial diski yerleştirildikten sonra geçen 7 günlük inkübasyon sürecinin sonunda, biyolojik mücadele ajanının petri kaplarındaki miselial gelişimi ve sporulasyon kapasitesi görülmektedir. Görsel bulgulara göre, tuz konsantrasyonu arttıkça, *T. harzianum* tarafından oluşturulan sporulasyona bağlı olarak meydana gelen yeşil renklenmede belirgin bir azalma dikkat çekmektedir. Kontrol gruplarında yaygın ve homojen bir yeşillenme gözlenirken, özellikle yüksek tuz dozlarında bu yeşillenmenin belirgin biçimde sınırlı ve düzensiz bir şekilde gerçekleştiği görülmektedir. Bu durum, artan tuz stresinin biyolojik ajan üzerinde baskılayıcı bir

etki yarattığı ve sporulasyon sürecini olumsuz yönde etkilediğini göstermektedir. Ancak bu baskılayıcı koşullara rağmen, TRIC8 izolatının sporulasyon kabiliyetini tamamen kaybetmemesi, onun çevresel strese karşı sahip olduğu uyumlu dayanıklılığın bir göstergesidir. Dolayısıyla, görsel değerlendirmeler kantitatif verilerle de örtüşecek biçimde, tuz stresinin sporulasyon üzerine doza bağlı bir baskılama etkisi yarattığını doğrularken; aynı zamanda TRIC8 izolatının yüksek tuzluluk koşullarında dahi spor üretimini sürdürebilmesi, bu biyolojik ajanı zorlayıcı çevresel koşullarda dahi uygulanabilir kılan önemli bir özellik olarak öne çıkmaktadır. Bu durum, izolatın sadece biyotik streslere değil, abiyotik stres faktörlerinden tuzluluğa karşı da dirençli bir biyokontrol ajanı olduğunu göstermektedir.



Şekil 3. Farklı tuz dozlarına *Trichoderma harzianum*'un miselial koloni diski yerleştirdikten 7 gün sonraki koloni gelişimi.

A: Kontrol petrisi, B:50 mM, C:100 mM D:150 mM tuz dozları

TARTIŞMA

Bu çalışmada elde edilen bulgular, *Trichoderma harzianum* (TRIC8) izolatının farklı tuz konsantrasyonları altında hem miselial gelişimini hem de konidi sporulasyonunu sürdürebildiğini ortaya koymaktadır. Özellikle 150 mM NaCl gibi yüksek tuzluluk koşullarında dahi belirli düzeyde miselial gelişim (7.04 cm) ve sporulasyon (1.1×10^7 konidi/koloni) gözlemlenmiştir. Bu durum biyolojik mücadele ajanının stres koşulları altında yaşamını sürdürebilme kapasitesinin yüksek olduğunu göstermektedir. Yine artan tuz dozlarına bağlı olarak sporulasyon yoğunluğunda azalmalar gözlense de bitkilerin tolere edebileceği tuzluluk düzeyi olan 50 mM'da sporulasyon oldukça düşük oranda (%27.27) azalmıştır. Çalışmamızda her ne kadar mutant izolat kullanılmasa da elde edilen bulgular, tuza toleransı yüksek *T. harzianum* mutantlarının 69 mM aralığında NaCl içeren PDA ortamında hem miselial gelişim hem de sporulasyon yeteneklerini koruduğunu bildiren Mohamed ve Haggag ve ark. (2006) ile 50-70 mM aralığında miselial gelişme ve sporulasyonda oldukça düşük oranda azalmalar tespit eden cok sayıda araştırmacının (Rawat ve ark., 2013; Mbarki ve ark., 2017; Özdeveci ve ark. 2019; Rawat ve ark., 2022; Abdelrhim ve ark., 2024) sonuçları ile uyum göstermiştir. Bununla birlikte daha önce konu ile ilgili yapılan çalışmaların bazılarında bitkilerin strese girebileceği tuzluluk düzeyleri dikkate alınmıştır. Yiğit (2011), *Trichoderma harzianum* T22 izolatının 1.25 M NaCl'ye kadar olan dozlarda miselial gelişimini sürdürebildiğini, ancak 0.25-1.25 M NaCl aralığında farklı pH koşullarına (pH 5 ve 8) bağlı olarak miselial gelişimin %12.94-%57.65 oranında engellediğini ve sporulasyonun her iki pH'da da 0.75 M NaCl dozunda tamamen durduğunu, en yüksek sporulasyonun ise (1.3×10^6 konidi/koloni) 0.25 M dozunda gerçekleştiğini bildirmiştir. Poosapati ve ark. (2014), tuza en tolerant izolatta 250-1000 mM arasındaki tuzluluk seviyelerinde koloni gelişiminde %50-60 arasında azalma olduğunu tespit etmişlerdir. Abu-Shanab ve ark. (2022), 200–500 mM NaCl dozlarında *T. harzianum*'un miselial gelişimini sürdürebildiğini raporlamışlardır. Toprakta elektiriksel iletkenlik (EC) değeri, tarımsal üretim açısından önemli bir kriterdir. EC değeri 2 dS/m'nin altında olan topraklar, genel olarak tarım için uygun kabul edilmekte ve bitki gelişimi bu koşullarda olumsuz etkilenmektedir. Ancak 4dS/m'nin üzerindeki topraklar 'tuzlu toprak' olarak sınıflandırılmakta ve bu düzeyde özellikle hassas bitki türlerinde gelişim gerilemeleri ve verim kayıpları görülmeye başlamaktadır. 8 d/S ve üzeri EC değerleri ise ağır tuzluluk

koşulları olarak değerlendirilmekte; bu ortamda, yalnızca tuz stresine dayanıklı (halofit) türler veya bazı toleranslı tarım bitkileri gelişim gösterebilirken, çoğu bitkide büyüme ciddi biçimde kısıtlanmaktadır (El-Ramady ve ark., 2024). Çalışmamızda kullanılan tuz dozlarının (50, 100 ve 150 mM NaCl), bitkilerin gelişimini sürdürebileceği seviyelerde seçilmesi hem biyolojik ajan hem de bitki açısından uygulanabilirliğin sağlanması bakımından önem taşımaktadır. Daha önceki bazı araştırmalarda kullanılan tuz dozlarının pratik tarım uygulamalarında bitki gelişimi açısından sınırlayıcı olabileceğinden, çalışmamızda kullanılan tuzluluk dozlarının yaklaşık olarak 1.5-8 dS/m aralığında toprak EC'sine karşılık gelmesi TRIC8 izolatının gerçek tarla koşullarındaki etkinliğini değerlendirmek açısından literatürdeki birçok çalışmaya kıyasla çevresel olarak daha anlamlı sonuçlar sunmasını sağlamıştır. Bu bağlamda TRIC8 izolatının özellikle yüksek tuz (150 mM) koşullarına az da olsa dayanabilmesi, tarımsal biyokontrol uygulamalarında umut vadeden bir aday haline getirdiğini düşündürmektedir.

SONUÇ

Bu çalışma, *T. harzianum* (TRIC8) izolatının farklı tuz konsantrasyonları altında hem miselial gelişimini hem de konidi sporulasyonunu sürdürebildiğini ortaya koyarak, bu izolatın tuz stresine karşı tolerans geliştirebildiğini göstermiştir. Mevcut çalışmada tercih edilen tuz dozlarının hem literatürde karşılaştırılabilirliği olan hem de pratik tarım koşullarında bitki gelişimini engellemeyecek EC (elektiriksel iletkenlik) değerleriyle uyumlu olması, sonuçların tarımsal uygulamalara aktarılabilirliğini arttırmaktadır. 50-150 mM NaCl aralığı yaklaşık olarak 1.5-8 dS/m toprak EC'sine denk gelmekte olup, bu aralık, birçok tarım toprağında karşılaşılabilecek tuzluluk düzeyleri ile örtüşmektedir. *Trichoderma* türlerinin tuzluluğa karşı gösterdiği fizyolojik esneklik ve uyumlu yanıtlar, tarımsal uygulamalarda bu türlerin kullanım potansiyelini artırmaktadır. Bu bağlamda TRIC8 izolatı, özellikle tuz stresi altında topraklada sürdürülebilir tarım uygulamaları için umut vadeden biyolojik bir kontrol ajanı olarak değerlendirilebilir. Gelecekte yapılacak genetik ve fizyolojik düzeydeki detaylı çalışmalar, bu türlerin stres toleransı mekanizmalarının daha iyi anlaşılmasına ve biyoteknolojik uygulamalara entegrasyonuna katkı sağlayacaktır.

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PERSPECTIVES ON GENERAL AND PRIVATE HEALTH INSURANCE AMONG INDIVIDUALS WITHOUT PRIVATE HEALTH INSURANCE

ÖZEL SAĞLIK SİGORTASI OLMAYAN KİŞİLERDE GENEL SAĞLIK VE ÖZEL SAĞLIK SİGORTACILIĞINA BAKIŞ

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ABSTRACT

The Turkish Social Security System appears to be disconnected from health services and lacks objectives aimed at improving service quality. However, the financing structure and philosophy of the General Health Insurance system differ significantly. When individuals are unable to access adequate health services, they tend to seek Private Health Insurance. This descriptive study explores the attitudes of 360 individuals residing in Ankara who do not have Private Health Insurance, focusing on their views on General and Private Health Insurance. The data were collected via online surveys and analyzed using SPSS software. Among the participants, 74% were male and 26% were female; 63% were high school graduates and 1% held a university degree. Regarding social security affiliation, 28% were registered with SSK, 2% with Bağ-Kur, 66% with the Pension Fund, and 4% had no social security coverage. While 82.5% described their financial situation as average, 6.5% considered themselves low-income, and 1% identified as wealthy. Most participants prefer institutions covered by the social security system instead of spending out-of-pocket for health services. Discounts offered in the private sector are found attractive. However, the majority of individuals lack adequate knowledge about private health insurance. A stronger integration with general health insurance is seen as an important factor for the future. Accordingly, government initiatives in this area should be followed, and when a suitable foundation is established, general health insurance should be promoted and expanded. Moreover, the framework for supplementary insurance systems should be clearly defined.

Keywords: Health Insurance, Private Health Insurance, Public Health Insurance, Social Security Insurance, Complementary Health Insurance

ÖZET

Türkiye Sosyal Güvenlik Sistemi, sağlık hizmetleri açısından kopuk ve hizmet kalitesini geliştirme hedeflerinden uzak bir yapı sergilemektedir. Ancak Genel Sağlık Sigortası sisteminin finansman yapısı ve işleyiş felsefesi birbirinden ayrılmaktadır. Bireyler yeterli sağlık hizmetine ulaşamadığında Özel Sağlık Sigortası'na yönelmektedir. Ankara'da Özel Sağlık Sigortası bulunmayan 360 bireyin Genel ve Özel Sağlık Sigortası'na bakış açılarını inceleyen tanımlayıcı bir araştırma gerçekleştirilmiştir. Araştırma çevrim içi anket yöntemiyle yapılmış, elde edilen veriler SPSS programı ile analiz edilmiştir. Katılımcıların %74'ü erkek, %26'sı kadındır; %63'ü lise, %1'i üniversite mezunudur. Katılımcıların %28'i SSK, %2'si Bağ-Kur, %66'sı Emekli Sandığı üyesidir ve %4'ü herhangi bir sosyal güvenceden yoksundur. Katılımcıların %82,5'i ekonomik durumunu orta gelirli olarak tanımlarken, %6,5'i dar

gelirli, %1'i zengin olarak belirtmiştir. Sağlık harcamalarından kaçınan bireyler, sosyal güvenlik sistemlerinin kapsadığı kurumları tercih etmektedir; özel sektördeki fiyat indirimleri ise cazip bulunabilmektedir. Çoğu birey özel sağlık sigortası hakkında yeterli bilgiye sahip değildir. Genel sağlık sigortasıyla daha entegre bir sistemin gelecekte önemli rol oynayacağı düşünülmektedir. Bu doğrultuda, hükümetin bu konuda atacağı adımlar izlenmeli, uygun zemin sağlandığında genel sağlık sigortası teşvik edilmeli ve yaygınlaştırılmalıdır. Ayrıca tamamlayıcı sigorta sisteminin çerçevesi net biçimde tanımlanmalıdır.

Anahtar Kelimeler: Sağlık Sigortası, Özel Sağlık Sigortası, Kamu Sağlık Sigortası, Sosyal Güvenlik Sigortası, Tamamlayıcı Sağlık Sigortası

1.Giriş

Günümüzde, salgın hastalıklar başta olmak üzere çeşitli sağlık sorunlarının artış göstermesi, bireylerin sağlık alanına olan ilgisini artırmış ve sağlığı yaşamlarının öncelikli konularından biri haline getirmiştir. Bu durum, sağlık hizmetlerinin kalitesini ve erişilebilirliğini, ülkelerin gelişmişlik düzeylerini belirleyen temel göstergelerden biri haline getirmiştir.

Ekonomik bakımdan değerlendirildiğinde, ihtiyaçların sınırsız ancak kaynakların sınırlı olması, sağlık hizmetlerinin finansmanını önemli ve tartışmalı bir konu haline getirmektedir. Hiçbir ülkede tamamen ücretsiz bir sağlık hizmeti bulunmamaktadır; bu hizmetlerin bedeli dolaylı ya da doğrudan yollarla vatandaşlar tarafından finanse edilmektedir.

Türkiye'de mevcut sosyal güvenlik sistemi (SSK, Emekli Sandığı, BAĞ-KUR), sağlık hizmetlerinin sunumu açısından parçalı bir yapı arz etmekte ve temel amacı ülke genelindeki sağlık düzeyini iyileştirmekten ziyade sosyal güvenlik kapsamındaki yükümlülükleri yerine getirmektir. Genel Sağlık Sigortası (GSS) sistemi ise hizmet sunumu ile finansmanı birbirinden ayırmayı hedefleyen bir finansman modelidir. GSS, zaman zaman yanlış bir şekilde doğrudan hizmet sağlayıcı bir sistem olarak algılansa da esasen bir ödeme mekanizmasıdır. Bu sistem, özel sağlık sigortalarıyla birlikte değerlendirilmelidir. Zira bireyler kamu sağlık hizmetlerinden yeterli fayda sağlayamadıklarında özel sağlık sigortalarına yönelmektedir.

Özel sağlık sigortası, özel hukuk kapsamında yapılan bir sözleşme niteliği taşır. Tarafları gerçek kişiler veya özel hukuk tüzel kişileri olup, sözleşmenin içeriği tarafların karşılıklı rızasıyla belirlenir. Bu yönüyle kamu sağlık sigortasından farklıdır; çünkü kamu sağlık sigortasında sözleşme kamu hukuku çerçevesinde düzenlenir ve taraflardan biri kamu tüzel kişisi olan Sosyal Güvenlik Kurumu'dur. Ayrıca, kamu sağlık sigortasına belirli statülerdeki bireylerin (işçi, memur, esnaf vb.) katılması zorunlu iken, özel sağlık sigortası tamamen isteğe bağlıdır.

Bu çalışmada, özel sağlık sigortasının genel sağlık sigortası içindeki konumu ele alınmakta ve Ankara'da ikamet eden, özel sağlık sigortası bulunmayan bireylerin genel ve özel sağlık sigortasına yönelik bakış açıları araştırılmaktadır. Araştırmanın amacı, Türkiye'de sağlık hizmetlerinin finansmanında yaşanan dönüşümler sonrasında bireylerin bilgi düzeyi, tutumları ve yeni sistemlere karşı beklentilerini ortaya koymaktır. Ayrıca sağlık harcamalarının boyutu, bireylerin sağlık hizmeti alma kararlarını etkileyen faktörler ve harcama tercihlerinin arkasındaki nedenler incelenmiş; mevcut ve potansiyel kullanıcıların davranışları analiz edilmiştir.

2.Kavramsal Arka Plan

Sigorta kavramı, dünya genelinde farklı şekillerde tanımlanmakta ve çeşitli anlamlar taşımaktadır. Türkiye'de kullanılan "sigorta" kelimesi, İtalyanca, İspanyolca ve Portekizce'deki karşılıklarına benzer şekilde, sigortalıya yönelik bir güvence veya hizmet vaadi anlamına gelir (Uralcan, 2011). Sigortanın

temel işlevi, bireylerin ve kurumların belirsizlik karşısındaki ekonomik kayıplarını en aza indirmek ve sürdürülebilir bir yaşam standardı sağlamaktır (Rejda & McNamara, 2017).

Sigortaya dair yaklaşımlardan biri, bireylerin belirli riskleri prim karşılığında sigorta şirketine devretmesi; diğeri ise, benzer risk taşıyan bireylerin katkılarıyla oluşturulan bir havuzdan zararların karşılanmasıdır (Vaughan & Vaughan, 2008; Kırkbeşoğlu, 2015). Bu yaklaşımlar, riskin paylaşımı ve toplumsal dayanışma ilkeleri üzerine kuruludur (Skipper & Kwon, 2007).

Sağlık harcamalarının hızlı artışı kamu bütçeleri üzerindeki baskıyı artırmakta bu nedenle hükümetler sağlık hizmetlerinin finansmanında özel sektör katkısını artırmaya yönelmektedir (Orhaner, 2000). Dünya Sağlık Örgütü (WHO), finansal sürdürülebilirliği sağlamada kamu-özel iş birliğini önemli bir strateji olarak önermektedir (WHO, 2010). Bu çerçevede, özel sağlık sigortaları önem kazanmıştır. Ayrıca özel sağlık sigortaları, hizmet kalitesini artırmak ve bekleme sürelerini azaltmak açısından da avantaj sağlamaktadır (Pauly et al., 2006).

Sosyal güvenlik, bireyleri yaşamları boyunca karşılaşabilecekleri sosyal ve ekonomik risklere karşı korumayı amaçlayan bir sistemdir (Yazgan, 1981). Modern refah devletleri, bu güvenliği sağlamak için sosyal sigorta mekanizmalarını yaygınlaştırmaktadır (Esping-Andersen, 1990).

Genel Sağlık Sigortası (GSS), bireylerin gelirine bakılmaksızın kapsamlı bir koruma sunar. Ancak estetik işlemler, alternatif tıp ve bazı özel uygulamalar kapsam dışındadır. GSS, çağdaş kontrol sistemleriyle hem sağlık hizmeti sunumunu hem de kaynak kullanımını denetler (Maliye Bakanlığı, 2005; Orhaner, 2000). GSS'nin kapsam genişliği, sağlık hizmetlerine erişimde eşitliği artırsa da maliyet etkinliği açısından sürdürülebilirlik tartışmaları devam etmektedir (Saltman et al., 2004).

Özel sağlık sigortası ise, sosyal güvenlik sisteminden bağımsız olarak bireyin muayene, tedavi ve ilaç giderlerini karşılar (Varoğlu, 2013). Bu sigortalar genellikle daha hızlı erişim ve daha fazla seçenek sunarak hizmete erişimi kolaylaştırmaktadır (Thomson et al., 2013).

Kamu sağlık sigortasının yetersizliklerini gidermek üzere Türkiye'de üç tür gönüllü sağlık sigortası geliştirilmiştir (Kırkbeşoğlu, 2015; Varoğlu, 2013):

İkame edici: Kamu sigortasına alternatif,

Destekleyici: Hizmete erişimi hızlandırıcı,

Tamamlayıcı: Kamu sigortasının karşılamadığı hizmetleri sunan modeller.

Tamamlayıcı sigortaların avantajları arasında uygun maliyetli planlar ve kurumsal poliçeler öne çıkar. Provizyon temelli sistemler kontrolü güçlendirirken, GSS ile yaşanan yapısal uyumsuzluklar potansiyel tehdit oluşturmaktadır. Ayrıca tamamlayıcı sağlık sigortaları, özel hastane kullanımını teşvik ederek sağlık sisteminde iki kademeli bir yapı oluşmasına neden olabilmektedir (Maarse & Paulus, 2011). Bu durum, sağlıkta eşitsizlikleri artırabileceği için dikkatle yönetilmesi gereken bir alandır (OECD, 2021).

Türkiye'de sağlık sigortacılığı üzerine yapılan akademik çalışmalar hem özel hem de tamamlayıcı sigorta uygulamalarının kamu sağlık hizmetlerini destekleyici bir rol üstlendiğini ortaya koymaktadır. Gürsoy (2010), Türkiye'de özel sağlık sigortacılığının özellikle yüksek gelir gruplarında yaygınlaştığını ve bu durumun kamu sağlık hizmetlerine duyulan güvenle ilişkili olduğunu belirtmektedir. Altay ve Ayhan (2015) ise tamamlayıcı sağlık sigortalarının kamu sistemindeki eksiklikleri giderici bir işlev üstlendiğini ve sağlık hizmetlerine erişimi hızlandırarak sistem üzerindeki yükü hafiflettiğini vurgulamaktadır. OECD ülkeleriyle yapılan karşılaştırmalı çalışmasında Karadeniz (2012), Türkiye'nin genel sağlık sigortası sisteminin bazı Avrupa ülkelerine kıyasla daha merkeziyetçi bir yapıda olduğunu ve özel sigortaların henüz tam anlamıyla entegre olamadığını ifade etmektedir. Demir ve Karadeniz (2013) tarafından yapılan bir alan araştırmasında ise tüketicilerin özel sağlık sigortası hizmetlerinden memnuniyet düzeylerinin, hizmet hızı ve bilgilendirme kalitesiyle doğrudan ilişkili olduğu görülmüştür.

Yılmaz ve Koç (2019) tarafından gerçekleştirilen ekonometrik bir analizde ise gelir düzeyi, yaş, eğitim ve özel hastane kullanım alışkanlıklarının tamamlayıcı sağlık sigortası talebini belirleyen temel faktörler arasında yer aldığı belirlenmiştir. Bu çalışmalar, Türkiye'deki sağlık sigortacılığının yapısal dönüşüm sürecinde, bireylerin sosyoekonomik özelliklerinin ve sistemsel faktörlerin belirleyici olduğunu göstermektedir.

3.Araştırmanın Amacı ve Problemi

2020 itibarıyla Türkiye'de tamamlayıcı sağlık sigortası sahiplerinin sayısı 1,5 milyona ulaşmıştır. Ancak bu oran, nüfusla kıyaslandığında oldukça düşüktür (Varoğlu, 2013).

Bu durum, bireylerin özel sağlık sigortasına olan ilgisinin neden sınırlı olduğu sorusunu gündeme getirmektedir. Araştırmanın temel amacı, GSS'ye sahip bireylerin özel sağlık sigortası konusundaki bilgi, tutum ve yaklaşımlarını değerlendirmektir. Ayrıca sağlık alanındaki dönüşümlerin sigorta tercihlerine etkisi de incelenmiştir.

4.Araştırmanın Yöntemi

Araştırma, Ankara'da yaşayan ve özel sağlık sigortası bulunmayan bireylerle online anket yoluyla gerçekleştirilmiştir. Evrenin tamamına ulaşılamayacağından, %95 güven düzeyine göre belirlenen örneklem büyüklüğü en az 348 kişi olarak hesaplanmış; 360 katılımcıya ulaşılmıştır. Veriler, hem nitel hem de nicel yöntemlerle değerlendirilmiş; SPSS programıyla analiz edilmiş ve bağımsız değişkenler arası ilişkiler ki-kare testi ile incelenmiştir.

5.Araştırmanın Bulguları

5.1.Araştırmaya Katılanların Demografik Özellikleri

Araştırmaya katılan 360 kişinin %74'ü erkek, %26'sı kadındır. Katılımcıların büyük çoğunluğu (%95) üniversite mezunudur; yalnızca %5'i lise mezunudur. Katılımcıların meslek gruplarına göre dağılımında en yüksek oranı %58 ile emekliler oluşturmaktadır. Bunu %20 ile ev hanımı, öğrenci gibi kategoriler takip etmektedir. Teknik elemanlar ise %3 ile en düşük orana sahiptir. Katılımcıların sağlık güvencesi durumları incelendiğinde, %66'sının Emekli Sandığı'na, %28'inin SSK'ya, %2'sinin Bağ-Kur'a bağlı olduğu, %4'ünün ise herhangi bir sosyal güvenceye sahip olmadığı görülmüştür. Medeni durumları açısından değerlendirildiğinde ise katılımcıların %66'sı evli, %32,5'i bekar, %1,5'i ise boşanmıştır. Ekonomik düzeylerini kendi tanımlarına göre değerlendiren bireylerin %82,5'i kendisini orta gelirli, %6,5'i dar gelirli ve yalnızca %1'i zengin olarak tanımlamıştır. Bu veriler, özel sağlık sigortasına yönelik yaklaşımı etkileyebilecek sosyo-demografik faktörlerin değerlendirilmesinde temel bir çerçeve sunmaktadır.

5.2.Araştırmaya Katılanların Sağlık Sorunu Olduğunda Nerelere Gittiği Ve Tercih Etme Nedenlerinin Dağılımı

Araştırmaya katılan bireylerin büyük çoğunluğu (%81) sağlık sorunları karşısında kamu sağlık kurumlarını tercih ettiklerini belirtmiştir. Bu tercih, kamu kurumlarının ücretsiz ya da düşük maliyetli hizmet sunması ve sosyal güvence kapsamına dahil olmasıyla açıklanabilir. Özel sağlık kurumlarını tercih edenlerin oranı ise yalnızca %19'dur. Katılımcıların en son sağlık kuruluşuna başvuru süreleri incelendiğinde, %40,5'inin son 30 gün içerisinde bir sağlık kuruluşuna gittiği görülmektedir. Bu oran, bireylerin sağlık takibini düzenli olarak yaptıklarına işaret etmektedir. Öte yandan, %11'lik bir kesim son bir yıl içinde hiç sağlık kuruluşuna gitmemiştir. En sık başvuru yapılan bölümler arasında %18 ile Dahiliye, %15 ile Diş ve %11 ile kontrol amaçlı başvurular ilk sıralarda yer almaktadır. Bu bulgu, kronik rahatsızlıklar ve ağız-diş sağlığı konularının bireyler açısından önemli olduğunu göstermektedir. Hizmet alınan sağlık kuruluşları açısından bakıldığında, katılımcıların %51,2'si devlet hastanelerine, %10,8'i üniversite hastanelerine, %10'u ise International Hospital gibi özel hastanelere başvurmuştur. Özel muayenehane ve polikliniklerin ise düşük oranda tercih edildiği gözlemlenmiştir. Sağlık kuruluşu tercih

nedenlerine bakıldığında, en önemli iki etken "yakınlık" (%25) ve "sosyal güvence kapsamında olması" (%25) olarak öne çıkmaktadır. "Güvenilir olması" ise %16 oranında katılımcı tarafından tercih sebebi olarak belirtilmiştir. Bu durum, erişilebilirlik ve ekonomik güvencenin sağlık kurumu tercihlerinde belirleyici olduğunu göstermektedir.

5.3.Araştırmaya Katılanların Eşlerinin Sağlık Güvencesi, Sağlık Sorunu Olduğunda Nerelere Gittiği Ve Tercih Etme Nedenlerinin Dağılımı

Araştırmaya katılan bireylerin eşlerinin sağlık güvencesi incelendiğinde, %50'sinin Emekli Sandığı'na bağlı olduğu görülmektedir. Bu oran, çalışmanın örneklemi ile tutarlılık göstermektedir. Ancak yüksek oranda (%32) "cevapsız" seçeneğinin yer alması, katılımcıların eşlerinin sağlık durumu ve güvencesi hakkında yeterli bilgiye sahip olmadığını göstermektedir. Katılımcılar, eşlerinin sağlık sorunları durumunda en çok devlet hastanelerini tercih ettiğini (%42,5) ifade etmişlerdir. Özel hastane tercih oranı %7,5, üniversite hastaneleri %13, sağlık ocakları ise %4,2 ile sınırlı kalmıştır. Önemli bir oran olan %32 ise bu soruya yanıt vermemiştir. "Eşinizin en son ne zaman bir sağlık kuruluşuna gittiği" sorusuna verilen yanıtlara göre, %25'i son 1–3 ay içinde sağlık kuruluşuna başvuruda bulunmuştur. %22'si son 30 gün içerisinde sağlık hizmeti alırken %7,5'i son bir yıl veya daha önce gitmiştir. Bu alanda da %32,5 oranında bir "cevapsızlık" dikkat çekmektedir. Ziyaret nedenleri incelendiğinde, en çok başvurulan branş %26 ile Dâhiliye olmuştur. Bunu %12 ile Kulak Burun Boğaz ve %10 ile Kadın Doğum bölümleri takip etmektedir. Eşlerin hizmet aldığı sağlık kuruluşları içinde devlet hastaneleri %32 ile ilk sırayı alırken, üniversite hastaneleri %13,8 ve özel sağlık kuruluşları toplamda %15,8 oranında tercih edilmiştir. Bu veriler, eşlerin de sağlık hizmeti alımında büyük ölçüde kamuya bağımlı olduklarını ortaya koymaktadır. Sağlık kuruluşlarının tercih nedenleri arasında en yüksek oran %24 ile sosyal güvenceye sahip olmaktır. Yakınlık faktörü (%12) ve güvenilirlik (%7,5) diğer önemli etkenler arasında yer almaktadır. Ancak bu alanda da %31,6 oranında "cevapsız" bulunması, bilgi eksikliğine işaret etmektedir.

5.4.Araştırmaya Katılanların Ülkemizdeki Sağlık Hizmetlerinin Özelleşmesi Hakkındaki Düşünceleri

Araştırma kapsamında katılımcılara, Türkiye'deki sağlık hizmetlerinin özelleşmesiyle ilgili düşünceleri sorulmuştur. Elde edilen verilere göre, katılımcıların %53,3'ü sağlık hizmetlerinin özelleşmesini potansiyel olarak olumlu görmekte ancak bu sürece dair çeşitli çekinceler taşımaktadır. Bu oran, sağlık politikalarındaki özelleştirme eğilimlerinin toplumda belirli bir karşılık bulduğunu ancak güven sorununun da yüksek olduğunu göstermektedir. Katılımcıların %32,5'i özelleştirmenin sağlık hizmetleri açısından iyi sonuçlar doğurmayacağını düşünmektedir. Bu görüş, sağlık hizmetlerinde kamusal erişimin önemine inanan bireylerin sayısının da azımsanmayacak düzeyde olduğunu ortaya koymaktadır. "Tamamen olumlu" yaklaşanların oranı ise %12,5 ile sınırlı kalmıştır. Bu, özel sektöre duyulan güvenin düşük ya da ihtiyatlı olduğunu göstermektedir. Cevapsız oranının düşük olması (%1,6), katılımcıların bu konuya ilişkin belirli bir fikrinin olduğuna işaret etmektedir. Genel olarak, sağlık sisteminin özelleştirilmesine dair kamuoyunda kararsızlıkla birlikte temkinli bir iyimserlik hâkimdir.

5.5.Araştırmaya Katılanların Genel Sağlık Sigortası İle İlgili Düşüncelerinin Dağılımı

Araştırma kapsamında katılımcıların büyük bir çoğunluğunun (%87) Genel Sağlık Sigortası (GSS) kavramını daha önce duyduğu görülmektedir. Bu bulgu, GSS'nin toplum nezdinde oldukça bilinir bir sistem haline geldiğini göstermektedir. Ancak, sistem hakkında duyulan güvenle ilgili daha karmaşık bir tablo ortaya çıkmaktadır. Katılımcıların yalnızca %44,1'i GSS hakkında olumlu görüş bildirmiştir. Buna karşılık %47,5'i sistem hakkında olumlu düşüncelere sahip olsa da çeşitli çekinceler taşıdığını belirtmiştir. Bu oran, toplumda GSS'ye yönelik temkinli bir kabulleniş olduğunu göstermektedir. Bu çekinceler, muhtemelen hizmet kalitesi, erişilebilirlik, bürokratik işlemler veya hizmetlerin kapsamıyla ilgilidir. Olumsuz görüş belirtenlerin oranı %5,9 gibi görece düşük bir seviyede kalmıştır. Ancak bu oran bile, sistemdeki memnuniyetsizliklerin tamamen görmezden gelinemeyeceğini ortaya

koymaktadır. Cevapsız oranının %2,5 gibi düşük bir seviyede olması, konunun katılımcılar için tanıdık ve düşündürücü olduğunu da göstermektedir. Genel olarak bulgular, GSS'nin toplumda büyük ölçüde bilindiğini ancak kamuoyunun önemli bir kesiminde sistemin etkinliğine dair soru işaretlerinin devam ettiğini ortaya koymaktadır. Bu durum, sistemin daha şeffaf, kapsayıcı ve erişilebilir hale getirilmesi gerektiğini göstermektedir.

5.6.Araştırmaya Katılanların Genel Sağlık Sigortasının İçeriği İle İlgili Düşüncelerinin Dağılımı

Araştırmaya katılanların Genel Sağlık Sigortası (GSS) hakkında düşünceleri incelendiğinde, katılımcıların büyük bir kısmının sağlık sigortası kapsamında sağlıkla ilgili her şeyin bulunmasını istediği görülmüştür. Katılımcıların %68'i, GSS'nin sağlıkla ilgili her şeyi kapsaması gerektiğini belirtmiştir. Bu durum, sağlık hizmetlerine dair çok geniş bir beklenti olduğunu ve sağlık sigortasının yalnızca temel hizmetleri değil, tüm sağlık ihtiyaçlarını karşılamasını talep ettiklerini göstermektedir. Öte yandan, lüks harcamaların GSS kapsamında olmaması gerektiğini savunan katılımcıların oranı ise %61,6'dır. Bu oran, katılımcıların sigorta sisteminin yalnızca zorunlu sağlık hizmetlerini kapsamasını ve estetik ya da benzeri lüks hizmetlerin sigorta dışında bırakılmasını tercih ettiklerini ortaya koymaktadır. Ayrıca, Genel Sağlık Sigortası hakkında katılımcıların %25,8'i, her şeyi kapsaması gerektiğini belirtmiş, ancak estetik ve benzeri lüks harcamaların dışında tutulması gerektiği görüşünü ifade etmiştir. Bu bulgular, genel sağlık sigortasının kapsamının genişletilmesi gerektiği yönünde güçlü bir toplumsal beklenti olduğunu göstermektedir. Bununla birlikte, katılımcıların büyük bir kısmı, sağlıkla doğrudan bağlantılı hizmetlerin sigorta kapsamında olmasını talep ederken, lüks harcamaların dışarıda bırakılmasını istemektedir. Bu da sigorta sistemlerinin sürdürülebilirliğini ve toplumsal adaleti sağlamak adına önemli bir gösterge oluşturmaktadır.

5.7.Araştırmaya Katılanların Tamamlayıcı Sağlık Sigortası İle İlgili Düşüncelerinin Dağılımı

Araştırmaya katılanların Tamamlayıcı Sağlık Sigortası (TSS) ile ilgili düşünceleri incelendiğinde, katılımcıların %68,3'ü TSS hakkında daha önce bilgi sahibi olduklarını belirtmiş, ancak %39,1'lik bir kısmı bu sigorta türünü duymadıklarını ifade etmiştir. TSS hakkında bilgi sahibi olanların oranı ise %21,6'dır, ancak bu oran, katılımcıların büyük bir kısmının (%57,5) soruya cevapsız kalması nedeniyle sınırlıdır. Bu durum, tamamlayıcı sağlık sigortası hakkında yeterli bilgiye sahip olunmadığını ve katılımcıların konuyla ilgili belirsizlik yaşadıklarını göstermektedir. Yanıtlar arasında, TSS'nin kapsadığı hizmetlere dair verilen bilgiler, genellikle "muayene ücreti ve yapılan tetkikleri kapsayan sigorta" gibi genel açıklamalardan ibaret olmuştur. Bununla birlikte, tamamlayıcı sağlık sigortası hakkında tamamen ilgisiz yanıtlar da alınmıştır. Bu bulgular, katılımcıların tamamlayıcı sağlık sigortası konusundaki farkındalık seviyelerinin düşük olduğunu ve bu alandaki bilgi eksikliğinin önemli bir konu olduğunu ortaya koymaktadır.

5.8.Araştırmaya Katılanların Özel Sağlık Sigortası İle İlgili Düşüncelerinin Dağılımı

Araştırmaya katılanların Özel Sağlık Sigortası ile ilgili düşünceleri incelendiğinde, katılımcıların %65,8'i şu ana kadar özel sağlık sigortası yaptırmayı düşünmediklerini belirtirken, %33,3'ü ise özel sağlık sigortasını yaptırmayı düşünmüşlerdir. Özel sağlık sigortasına sahip olmayanların neden bu sigortayı tercih etmedikleri sorulduğunda, katılımcıların %33,3'ü "ihtiyaç duymadıklarını", %29,1'i "sosyal güvencelerinin bulunduğunu" ve %20,8'i ise "parasal nedenlerden dolayı" özel sağlık sigortasına başvurmadıklarını ifade etmişlerdir. Diğer yanıtlar arasında ise "güvenmedikleri için", "vakit bulamadıkları için" gibi çeşitli sebepler de yer almıştır. Bu bulgular, katılımcıların çoğunluğunun özel sağlık sigortasına ihtiyaç duymadığını ve sosyal güvencelerinin yeterli olduğunu düşündüklerini, bununla birlikte ekonomik sebeplerin de önemli bir engel teşkil ettiğini göstermektedir.

5.9.Araştırmaya Katılanların "Şimdiye Kadar Herhangi Bir Özel Sağlık Sigortası Temsilcisiyle Görüşmeniz Oldu Mu?" Sorusuna Yanıtlar

Araştırmaya katılanların "Şimdiye kadar herhangi bir özel sağlık sigortası temsilcisiyle görüşmeniz oldu mu?" sorusuna verdikleri yanıtlara göre, katılımcıların %68,3'ü herhangi bir özel sağlık sigortası temsilcisiyle görüşmediklerini belirtirken, %30,8'i ise böyle bir görüşme yapmışlardır. Bu bulgu, katılımcıların büyük bir kısmının özel sağlık sigortası ile ilgili temsilcilerle doğrudan iletişim kurmadığını, ancak bir kısmının bu tür bir görüşme deneyimi yaşadığını göstermektedir.

5.10.Araştırmaya Katılanların Hangi Sigorta Şirketinin Temsilcisi İle Görüştüğü

Araştırmaya katılanlara "Hangi sigorta temsilcisi ile görüştünüz?" sorusu sorulduğunda, katılımcıların %81'inin hangi sigorta şirketi temsilcisiyle görüştüğünü hatırlamadığı belirlenmiştir. Geri kalan katılımcıların ise en fazla görüştüğü sigorta şirketi %3,3 ile Ak Sigorta olmuştur. Diğer sigorta şirketleri arasında Koç Allianz ve Diğerleri (HSBC, Universal, American Life, Genel Sigorta) %1,6 oranıyla sıralanırken, Aksa Oyak ve Ak Sigorta da sırasıyla %5 ve %3,3 oranında görüşülen şirketler arasında yer almaktadır. Bu veriler, sigorta şirketleriyle yapılan görüşmelerin çoğunun katılımcıların hatırlamaması nedeniyle net bir sonuca varılamadığını, ancak bazı büyük sigorta şirketlerinin temsilcileriyle görüşmelerin gerçekleştiğini göstermektedir.

5.11.Araştırmadaki Katılımcıların Cinsiyetine Göre Sağlık Sorunu Olduğunda Gittiği Yer (Kamu-Özel)

Araştırmaya katılanların sağlık sorunu olduğunda gittikleri yer ile cinsiyetleri arasındaki ilişkiyi incelediğimizde, %81'inin kamu kuruluşlarını tercih ettiği, %19'unun ise özel sağlık hizmetlerini tercih ettiği görülmüştür. Cinsiyet açısından bakıldığında, kadınların %71'i kamu kurumlarına, %29'u ise özel sağlık hizmetlerine gitmeyi tercih ederken, erkeklerin %84'ü kamu sağlık hizmetlerine, %16'sı ise özel sağlık hizmetlerine gitmiştir. Bu veriler doğrultusunda, kadınlar özel sağlık hizmetlerine daha fazla yönelirken, erkekler kamu sağlık hizmetlerine daha fazla başvurmaktadır.

İstatistiksel analizde ise, $\chi 2=6,7$ ve $p=0,009$ sonuçları elde edilmiştir. p değeri 0,05'ten küçük olduğu için H0 hipotezi reddedilmiştir. Bu da demektir ki, sağlık sorunu olduğunda gittiği yer ile cinsiyet arasında bir bağımlılık bulunmaktadır. Yani, cinsiyetin sağlık hizmeti tercihlerinde etkili bir faktör olduğu söylenebilir.

5.12.Araştırmadaki Katılımcıların Ekonomik Durumunu Değerlendirmesine Göre Sağlık Sorunu Olduğunda Gittiği Yer (Kamu-Özel)

Araştırmaya katılanların ekonomik düzeylerine göre sağlık sorunu olduğunda gittikleri yer incelendiğinde, %81'inin kamu kuruluşlarına gitmeyi tercih ettiği, %19'unun ise özel sağlık hizmetlerine yöneldiği görülmüştür. Dar gelirli bireylerin tamamı kamuya yönelirken, zengin bireylerin yarısı kamuya, yarısı ise özel sağlık hizmetlerine gitmeyi tercih etmektedir. Orta gelirli bireyler ise çoğunlukla (%78) kamu sağlık hizmetlerine başvururken, %22'si özel sağlık hizmetlerini tercih etmektedir. İstatistiksel analiz sonuçları $\chi 2=25,5$ ve $p=0,000$ olarak bulunmuştur. P değeri 0,05'ten küçük olduğu için H0 hipotezi reddedilmiş ve sağlık sorunu olduğunda gittiği yer ile ekonomik düzey arasında bir bağımlılık olduğu sonucuna varılmıştır. Yani, ekonomik düzeyin, sağlık hizmeti tercihlerinde önemli bir rol oynadığı ve bireylerin gelir seviyelerinin sağlık hizmeti tercihini etkilediği söylenebilir.

5.13.Araştırmaya Katılanların Cinsiyetine Göre Sağlık Hizmetlerinin Özelleştirilmesi Hakkındaki Düşünceleri

Araştırmaya katılanların cinsiyetine göre sağlık hizmetlerinin özelleştirilmesi hakkındaki düşünceleri incelendiğinde, genel olarak %54'ünün özelleştirmeye olumlu ancak çekinceleri olduğunu belirtmiştir. Kadınlar arasında %54,8, erkekler arasında ise %54 bu düşünceyi paylaşırken, %33'ü tamamen olumsuz bir görüşe sahip olmuştur. Erkeklerin %16'sı tamamen olumlu düşünürken, kadınlarda bu oran %3,2'dir. İstatistiksel analiz sonuçlarına göre, $\chi 2=11,95$ ve $p=0,003$ bulunmuş olup, p değeri 0,05'ten küçük

olduğundan H0 hipotezi reddedilmiştir. Bu da demektir ki, özelleştirme hakkındaki düşünceler ile cinsiyet arasında bir bağımlılık vardır. Yani, cinsiyetin, sağlık hizmetlerinin özelleştirilmesi hakkındaki görüşlerde etkili bir faktör olduğu söylenebilir.

5.14.Araştırmaya Katılanların Ekonomik Düzeyini Tanımlamalarına Göre Sağlık Hizmetlerinin Özelleştirilmesi Hakkındaki Düşünceleri

Araştırmaya katılanların ekonomik düzeyine göre sağlık hizmetlerinin özelleştirilmesi hakkındaki düşünceleri incelendiğinde, %54'ünün özelleştirmeye olumlu ancak çekinceleri olduğunu belirttiği görülmektedir. Zengin bireyler arasında özelleştirmeye yönelik tamamen olumlu görüş bulunmazken, orta gelirli bireylerin %14,5'i tamamen olumlu, dar gelirli bireylerin ise %5'i tamamen olumlu görüş belirtmiştir. Dar gelirli bireylerin %63'ü ise özelleştirmeyi tamamen olumsuz olarak değerlendirmiştir. Orta gelirli bireylerde %27,5 bu görüşü paylaşırken, zengin bireylerde olumsuz görüş bulunmamaktadır. İstatistiksel analizde $\chi 2=32,30$ ve $p=0,000$ değerleri bulunmuş olup, p değeri 0,05'ten küçük olduğundan H0 hipotezi reddedilmiştir. Bu da, özelleştirme hakkındaki düşünceler ile ekonomik durum arasında bir bağımlılık olduğunu gösterir. Özellikle, dar gelirli bireylerin çoğunluğu özelleştirmeyi olumsuz değerlendirmekte ve orta gelirli bireyler çekinceleriyle birlikte olumlu görüş belirlemektedir.

5.15.Araştırmaya Katılanların Mesleğine Göre Özel Sağlık Sigortası Kapsamında Olmama Nedenleri

Araştırmaya katılanların mesleklerine göre özel sağlık sigortası kapsamında olmama nedenleri incelendiğinde, "ihtiyaç duymama" nedeninin en yüksek olduğu grup ev hanımları, öğrenciler vb. olup, bu grup %48 oranında bu durumu belirtmiştir. Ayrıca, emeklilerde de %40 oranıyla bu neden en yüksek ikinci sıradadır. Diğer yandan, iş adamı ve esnaf grubunda da %40 oranında "parasal nedenlerden dolayı" sigorta kapsamına girmediklerini belirtmişlerdir. Entelektüel meslek grubunda, %60 oranında "parasal nedenlerden dolayı" sigorta kapsamında olmadıkları görülürken, sosyal güvencesi olan katılımcıların en yüksek oranı devlet memurlarında %46 olarak kaydedilmiştir. Bu oran, emeklilerde de %33 civarındadır. Çeşitli diğer nedenler arasında, "ek hastalıklar için ek para istenmesi" ve "cepten ödeme yapmanın daha rahat olması" gibi sebeplerle sigorta kapsamında olmama oranları %2-15 arasında değişiklik göstermektedir. Genel olarak, katılımcıların en yaygın yanıtı, sigorta kapsamında olmama nedenleri arasında "ihtiyaç duymama" ve "parasal nedenler" olarak öne çıkmaktadır.

5.16.Araştırmaya Katılanların Sosyal Güvence Durumuna Göre Tamamlayıcı Sağlık Sigortasını Duyma Durumu

Araştırmaya katılanların sosyal güvence durumuna göre tamamlayıcı sağlık sigortasını duyma durumu incelendiğinde, sağlık güvencesi olan gruplarda tamamlayıcı sağlık sigortasını duyanların oranı %56 ile %64 arasında değişiklik göstermektedir. Bu oran sırasıyla SSK grubunda %56, Bağ-Kur grubunda %50, ve Emekli Sandığı grubunda %64 olarak belirlenmiştir. Ancak, sağlık güvencesi olmayan bireyler arasında tamamlayıcı sağlık sigortasını duymayanların oranı oldukça yüksektir ve %75'e kadar çıkmaktadır. Bu durum, sağlık güvencesi olmayan bireylerin tamamlayıcı sağlık sigortası hakkında daha az bilgiye sahip olduğunu göstermektedir. Sosyal güvencesi olan gruplarda ise sigorta hakkında duyma oranı genel olarak yüksek olmakla birlikte, sağlık güvencesi bulunmayan katılımcılar arasında bilgi eksikliğinin daha yaygın olduğu anlaşılmaktadır.

6.Tartışma

Araştırmamıza göre, özel sağlık sigortasına sahip olmayan bireylerin kendilerini zengin olarak tanımlama oranı oldukça düşük görünmektedir. Bu durum, özel sigorta sahipliği ile ekonomik durum arasındaki ilişkiyi ortaya koymaktadır; zira genellikle daha düşük gelir gruplarındaki bireylerin özel sağlık sigortasından yararlanmadığı ve kamu sağlık hizmetlerini tercih ettikleri görülmektedir.

Araştırmaya katılanların sağlık hizmeti kullanım tercihlerine bakıldığında, yüksek oranda kamu kuruluşları, düşük oranda ise özel sektör kuruluşları tercih edilmiştir. Kamu kuruluşları arasında devlet hastaneleri ve üniversite hastaneleri en çok tercih edilen sağlık hizmeti sağlayıcılarıdır. Bu bulgu, kamu sağlık hizmetlerinin geniş erişim imkânı sunduğunu ve genellikle düşük gelirli bireyler tarafından tercih edildiğini göstermektedir. Kamuya yönelmenin bir diğer nedeni de, sağlık sigortası olmayan bireylerin özel sektöre ödeme yapma konusunda karşılaştıkları maddi zorluklardır.

Özel sigorta kapsamında olmayanlar arasında bir grup kişi son bir ay içinde sağlık hizmeti aldığını belirtmiş, ayrıca son bir yıl içinde sağlık hizmeti kullanım oranı yarıdan fazla olarak gözlemlenmiştir. Bu da sağlık hizmeti kullanımıyla ilgili önemli bir ipucu sunmaktadır: Sigorta olmayan bireyler, sağlık hizmetlerinden yararlanabilmek için genellikle kamuyu tercih etmektedir. En sık başvurulan sağlık alanları ise kontrol, dâhiliye, kadın-doğum, diş, KBB ve kardiyoloji gibi temel sağlık hizmetleri olmuştur.

Genel Sağlık Sigortası, devlet eliyle sigorta teminatı sağlamaktadır ve ülkemizde sağlık sisteminin temel direğidir. Özel sigorta şirketlerinin sağlık alanında yatırım yapmaya isteksiz olmalarının, özel sigortaların yetersizliğini ve gelişmemişliğini ortaya koyduğu anlaşılmaktadır. Bu durumda, devletin sağlık sistemine müdahale etmesi ve sistemin işlerliğini artıracak çözümler üretmesi gerektiği açıktır.

Tamamlayıcı Sağlık Sigortası, sağlık hizmetlerinin sigorta kapsamı dışında kalan kısmını karşılayan bir poliçedir. Araştırmamızda, tamamlayıcı sağlık sigortasına dair bilgi sahibi olan ve bu sigorta türünü duyan katılımcı oranı oldukça düşüktür. Ayrıca, bu konuda bilgi veren katılımcı sayısı da sınırlıdır, bu da sektördeki tanıtım ve pazarlama eksikliklerine işaret etmektedir.

Özel sağlık sigortası yaptırmama sebeplerine gelindiğinde, katılımcıların büyük bir kısmı ihtiyaç duymadığını ve sosyal güvenceleri olduğunu belirtmiştir. Ayrıca, parasal nedenler de önemli bir engel olarak öne çıkmaktadır. Bu bulgu, sağlık sigortasına yönelik farkındalık yaratılması gerektiğini ve bireylerin özel sigortaya olan ihtiyacı konusunda daha fazla bilgilendirilmesi gerektiğini göstermektedir.

Özel sigorta kapsamında olmayanlar arasında, özellikle Bağ-Kur üyeleri ve Emekli Sandığı üyeleri arasında, sağlık hizmeti kullanımı tercihinin tamamen kamudan yana olduğu gözlemlenmiştir. Bu, söz konusu grup üyelerinin kamu sağlık hizmetlerine alışkanlıkları ve cepten ödeme yapmaktan kaçınmalarıyla açıklanabilir.

Dar gelirli bireylerin tamamı kamuyu tercih etmekteyken, maddi durum iyileştikçe özel sektöre yönelme eğilimi artmaktadır. Bu durum, kamunun tercih edilmesinin en önemli nedeninin, büyük oranda sosyal güvencelerin sağladığı teminatlar olduğu sonucunu doğurmaktadır. Ancak kamudaki eksiklikler araştırılmalı ve bu eksiklikler giderilmelidir.

Özel sağlık sigortası olmayan bireylerin büyük çoğunluğunun orta gelirli oldukları anlaşılmaktadır. Bu grup, sağlık sigortası hakkında temel bilgilere sahip olmamakta, bu da sektördeki tanıtım eksikliklerini ortaya koymaktadır. Genel sağlık sigortası, tamamlayıcı sigorta ve özel sigorta gibi temel sigorta bilgilerine hâkim olmamaları, sektörün potansiyel müşteri kitlesine yeterince ulaşamadığının bir göstergesidir. Bu nedenle, sağlık sigortası sektörü, tanıtım faaliyetlerini artırmalı ve daha fazla bireye ulaşmayı hedeflemelidir.

Sonuçta kamu sağlık hizmetleri, düşük gelirli bireyler tarafından daha fazla tercih edilmekte, özel sigorta ise daha çok ekonomik durumu iyi olan bireyler tarafından benimsenmektedir. Bununla birlikte, sağlık sigortası ve özellikle tamamlayıcı sağlık sigortası konusunda halkın bilinçlenmesi gerektiği açıktır. Bu konuda yapılacak tanıtım ve farkındalık çalışmaları, sağlık sigortası sektörünün gelişmesine önemli katkılar sağlayabilir.

7.Sonuçlar ve Öneriler

Bu araştırmanın bulguları, özel sağlık sigortası ve sağlık hizmetleri kullanım alışkanlıkları konusunda önemli sonuçlar ortaya koymaktadır. Araştırmaya katılan bireylerin çoğunluğu, özel sağlık sigortasına sahip olmayan ve kamuyu tercih eden bireylerden oluşmaktadır. Özellikle sağlık sigortası olmayan kişilerin büyük bir kısmı, sağlık hizmeti almak için kamusal sağlık kuruluşlarını kullanmayı tercih etmektedir. Kamu hastanelerine başvurunun yaygın olması, bu sağlık kuruluşlarının sosyal güvence sağlaması ve maddi olarak daha ulaşılabilir olmaları gibi nedenlere dayanmaktadır. Bu, ülkedeki sağlık sigortası sistemi ve özel sigorta sektörüne dair bazı önemli soru işaretlerini ortaya koymaktadır. Kamu kuruluşlarında en fazla tercih edilen sağlık hizmetleri devlet hastaneleri ve üniversite hastaneleri olmuştur. Bununla birlikte, özel sektör hizmetleri, maddi engeller ve bilinç eksiklikleri nedeniyle daha az tercih edilmiştir.

Araştırmada, özel sağlık sigortasına sahip olmayan bireylerin çoğunun, sigorta yaptırmama sebeplerini ihtiyaç duymamaları ve sosyal güvenceye sahip olmaları olarak açıklamaları dikkat çekmiştir. Bu durum, özel sigortaya yönelik düşük talebin ve farkındalığın başlıca nedenleri arasında sayılabilir. Özellikle dar gelirli bireyler için özel sağlık sigortası, parasal zorluklar nedeniyle erişilemez bir seçenek olarak kalmaktadır. Ayrıca, katılımcıların tamamlayıcı sağlık sigortası hakkında çok az bilgiye sahip olmaları ve bu konudaki farkındalıklarının düşük olması, sektörün henüz potansiyel müşteri kitlesine ulaşmada yetersiz kaldığını göstermektedir. Çoğu kişi, özel sağlık sigortasına dair temelde bilgi eksikliği yaşamaktadır. Bu eksiklik, sigorta şirketlerinin pazarlama ve tanıtım faaliyetlerine yeterince yatırım yapmadığını ve sektördeki bilinçlendirmenin yeterince yapılmadığını gösteriyor.

Araştırmanın bir diğer önemli bulgusu, sigorta ve sağlık hizmetleri konusunda kararların, bireylerin sosyal güvenceleri, ekonomik durumları ve meslek gruplarına bağlı olarak şekillendiğidir. Bağ-Kur ve Emekli Sandığı gibi sosyal güvenceye sahip bireylerin, sağlık hizmetleri için genellikle kamuyu tercih ettiği, ayrıca dar gelirli bireylerin tamamının kamu sağlık hizmetlerini seçtiği gözlemlenmiştir. Bu durum, sosyal güvencenin önemli bir tercih faktörü olduğunu ortaya koymaktadır. Kamu sağlık hizmetlerine olan yönelim, kamu sağlık kuruluşlarının sağladığı sosyal güvence ve devlet katkıları ile doğrudan ilişkilidir. Bununla birlikte, gelir düzeyi arttıkça, bireylerin özel sağlık sigortasına yönelme oranı artmaktadır. Bu da, özel sigorta şirketlerinin, daha yüksek gelir grubundaki bireyler için daha cazip teklifler sunduğunu göstermektedir.

Özellikle dar gelirli bireyler arasında sağlık sigortası ve tamamlayıcı sigorta hakkında farkındalığın düşük olması, sigorta şirketlerinin bu kitleye yönelik daha fazla çaba göstermeleri gerektiğini ortaya koymaktadır. Ayrıca, bu bireylerin kamuyu tercih etmeleri, kamusal sağlık hizmetlerinin eksik yönleriyle de ilgilidir. Kamu sağlık hizmetlerinde yaşanan aksaklıklar, özel sigorta şirketlerinin potansiyel müşteri kitlesi üzerindeki etkisini zayıflatmaktadır. Bu durum, kamusal sağlık sisteminin daha etkin ve verimli hale getirilmesinin önemini vurgulamaktadır. Kamu kuruluşlarının hizmet kalitesinin arttırılması, daha hızlı ve kaliteli sağlık hizmetlerinin sunulması, özel sigortaya olan ilgiyi azaltabilir. Ancak, sigorta sisteminin genişletilmesi ve erişilebilir hale getirilmesi için özel sektörün de devreye girmesi gerekmektedir.

Araştırma sonuçları, sigorta sektöründeki farkındalık eksiklikleri ve pazarlama stratejilerinin yetersizliği üzerine önemli bulgular sunmuştur. Katılımcılar, sağlık sigortası konusunda temel bilgilerden dahi haberdar olmamakta, bu da sigorta sektörünün potansiyel müşteri kitlesine ulaşmada ne kadar sınırlı kaldığını göstermektedir. Bu nedenle, sigorta şirketlerinin, özel sağlık sigortası, genel sağlık sigortası ve tamamlayıcı sigorta gibi kavramları daha geniş bir kitleye tanıtmak amacıyla daha etkili kampanyalar yürütmesi gerekmektedir. Ayrıca, sigorta şirketlerinin, sosyal güvence sağlayamayan bireylere yönelik, düşük maliyetli sigorta paketleri ve ödeme kolaylıkları sunarak, sağlık sigortasını daha geniş bir kitleye ulaştırmaları önemlidir.

Özel sağlık sigortası ile ilgili olarak, sigorta şirketlerinin daha ulaşılabilir fiyatlar ve esnek ödeme planları sunmaları, dar gelirli ve orta gelirli bireylerin sigortaya olan ilgisini artırabilir. Ayrıca, tamamlayıcı sağlık sigortası konusunda, sektörde daha fazla farkındalık yaratmak amacıyla kamu ve özel sektör işbirlikleri ile seminerler ve eğitim programları düzenlenmesi faydalı olabilir. Bu tür programlar, sigorta kavramına dair bilgi eksikliklerini giderebilir ve sigorta sektörünün büyümesine katkıda bulunabilir.

Sonuç olarak sigorta sektörünün büyümesi için, sağlık sigortası ve tamamlayıcı sağlık sigortasına yönelik bilinçlendirici faaliyetler artırılmalı ve sigorta şirketleri, farklı gelir gruplarına hitap eden daha uygun sigorta planları geliştirmelidir. Kamu sağlık hizmetleri ise, kaliteyi artırarak ve hizmet hızını iyileştirerek, daha fazla bireyi bünyesine çekebilir. Ayrıca, sigorta sektörünün daha fazla tanıtım ve pazarlama yapması, ve sosyal güvenceye sahip olmayan gruplara yönelik kampanyalar geliştirmesi, sektördeki potansiyel müşterilerin ilgisini artıracaktır. Sağlık hizmetlerinin daha erişilebilir hale gelmesi ve sigorta şirketlerinin bu alanda daha fazla yatırım yapması, ülkedeki sağlık sisteminin sürdürülebilirliğini ve kalitesini artıracaktır.

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HOPELESSNESS SCALE FOR SCIENCE EDUCATION: A STUDY ON VALIDITY AND RELIABILITY

FEN BİLİMLERİ UMUTSUZLUK DÜZEYİ ÖLÇEĞİ: GEÇERLİK ve GÜVENİRLİK ÇALIŞMASI

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ABSTRACT

In today's educational landscape, a significant number of students experience feelings of hopelessness in academic contexts due to increased academic pressures, dense curricula, exam-related anxiety, and high achievement expectations. Particularly in science education, the cognitive complexity of the subject matter may exacerbate students' feelings of inadequacy, leading to diminished motivation and the emergence of hopelessness. In this regard, the present study aimed to develop a valid and reliable measurement tool to assess the level of hopelessness middle school students experience specifically toward science courses. The research followed a comprehensive psychometric analysis framework to establish the construct validity and reliability of the developed scale. Exploratory Factor Analysis (EFA) was conducted with data from 626 middle school students, while Confirmatory Factor Analysis (CFA) was applied to responses from a separate sample of 631 students. The EFA results revealed a four-factor structure consisting of 31 items, which explained 58.93% of the total variance. The CFA results supported the model's fit with acceptable goodness-of-fit indices ($\chi^2/df = 2.90$; RMSEA = 0.05; CFI = 0.98), confirming the factorial structure identified through EFA. Furthermore, convergent and discriminant validity values, as well as composite reliability (CR) and Cronbach's alpha coefficients, indicated strong internal consistency and structural validity of the scale. The four sub-dimensions identified were named "Self-Efficacy," "Disinterest," "Anxiety," and "Social Pressure." Designed as a five-point Likert-type instrument, the scale has been demonstrated to be a psychometrically sound tool for assessing students' hopelessness toward science lessons at the middle school level. Findings suggest that the scale can be effectively used by educators and researchers in identifying students' affective learning barriers and in developing targeted intervention programs that address hopelessness and enhance student engagement in science education.

Keywords: Science education, hopelessness, middle school students, scale development, validity, reliability.

ÖZET

Günümüz eğitim ortamında pek çok öğrenci, akademik baskılar, yoğun ders programları, sınav kaygısı ve yüksek başarı beklentileri nedeniyle umutsuzluk duyguları yaşayabilmektedir. Özellikle fen bilimleri derslerinde karşılaşılan kavramsal karmaşıklık, öğrencilerde yetersizlik hissini artırmakta ve motivasyon kaybına yol açmaktadır. Bu bağlamda, bu araştırmada ortaokul öğrencilerinin fen bilimleri dersine yönelik umutsuzluk düzeylerini belirlemeye yönelik geçerli ve güvenilir bir ölçme aracı geliştirilmesi amaçlanmıştır. Çalışma, geliştirilen ölçeğin yapı geçerliğini ve güvenirliğini test etmek amacıyla çok aşamalı psikometrik analiz süreçlerini içermektedir. Açımlayıcı Faktör Analizi (AFA), 626 ortaokul öğrencisinden elde edilen verilerle gerçekleştirilmiş ve 31 maddeden oluşan dört faktörlü bir yapı ortaya konmuştur. Elde edilen yapı toplam varyansın %58,93'ünü açıklamaktadır. Doğrulayıcı Faktör Analizi (DFA), farklı bir örneklem grubu (n=631) ile yürütülmüş ve modelin kabul edilebilir

uyum düzeyine sahip olduğu belirlenmiştir (χ^2/sd = 2,90; RMSEA = 0,05; CFI = 0,98). Ayrıca, birleşik güvenirlik (CR), yakınsak ve ıraksak geçerlik ile Cronbach Alfa katsayıları da ölçeğin iç tutarlılığı ve yapı geçerliğini desteklemektedir. "Öz Yeterlik", "İlgisizlik", "Endişe" ve "Sosyal Baskı" olmak üzere dört alt boyuttan oluşan ölçek, beşli Likert tipi olarak tasarlanmıştır. Geliştirilen bu ölçek, fen bilimleri dersine yönelik umutsuzluk düzeyini değerlendirmek amacıyla kullanılabilecek geçerli ve güvenilir bir araçtır. Bulgular doğrultusunda, öğretmen ve araştırmacıların, öğrencilerin duyuşsal özelliklerini dikkate alarak müdahale programları geliştirmeleri önerilmektedir.

Anahtar Kelimeler: Fen bilimleri, umutsuzluk, ortaokul öğrencileri, ölçek geliştirme, geçerlik, güvenirlik.

QUANTIFYING AERODYNAMIC TRADE-OFFS IN SINGLE-SLOTTED FLAP CONFIGURATIONS

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ABSTRACT

This study employs computational fluid dynamics (CFD) to investigate the aerodynamic impact of a single-slotted flap on a modified Cessna 208B Grand Caravan wing. Numerical simulations were conducted using ANSYS Fluent with the k-ε Realisable turbulence model, examining flap deflection angles (αF) of 0°, 15°, and 30° across angles of attack (α) ranging from 0° to 18°. The analysis, validated via grid independence testing and benchmarked against experimental protocols, assessed lift coefficient (C_L), drag coefficient (C_D), pressure distributions, vorticity magnitude, and velocity contours at a cruise velocity of 96 m/s under sea-level conditions. Results demonstrate that higher flap angles significantly augment lift at low α (e.g., 23% increase at αF=30° versus αF=0°), yet induce earlier flow separation, reducing maximum C_L *from* 0.745 (αF=0°) to 0.640 (αF=30°). Conversely, drag coefficients rise markedly with αF, peaking at C_D=0.165 for αF=30°—a 77.4% increase relative to αF=0°. The lift-to-drag ratio (C_L/C_D) similarly degrades from 13.80 (αF=0°, α=8°) to 10.20 (αF=30°). Vorticity contours reveal enlarged, dispersed vortices at elevated αF, correlating with adverse pressure gradients and turbulence intensification. These findings underscore a critical trade-off: while higher flap angles enhance low-speed lift for takeoff and landing, they detrimentally compromise aerodynamic efficiency and stall resilience.

Keywords: Aerodynamic, aircraft, airplane, wing, vibration

1. INTRODUCTION

The aerodynamic performance of aircraft wings is critically influenced by the complex fluid dynamics occurring at the boundary layer, where interactions between adjacent layers can precipitate three-dimensional flow separation, subsequently inducing detrimental secondary flows that compromise lift generation and overall airfoil efficiency [1]. This phenomenon necessitates advanced high-lift devices like slotted flaps, which mitigate separation by channeling high-energy airflow from the lower wing surface to re-energize the boundary layer over the upper surface, thereby delaying stall and reducing drag coefficients [2–5]. Computational Fluid Dynamics (CFD) has emerged as an indispensable tool for analyzing such aerodynamic interactions, enabling high-fidelity simulations of fluid flow, heat transfer, and turbulence through numerical solutions of the Navier-Stokes equations [6,7]. Previous investigations into slotted flaps—including Kasem's hysteresis analysis [3], Chapman's NACA 4414 simulations [4], Foster's foundational studies [5], and Velkova's gap optimization research [6,8]—have established their efficacy in enhancing lift-to-drag ratios; however, Todorov's work on lightweight airfoils [9] identified unresolved gaps in understanding their behavior on larger aircraft like the Cessna 208B Grand Caravan, which employs the NACA 23012 airfoil [10]. To address this, the present study leverages ANSYS Fluent CFD software with a K-ε Realizable turbulence model to conduct three-dimensional simulations of a modified Cessna 208B wing featuring a single-slotted flap at deflection angles (αF) of 0°, 15°, and 30°, across attack angles (α) of 0°–18° under sea-level cruise conditions (96 m/s, Re ≈ 3×10^6) [11–13]. The methodology adheres to Todorov's validation protocols [9], employing a 1:1 scale wing model within a wind tunnel-like domain (validated via grid independence tests per Mulvany [14] and Hariyadi [15]) to analyse lift (CL), drag (CD), pressure coefficients, vorticity

magnitude, and velocity contours. Key findings reveal that while higher flap angles (e.g., αF=30°) augment low-α lift by 23% compared to αF=0°, they also precipitate earlier stall (maximum CL reduced from 0.745 to 0.640) and increase CD by 77.4% due to amplified flow separation and turbulence [16]. Conversely, αF=0° yields peak aerodynamic efficiency (CL/CD=13.80 at α=8°), whereas αF=30° reduces this ratio to 10.20, underscoring a critical trade-off between lift enhancement and drag penalties [17]. Vorticity analyses confirm the presence of larger, dispersed vortices at elevated flap angles, correlating with pressure coefficient (Cp) distributions that exhibit intensified low-pressure zones and adverse gradients. Meanwhile, displacement oscillations under varying RPM (100–400) further illustrate drag-induced instabilities [18,19]. These insights demonstrate that moderate flap angles (αF=15°) optimise the balance between lift augmentation and stall delay, validating slotted flaps' operational superiority during takeoff/landing despite efficiency compromises [19]. This research thus provides a framework for optimizing high-lift configurations on utility aircraft, with implications for reducing fuel consumption and improving low-speed manoeuvrability.

2. METHODOLOGY

The three-dimensional numerical simulation will be employed in this strategy for searching. The program will be Ansys Fluent, and the K-ε Realisable turbulent model will be used. Simulation consists of three stages: pre-processing, processing, and post-processing. According to Todorov's study, the test object employs a Cessna C208b Grand Caravan wing, the dimensions of which are 1:1 to the flap geometry and actual dimensions [8] to validate the results acquired.

2.1 Boundary Conditions and Simulation Domain

A domain is a model that represents the test item. The domain determination needs to be adjusted to achieve the intended results under optimal conditions. [9]. In this case, the domain of the test section is a wing modeled as a wind tunnel. In Fig. 1, it is shown for each boundary condition. The aircraft's cruising speed of 96 (m/s) is the boundary condition applied at the intake. Mulvany is a basis for compiling the simulation domain. [10] and Hayride's research [11] up to five chord lines behind the trailing edge (Fig. 2 and fig3).

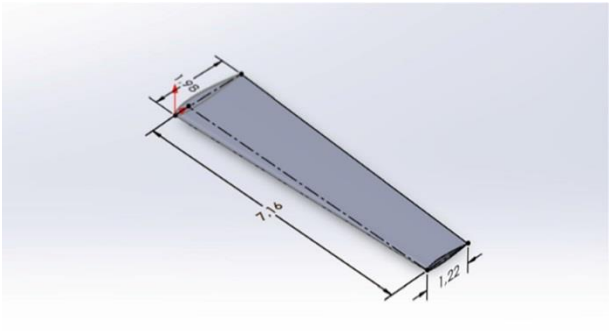


Figure 1. The simulation's wing geometry.

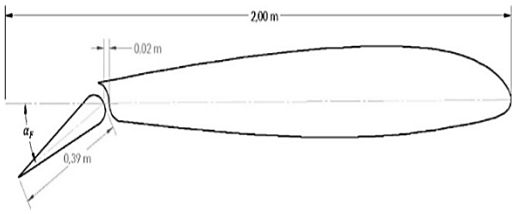


Figure 2. Simulation geometry of the wing with single slotted flap.

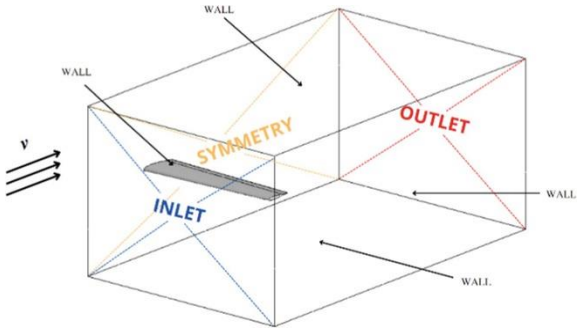


Figure 3. Boundary condition and simulation domain.

2.1 Test of grid independence

Accurate data is required by simulation software at both the preprocessing and postprocessing stages. A grid independence test must be conducted to determine the optimal grid structure and resolution that can approximate the actual conditions most accurately [12]. It ensures the repeatability of meshing and defines the optimal grid setting. The grid independence test compares different meshing types based on their numerical values of CD, shown in Table 1. Each meshing type is tested for the minimum value of CD that yields a reliable and reasonably accurate result in the simulation. A low and consistent CD value is one of the factors considered in numerical simulation. Thus, by Anderson's criteria, mesh five will serve as a reference for the following simulation. [13] .

Table 1. Grid independence test results for test object without flap configuration.

Mesh Type	Element Count	Node Count	Drag Force (N)	Drag Coefficient (CD)
Mesh-1	2,973,528	536,344	551.932	0.007103
Mesh-2	3,144,327	567,622	551.113	0.007093
Mesh-3	3,342,603	603,273	552.029	0.007105
Mesh-4	3,579,492	646,215	554.961	0.007142
Mesh-5	3,985,830	719,004	552.925	0.007116
Mesh-6	4,345,541	783,368	553.072	0.007118
Mesh-7	4,776,373	861,801	554.978	0.007027
Mesh-8	5,308,558	957,603	554.463	0.007156
Mesh-9	5,830,581	1,049,415	551.257	0.007002
Mesh-10	6,472,375	1,090,534	552.242	0.007157

3. RESULT AND DISCUSSION

Numerical simulations of the Cessna 208b Grand Caravan wing were performed for various flap angles. Emphasis shall be placed on lift, drag, and the lift-to-drag ratio, supported by pressure coefficients, velocity contours, and vorticity magnitudes. Results provide insight into how changes in flap angle might affect aircraft performance across a variety of conditions.

3.1 Velocity Contour Analysis

A line Velocity contours highlight flow behavior over the wing surface, revealing areas of acceleration, deceleration, and turbulence. At αF = 15°, a notable velocity differential develops between the upper and lower surfaces, enhancing lift production while introducing moderate turbulence near the trailing edge. With αF = 30°, the airflow separates earlier along the upper surface, producing larger regions of recirculation and turbulence. At α = 16°, the separation zone expands significantly, leading to higher drag and reduced aerodynamic efficiency. This trend is consistent with pressure drops along the upper surface, causing increased adverse pressure gradients. At lower RPM conditions (100, V = 3 m/s), displacement trends remain moderate, with minimal lift variations before stall. However, as RPM increases, the impact of lift augmentation becomes more pronounced. As shown in Figure 4, the displacement trends at RPM = 100 indicate a gradual increase in lift before stall, but with less intensity compared to higher RPM cases. Simulations at α = 0° indicate minimal separation, with streamlined flow dominating. At α = 8°, flow separation begins to emerge, growing substantially at α = 16°. These observations highlight the importance of managing flap angles to balance lift and drag across various operational conditions effectively.

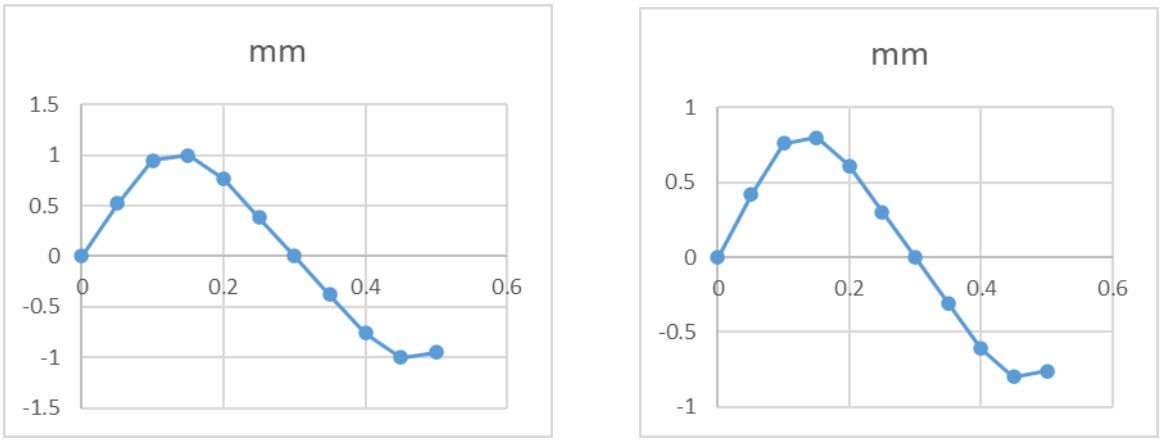


Figure. 4. Displacement vs. time at RPM = 100 and V = 3 m/s, illustrating baseline lift behavior before higher RPM effects are introduced.

3.2 Pressure Coefficient Distribution

Pressure coefficient (Cp) contours reveal pressure variations across the wing. Higher flap angles amplify pressure changes, particularly near the leading edge, where low-pressure zones intensify. At αF = 0°, the pressure distribution remains smooth, minimizing flow separation. Increasing the flap angle to αF = 15° generates stronger low-pressure zones along the upper surface, accelerating flow and increasing lift. At αF = 30°, Cp contours display broader low-pressure zones with irregular shapes, indicating turbulent flow and earlier separation. The trailing edge shows higher pressures at larger flap angles, consistent

with drag increases due to flow detachment and recirculation. These patterns align with lift and drag coefficients, affirming the impact of flap deflections on aerodynamic performance.

3.3 Coefficient of lift

The coefficient of lift (CL) was evaluated for flap angles (αF) of 0°, 15°, and 30° across various angles of attack (α). Figure 5 displays the relationship between CL and α.

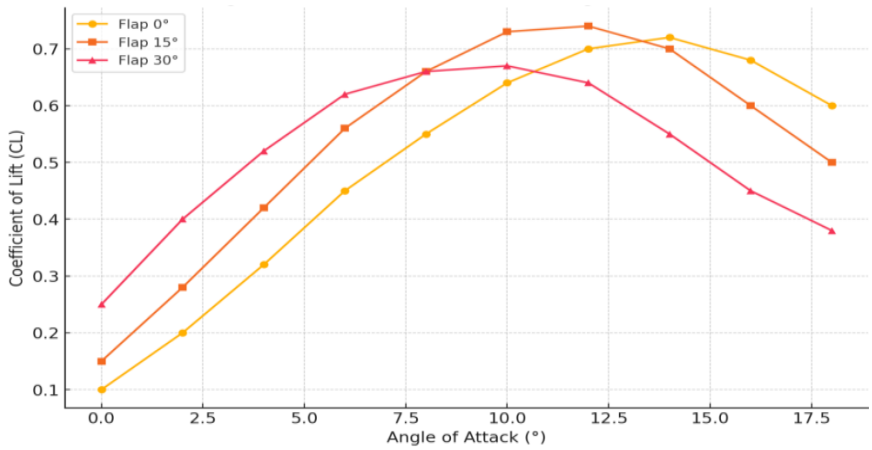
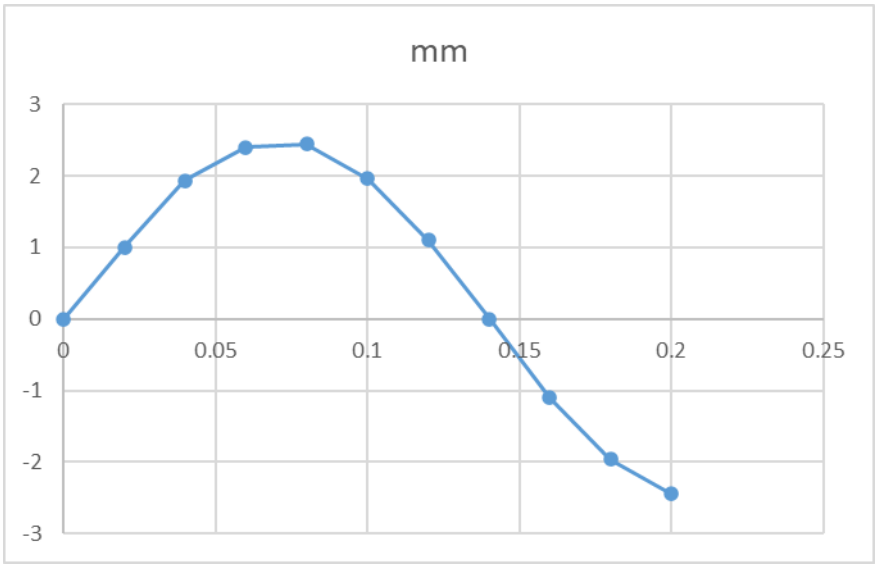
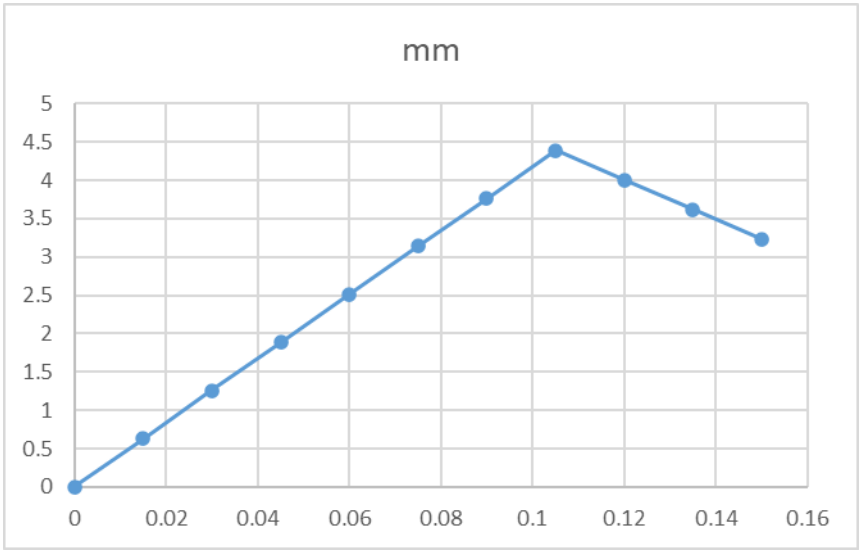


Figure 5. Coefficient of lift vs angle of attack.

Results reveal that increasing flap angles significantly enhances CL at lower angles of attack. For αF = 0°, the maximum CL achieved is approximately 0.745 at α = 18°. However, at αF of 30°, the maximum CL decreases slightly to 0.640 at α of 14°, indicating an earlier stall due to increased flow separation. Despite this reduction in maximum CL, higher flap angles maintain improved lift performance at low attack angles, making them suitable for takeoff and landing phases. At intermediate flap settings (αF = 15°), CL values are higher than at αF = 0° but lower than at αF = 30°. This suggests that moderate flap angles strike a balance between lift enhancement and stall delay, offering flexibility in operational performance. Fig. 6 gives the variation of angular displacements concerning angle of attack and CL for the following conditions: (a) RPM = 300, V = 10 m/s; Lift increases till stall conditions are reached. (b) RPM = 400, V = 14 m/s: The same effect is observed but more accentuated, demonstrating a more substantial lift increase before stall.



(a)



(b)

Figure 6. Displacement vs. time at varying RPMs: (a) RPM = 400, V = 14 m/s; (b) RPM = 300, V = 10 m/s, showing lift behavior leading up to stall.

3.4 Coefficient of drag

Drag coefficient (CD) values corresponding to flap angles (αF) of 0°, 15°, and 30° are shown in Figure 7. As expected, CD rises with increasing flap angles, due to larger exposed areas and enhanced flow disturbances.

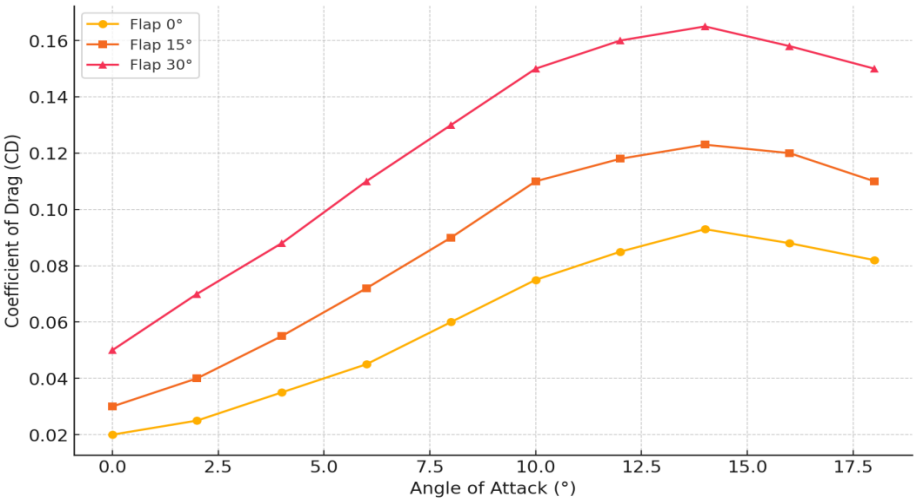


Figure 7. Coefficient of drag vs angle of attack.

For αF = 0°, drag remains relatively low, with a maximum value of 0.093 at α = 18°. At αF = 15°, the drag coefficient rises moderately to 0.123, while αF = 30° produces the highest drag, peaking at 0.165. This behavior reflects the increased frontal area and stronger turbulence caused by larger flap deflections. Higher drag at larger flap angles suggests a trade-off between lift enhancement and aerodynamic efficiency. While larger flap angles generate more lift, their higher drag coefficients emphasize their use during low-speed maneuvers, such as takeoff and landing, where enhanced lift compensates for drag penalties. The coefficient of drag is directly affected by the displacement created because of aerodynamic resistance. From Figure 4, when RPM = 100 and V = 3 m/s, there is a progressive increase in the displacement against time due to the drag forces. For increased velocities, at RPM = 200 and V = 7 m/s in Figure 8, increased flow velocities produce the most significant oscillations of displacement amplitude.

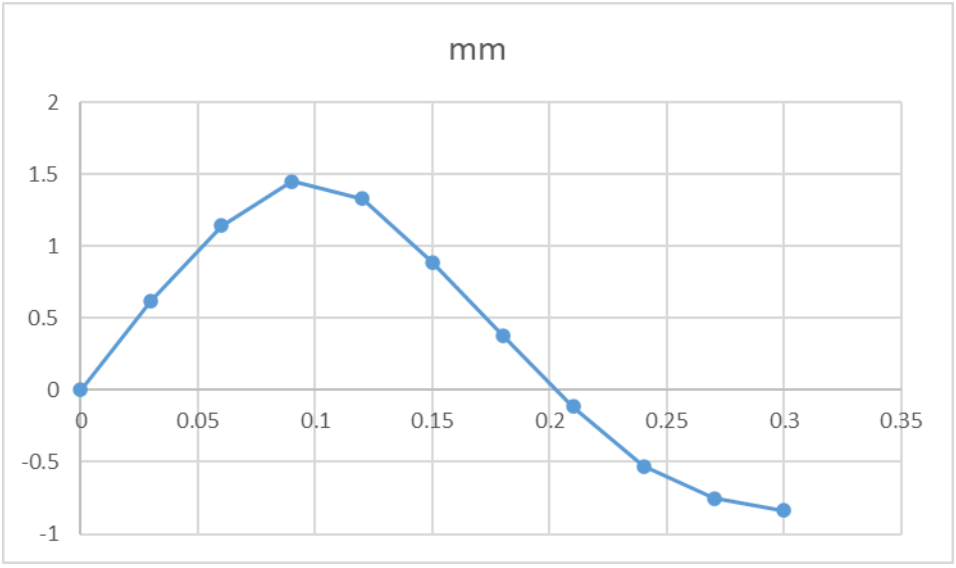


Figure. 8. Displacement vs. time at RPM = 200 and V = 7 m/s, demonstrating drag-induced oscillations in displacement over time.

3.5 lift-to-drag ratio

Figure 9 illustrates the variation of the lift-to-drag ratio (CL/CD) with angles of attack. The highest CL/CD value, approximately 13.80, is achieved at $\alpha = 8°$ for $\alpha F = 0°$. This configuration offers optimal aerodynamic efficiency, balancing lift and drag.

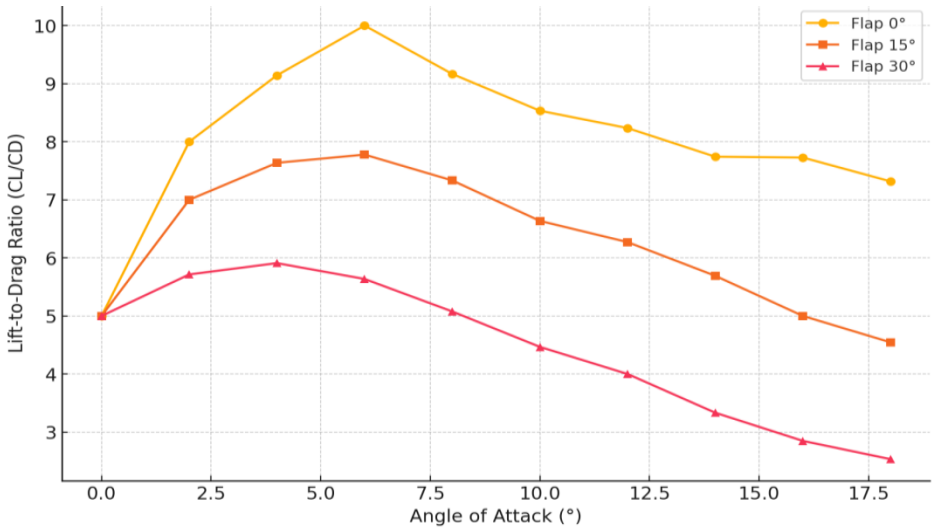


Figure 9. Lift-to-drag ratio vs angle of attack.

For $\alpha F = 15°$, the peak CL/CD value drops slightly to 12.45, while $\alpha F = 30°$ further reduces it to 10.20. Despite lower efficiency at higher flap angles, the enhanced lift production compensates for increased drag at lower speeds, resulting in better performance during the takeoff and initial climb phases. As the angle of attack increases, CL/CD values decrease across all flap angles due to drag buildup. These findings confirm that higher flap angles are more advantageous in scenarios prioritizing lift over efficiency. The lift-to-drag ratio is the most critical factor that determines the aerodynamic efficiency. Figure 10 shows how, for RPM of 400 and V of 14 m/s, the relationship between CL/CD varies with the change in flap deployment due to the changing trends of displacement.

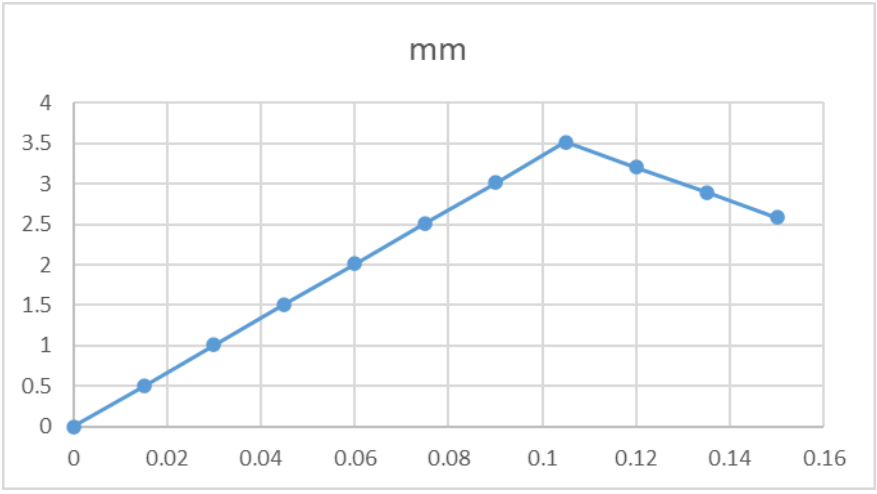


Figure 10. Displacement versus time at RPM = 400 and V = 14, representing the relationship between lift and drag efficiency.

3.6 vorticity magnitude contours

Figure 11 presents vorticity contours, which illustrate the flow rotation and turbulence. At α = 0° and αF = 0°, vortices are compact and confined near the trailing edge. Increasing α to 8° elongates the vortex zones, reflecting stronger lift forces. Higher flap angles produce more pronounced vortices, with αF = 30° generating larger and more dispersed vortices. At α = 16°, turbulent regions intensify, emphasizing drag buildup and reduced aerodynamic efficiency.

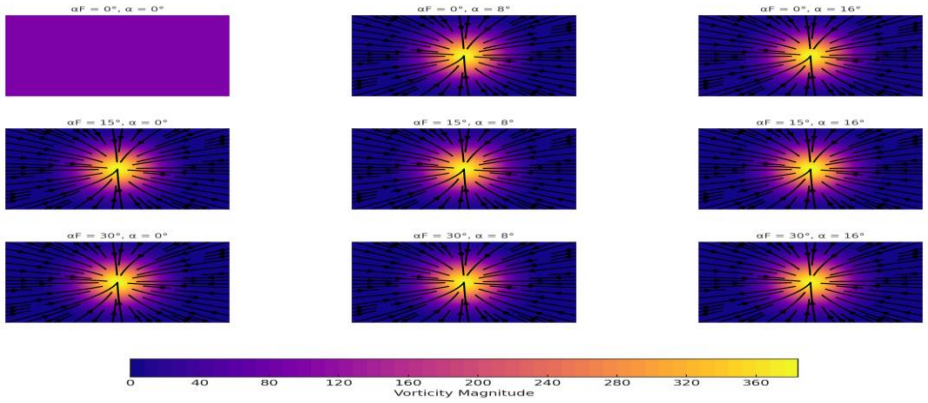


Figure 11. Vorticity magnitude contours - cessna 208b grand caravan.

4. CONCLUSION

The numerical simulation of the Cessna C208b Grand Caravan wing with single-slotted flap modifications provides the following conclusions:

1. Raising flap angles increases lift at low angles of attack, but reduces maximum CL values due to earlier stall.
2. Drag coefficients rise significantly with higher flap angles, emphasizing trade-offs between lift enhancement and aerodynamic efficiency.
3. Lift-to-drag ratios decrease with higher flap angles, yet maintain acceptable performance for takeoff and landing phases.
4. Velocity and pressure contours highlight intensified separation and turbulence at higher flap angles, aligning with the observed changes in lift and drag.
5. Vorticity analysis reveals stronger vortices at larger flap angles, confirming increased induced drag and flow disturbances.

These findings provide insights into optimizing wing configurations for different flight phases, balancing lift, drag, and aerodynamic efficiency through appropriate flap angle selections.

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ANALYSIS OF RADIATION DOSE LEVELS FOR GUARDS WHO EXPOSED TO RADIATION FROM PRISONER PATIENTS IN PET/CT UNITS

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ABSTRACT

A PET/CT system is a nuclear imaging technique that provides both functional (PET) and anatomical (CT) information in a single examination. The most commonly used radioisotope for imaging is fluorine-18 (F-18), which has a half-life of 109 minutes. After the injection of F-18 fluorodeoxyglucose (FDG), a pair of 511 keV annihilation photons is emitted in opposite directions from the patient.

In PET/CT units, patients typically wait in a designated rest area after injection. However, when the patient is a prisoner, medical care remains a fundamental human right, while continuous supervision by guards is required. This raises concerns regarding radiation safety for the guards. This study aims to measure and evaluate the radiation dose received by prison guards who must remain close to the patient throughout the imaging process.

Radiation dose measurements were conducted at 12 different locations around the patient; 25 cm, 50 cm, 100 cm, and 200 cm from the head, chest, and feet. A GM counter was used to record dose rates at three different time points: immediately after injection, one hour later, and just before the patient's discharge.

The results showed that the radiation dose varied depending on both time and distance from the patient. However, in compliance with international and national radiation safety regulations, the measured radiation exposure levels for guards remained within safe limits. No significant radiation hazard was detected for guards who remained in close contact with the patient for approximately two hours following the F-18 FDG injection during the PET/CT imaging process.

Keywords: Radiation exposure, PET/CT, radiation safety

PREDICTING DIABETES WITH INTERPRETABLE MACHINE LEARNING: A COMPARATIVE STUDY OF CLASSICAL AND DEEP MODELS

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ABSTRACT

Timely and accurate prediction of diabetes is essential for reducing long-term complications and improving clinical outcomes. With the increasing availability of structured patient data, machine learning (ML) has emerged as a promising approach for identifying individuals at risk of chronic conditions such as diabetes. In this study, we conduct a comparative evaluation of five ML models—Logistic Regression, Random Forest, XGBoost, Multi-Layer Perceptron (MLP), and TabNet—on a real-world tabular dataset for binary diabetes classification.

The dataset, publicly available and widely used in medical AI benchmarking studies, contains anonymized physiological and diagnostic attributes relevant to diabetes prediction. To ensure consistency and fairness across all models, we applied z-score normalization to the input features and performed five-fold stratified cross-validation. For TabNet, which is not natively compatible with standard scikit-learn pipelines, a custom cross-validation routine was implemented to maintain experimental parity. Model performance was assessed using Accuracy, F1 Score, and the Area Under the Receiver Operating Characteristic Curve (ROC AUC).

TabNet demonstrated the highest overall predictive performance, achieving strong accuracy and the most stable ROC AUC across folds. Beyond predictive metrics, this study emphasizes the importance of model interpretability in healthcare contexts. TabNet's attention-based architecture enabled the extraction of both global feature importance and local explanations for individual predictions. Features such as glucose levels and body mass index (BMI) emerged as key predictors across multiple evaluation layers.

Overall, the findings support the use of interpretable deep learning models in medical risk prediction tasks and highlight TabNet's potential as a reliable, transparent tool for decision support in clinical practice.

Keywords: Diabetes prediction; Interpretable machine learning; TabNet; Deep learning; Healthcare analytics; Explainable AI; Model comparison; Clinical decision support.

1. Introduction

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia, which, if left untreated, can lead to severe complications including cardiovascular disease, neuropathy, nephropathy, and retinopathy. According to the International Diabetes Federation (IDF), over 537 million adults worldwide are affected by diabetes, a number expected to rise to 643 million by 2030. This alarming growth underscores the urgency for effective early detection mechanisms. Accurate predictive systems can enable timely interventions, ultimately reducing morbidity, mortality, and healthcare costs.

The rapid development of machine learning (ML) and deep learning (DL) has opened new avenues for predictive healthcare. Unlike traditional statistical approaches, ML models are capable of capturing non-

linear relationships and interactions between features, allowing for more nuanced and accurate predictions. Nevertheless, in clinical environments, predictive accuracy must be complemented by transparency. Clinicians and healthcare practitioners require not only high-performing models but also interpretable outputs to justify diagnostic and treatment decisions.

In this work, we present a rigorous comparative evaluation of five different models—Logistic Regression, Random Forest, XGBoost, MLP, and TabNet—applied to a well-established benchmark dataset for diabetes prediction. While the first four represent widely adopted classical and deep learning approaches, TabNet stands out for its ability to provide inherent interpretability through sequential attention-based feature selection. This study not only measures and compares predictive performance but also investigates interpretability aspects, positioning TabNet as a potential candidate for clinical decision support systems.

2. Related Work

Over the past decade, the role of machine learning in diabetes research has expanded from simple classification tasks to complex, data-driven models that can predict, diagnose, and even guide the management of the disease. Early surveys, such as the one by Kavakiotis et al. [1], painted a broad picture of how ML and data mining have been applied in this field, from identifying individuals at risk to monitoring complications over time. More recent reviews by Sharma and Shah [5] and Afsaneh et al. [12] show how the field has matured, with an increasing variety of algorithms, richer datasets, and a growing emphasis on model interpretability for clinical adoption.

Many studies have tackled the challenge of predicting the onset of diabetes. Mujumdar and Vaidehi [2] compared several algorithms and found that ensemble-based methods often perform better than single learners. Lai et al. [7] and Zou et al. [4] echoed these findings, noting that tree-based ensembles and support vector machines consistently deliver strong results. Chou et al. [6] pushed the boundaries by integrating lifestyle factors with clinical data, showing that this combination can make predictions more robust across diverse patient groups.

Prediction, however, is only one part of the story. Dagliati et al. [3] looked further ahead by developing models to forecast diabetes-related complications, underlining the value of long-term patient data. In a similar spirit, Dinh et al. [14] created models that could simultaneously predict diabetes and cardiovascular disease risk, while Plis et al. [15] focused on real-time blood glucose prediction to support day-to-day disease management.

On the practical side, researchers such as Soni and Varma [8], Rani [10], and Vijayan and Anjali [11] have worked on lightweight prediction systems that could be deployed in clinics with limited resources. Others, like Abdulhadi and Al-Mousa [13], have embraced more computationally demanding techniques, including gradient boosting and neural networks, to improve accuracy in diverse populations.

Comparative analyses have also provided valuable perspective. Wei et al. [9] examined the strengths and weaknesses of different ML approaches for diabetes identification, stressing the need for a careful balance between sensitivity and specificity. The comprehensive review by Afsaneh et al. [12] goes a step further, highlighting how deep learning is being used not only for classification but also for prognosis and personalized care planning.

Taken together, these studies show a field that is both rich in technical innovation and increasingly mindful of clinical realities. Yet, challenges remain—particularly in making models transparent, ensuring they generalize well across populations, and integrating them smoothly into everyday healthcare workflows. This study builds on that foundation by comparing a range of classical models

with TabNet, a deep learning method that offers both high predictive accuracy and built-in interpretability.

3. Methodology

The study utilized the Pima Indians Diabetes Dataset, a well-established benchmark in medical machine learning research. It contains 768 patient records with eight quantitative attributes capturing demographic, lifestyle, and physiological characteristics, alongside a binary indicator denoting the presence or absence of diabetes. Variables include factors such as pregnancy count, plasma glucose concentration, diastolic blood pressure, skinfold thickness, serum insulin levels, body mass index (BMI), a diabetes pedigree function score, and age. These attributes are continuous in nature and exhibit varied ranges, making normalization a crucial preprocessing step.

Initial data preparation focused on addressing biologically implausible zero values present in variables such as BMI, blood pressure, and skin thickness. These were replaced with median values derived from the non-zero observations of each respective feature, thereby preserving the central tendency and distribution. Subsequently, all features were standardized to ensure comparability and to stabilize model optimization.

Five machine learning models were selected for evaluation. Logistic Regression served as a traditional baseline, offering a direct probabilistic interpretation of class membership. Random Forest and XGBoost represented tree-based ensemble methods, well known for their ability to capture complex feature interactions while providing robustness to noisy data. The Multi-Layer Perceptron (MLP) was employed as a feedforward neural network capable of modeling non-linear decision boundaries. Finally, TabNet, an interpretable deep learning model leveraging sequential attention-based feature selection, was implemented to explore its capacity for both predictive accuracy and built-in transparency.

Model hyperparameters for classical algorithms were tuned using grid search within stratified five-fold cross-validation to ensure balanced representation of both classes in each fold. Due to its computational requirements and specialized architecture, TabNet was optimized through targeted parameter tuning while maintaining consistency in training and evaluation protocols. Performance was assessed using multiple complementary metrics—ROC AUC, precision, recall, and F1 score—selected to capture both discriminative power and the trade-offs between false positives and false negatives.

4. Results

Across all evaluations, TabNet emerged as the top-performing model in terms of overall ROC AUC, demonstrating both high accuracy and remarkable stability across the cross-validation folds.

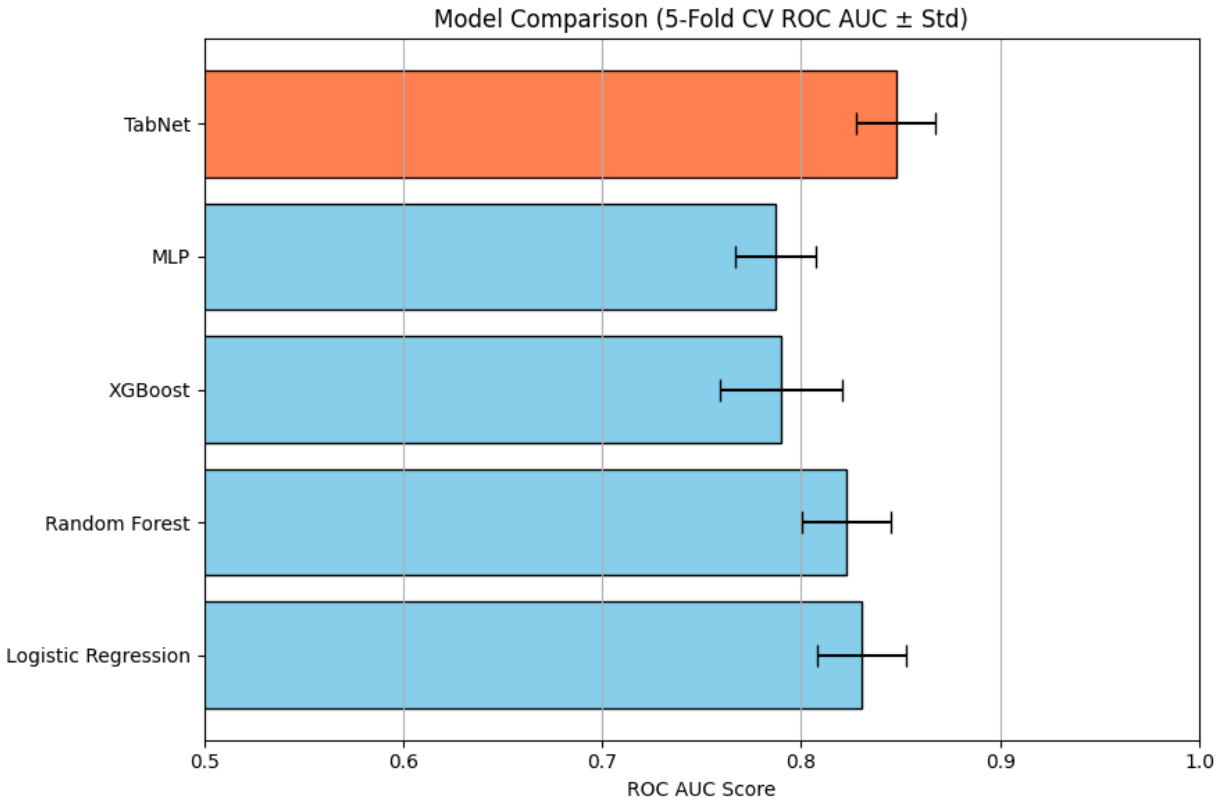


Figure 1.

The comparative analysis revealed that while Logistic Regression and Random Forest delivered competitive results, their performance exhibited slightly higher variability. XGBoost and MLP performed well but did not surpass TabNet's balanced combination of precision, recall, and stability.

The analysis of feature importance generated by TabNet's attention mechanism reinforced known medical associations. Glucose concentration and BMI consistently dominated the importance rankings, reflecting their established role as primary indicators in diabetes risk assessment. Age and blood pressure were moderately influential, whereas skinfold thickness and insulin contributed minimally to predictive performance.

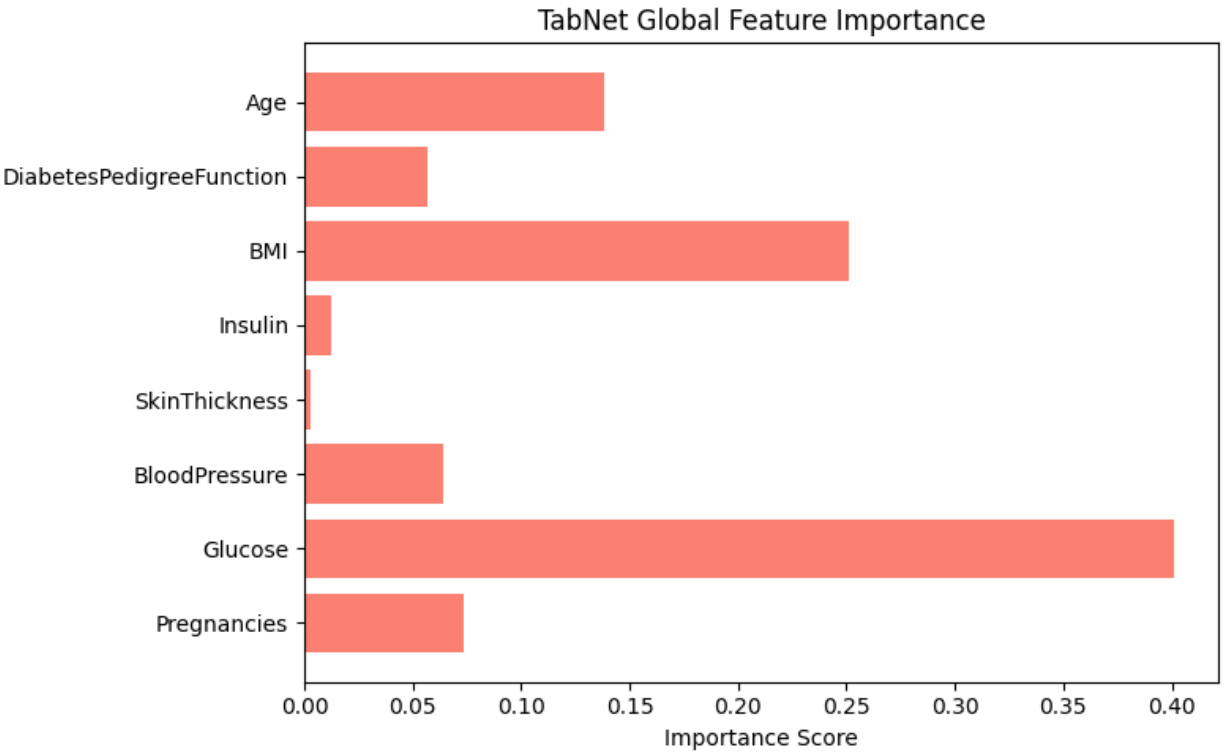


Figure 2.

This alignment between model outputs and clinical understanding not only enhances trust in the results but also underscores TabNet's capability to prioritize medically relevant attributes without external interpretability tools.

Precision, recall, and F1 score comparisons indicated that TabNet produced fewer false positives than other models, which is beneficial in minimizing unnecessary medical interventions. However, this precision came with a marginal reduction in recall relative to Logistic Regression and the MLP, suggesting that a small proportion of positive cases were missed.

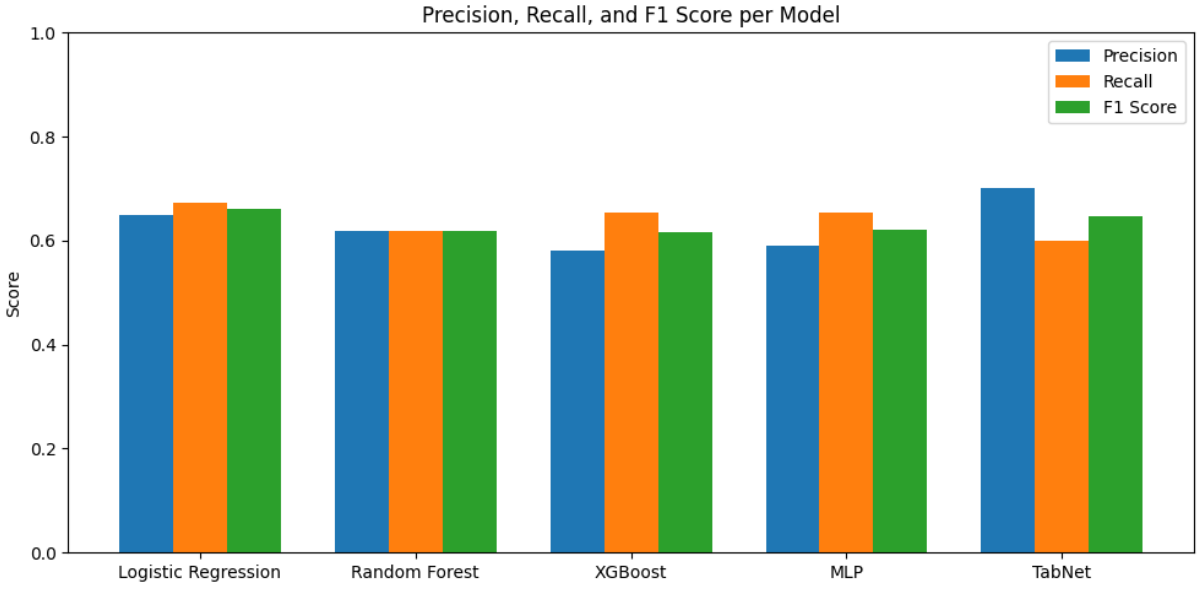


Figure 3.

Such a trade-off is context-dependent and can be addressed through threshold adjustments in clinical deployment. The confusion matrix for TabNet further illustrated this trade-off. While the model maintained a strong capacity to correctly identify non-diabetic patients, some diabetic cases were misclassified, reflecting a cautious prediction approach.

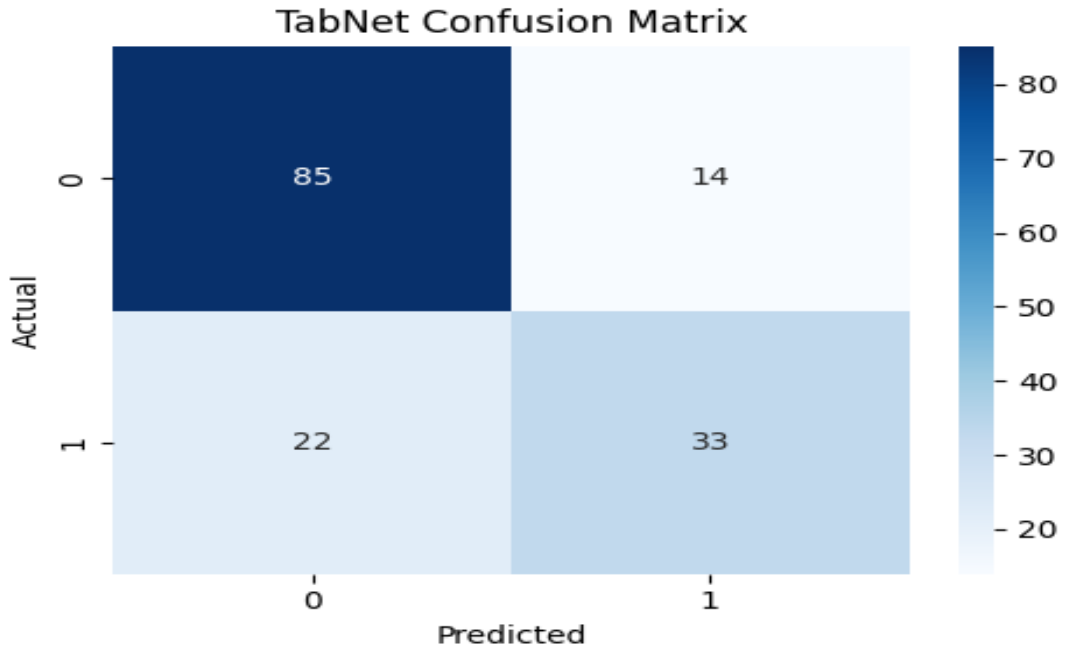


Figure 4.

In a healthcare context, the implications of such errors require careful consideration, particularly when prioritizing sensitivity for early disease detection. Overall, the results highlight the advantage of an interpretable deep learning approach that not only achieves competitive predictive performance but also inherently explains its decisions in a manner consistent with established medical knowledge.

5. Discussion

The findings of this study underscore the value of integrating interpretability into high-performing predictive models for clinical applications. TabNet's strong performance, coupled with its ability to generate feature attributions natively, offers a clear advantage over traditional deep learning approaches that rely on external post-hoc explainability tools. This built-in transparency ensures that clinicians can understand and trust the factors influencing each prediction, a critical requirement for medical decision support.

From a clinical perspective, the prominence of glucose and BMI in the model's ranking aligns with established diagnostic guidelines, enhancing the model's face validity. The observed trade-off between precision and recall for TabNet is noteworthy: while the model minimizes false positives, it may under-detect some diabetic cases. This trade-off is particularly relevant in screening contexts, where higher recall might be prioritized to ensure early intervention.

These results also emphasize the limitations of working with relatively small datasets, as they can constrain the diversity of learned patterns and potentially overestimate generalization performance. The use of cross-validation partially mitigates this risk, but future studies should validate findings on larger and more heterogeneous populations. Additionally, the stability of TabNet's ROC AUC across folds suggests robustness to sample variability, which is encouraging for potential real-world deployment.

6. Conclusion and Future Work

This study provides evidence that interpretable deep learning models such as TabNet can serve as reliable and transparent tools for diabetes prediction. By delivering both strong predictive performance

and clinically coherent explanations, TabNet bridges the gap between accuracy and interpretability, addressing a long-standing challenge in the application of AI to healthcare.

Future research will focus on validating these findings in multi-institutional datasets, integrating temporal health records to capture disease progression, and exploring hybrid ensemble strategies that combine TabNet with complementary models. Special attention will be given to optimizing for higher recall in early detection scenarios, ensuring that potential cases are not overlooked in clinical practice.

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PRESCRIPTION DRUG MISUSE (PDP): A COESSENTIAL AND DESCRIPTIVE TYPE OF STUDY IN PUBLIC AND PHARMACIES TO EVALUATE ROOT CAUSE OF DRUG MISUSE

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ABSTRACT

Background and purpose:

Prescription drug misuse (PDM) represents an emerging global issue. The present Data indicate that young adults are misusing prescription drugs tremendously. People are at risk of developing health problems because of PDM. The study aimed to identify factors associated with PDM among health workers (Pharmacists/Pharmacy Staff) and the Public in Lahore, Pakistan.

Method and instrument:

The present study was a cross-sectional, closed-ended, questionnaire-based survey conducted between July 01 to October 31, 2021. A total of 500 people participated in the study (including 250 participants from the public and 250 Doctors / Medical staff from Pharmacies / Medical Stores). The issue of PDM among two significant groups was measured from different areas including Hospitals, Community Pharmacies, and Private Clinics of Lahore, Pakistan. Descriptive and Chi-square analysis using SPSS was utilized to analyze and evaluate data to determine the root cause of PDM.

Objective:

The objective of the study was to make a closed-ended questionnaire to address changing policies regarding Prescription drug Misuse (PDM), Choosing the best methodology to prevent PDM, ensure effective and responsive planning of drug use for prevention, treatment, and care services, identify common errors, and key points that the PDM may have made.

Results:

The Data from Chi-square have suggested that there was a strong correlation between PDM, Education Level, Socioeconomic Status (SES), Family income, Age of the patient, Area Distribution, Availability of Pharmacist at Pharmacy, and Physician Prescription Writing as the value of P<5% or 0.05, the level of significance. So, the need of the hour is to change the attitude and knowledge of all in the community and at the National Level.

Conclusion:

The survey was done periodically at a specified time to continuously produce data that reflect current changes in PDM at the local level. The primary aims of this study were to design a strategy to prevent PDM, eliminate the risk of PDM, develop and validate a scale measuring attitude towards PDM for non-medical reasons, evaluation of the impact of health with education on PDM, and explain the possible ways by which PDM can be prevented.

Keywords: Prescription drug misuse (PDM), Prescription Drug Prevention (PDP), Prescription Misuse (PM), Prescription Drug Monitoring Program (PDMP).

THE EFFECT OF POWER SOURCES USED BY SCHOOL ADMINISTRATORS ON THE ORGANIZATIONAL COMMITMENT OF TEACHERS

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ABSTRACT

School administrators' behavior in directing teachers toward organizational goals can vary depending on the management and leadership approach they adopt. A principal with a democratic leadership approach may use expert knowledge as a source of power, while a principal with a repressive approach may use the power of reward or punishment. The principal's influence on employees, which is the basis of managerial power sources, can affect teachers' organizational commitment behavior. This study examines the impact of the influence tactics used by school administrators to direct teachers toward school goals on teachers' organizational commitment behavior. The Administrators' Teacher Influence Tactics Scale, developed by Celep and Kaya (2021), was used to collect research data. This scale consists of 46 items and the dimensions of Rule, Expertise, Mutual Benefit, Reward, and Relationship. The other scale, the Teachers' Organizational Commitment Scale, developed by Celep (1996), was used. The scale consists of 3 dimensions: school, teaching profession, and politics, and 38 questions. Research results indicate that when a school principal uses positional power, rewards, and punishments to direct teachers toward school goals, teachers' political commitment increases while their commitment to the school and the teaching profession decreases. Conversely, when a school principal uses their expertise and relationship power, teachers' commitment to their school and profession increases while their political commitment decreases.

Keywords: organizational commitment, commitment to school, professional commitment, commitment to politic, sources of administrative power, Influence tactics,

INVESTIGATION OF FITNESS CENTER DENSITY, INFRASTRUCTURE, AND INSTRUCTOR DEMOGRAPHICS IN TIRANA, ALBANIA

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ABSTRACT

Background: The rising popularity of fitness centers reflects a global trend toward prioritizing physical activity for health and wellness. Urban centers like Tirana are increasingly hosting a growing number of such facilities, yet little empirical data exists on their prevalence, infrastructure, and demographic characteristics.

Aim of the Study: This study aims to investigate the spatial characteristics, instructor demographics, and distribution patterns of fitness centers in Tirana, Albania, to provide a foundational understanding for policy and health planning.

Methods: A structured questionnaire was distributed across 30 fitness centers in Tirana, collecting data on gym dimensions, number and gender of instructors, and instructor age. Descriptive statistics were computed using Microsoft Excel to identify patterns in gym size, height, and human resources.

Results: The average gym space per center was 610.67 m² (SD = 258.24), with mean heights of 3.37 m (SD = 0.56). Male instructors dominated staffing across all gyms, particularly in single-instructor centers (83.3%). Instructor age averaged 38.3 years in gyms with one instructor, decreasing as the number of instructors increased.

Conclusion: While Tirana hosts a variety of fitness centers, there is a significant disparity in facility size and instructor resources. To meet growing demand, policies should promote equitable expansion of gyms, with a focus on inclusivity and infrastructure.

Keywords: fitness centers, fitness instructors, gym, questionnaires.

Introduction

Over the past two decades, physical inactivity has emerged as a leading risk factor contributing to global morbidity and mortality (World Health Organization [WHO], 2020). Fitness centers have evolved into critical infrastructures that support individuals in achieving recommended physical activity levels, as advised by the American College of Sports Medicine (ACSM) and WHO. In the context of urban environments, these facilities not only offer structured physical exercise but also promote a culture of wellness and preventive health (Trost et al., 2002; Bauman et al., 2012).

Tirana, Albania's capital and largest city, is undergoing rapid urbanization, which is accompanied by lifestyle changes including increased sedentarism and dietary shifts (INSTAT, 2022). The proliferation of fitness centers offers a potential counterbalance to these trends. However, despite their growing presence, empirical data on their density, infrastructure, and staffing remains sparse. Assessing the distribution and characteristics of these centers is critical for urban health planning and the development of evidence-based policies.

Prior studies have highlighted the role of gym accessibility in shaping physical activity behavior (Sallis et al., 2011; Giles-Corti et al., 2005). Additionally, the gender distribution and qualifications of fitness instructors can influence user engagement and satisfaction (Papadopoulos et al., 2020). Service quality and environment, including space and equipment availability, also correlate with member retention and

effectiveness of training programs (Chen et al., 2008; Brady & Cronin, 2001). This study responds to the current research gap by analyzing the fitness center landscape in Tirana through direct survey methods. It examines spatial dimensions, gender and age of instructors, and center size to inform municipal strategies and fitness industry development.

Methodology

This study employed a cross-sectional, quantitative research design utilizing structured questionnaires. The primary goal was to collect standardized data from fitness centers across Tirana to assess the density and demographic patterns of fitness facilities. The design enables a snapshot of current conditions and is appropriate for descriptive analyses (Creswell & Creswell, 2018).

Participants and Sampling

Thirty fitness centers across Tirana were selected using purposive sampling, ensuring a balance in terms of geographic distribution and facility size. Centers were included if they had at least one certified instructor and were operational at the time of data collection. This non-probability method was chosen due to feasibility and relevance for exploratory urban studies (Marshall, 1996).

Instrument Design

A structured questionnaire was designed in collaboration with the Albanian Sports Sciences Association (ASSA). The instrument included both closed- and open-ended items focusing on gym characteristics (floor area, ceiling height), staff attributes (age, gender, number of instructors), and operational details. The questionnaire was pre-tested in five centers to ensure clarity and reliability.

Data Collection Procedure

Data collection was carried out over a three-week period in Spring 2024. Trained research assistants conducted in-person visits to each center, administered the survey directly to managers or head instructors, and recorded responses. Ethical approval for the study was granted by the Institutional Review Board at the Sports University of Tirana. Participants provided informed consent and were assured of anonymity and data confidentiality.

Statistical Analysis

All data were entered and analyzed using Microsoft Excel 365. Descriptive statistics were used to calculate means, standard deviations, minimums, and maximums for key variables. Frequencies and percentages were computed to understand the gender distribution of instructors. Although inferential testing was not applied, future studies may incorporate multi-variable analyses or regression models to explore associations between facility size, staffing, and user outcomes (Field, 2018).

Results

Descriptive statistical analysis was conducted on data gathered from 30 fitness centers across Tirana. The primary variables assessed included gym height, gym space, the number of instructors, instructor age, and gender distribution. The data provides insights into infrastructure and human resource patterns in urban fitness environments.

Gym Size and Height

The average gym space across all centers was 610.67 m² (SD = 258.24), with individual gym sizes ranging from 80 m² to 1200 m². The average ceiling height was 3.37 meters (SD = 0.56), with a minimum of 2.2 meters and a maximum of 5 meters. Notably, larger gyms tended to employ more instructors, indicating a possible correlation between facility size and staffing capacity.

Table 1 shows the descriptive statistics of the minimum, maximum, mean value and SD of gym height and gym space in Tirana.

	N	Minimum	Maximum	Mean	Std. Deviation
Gym_Height_m	30	2.2	5.0	3.370	.5566
Gym_Space_m2	30	80.0	1200.0	610.667	258.2425
Valid N (listwise)	30				

Instructor Distribution by Gym Size

Gyms with one instructor (n = 5) averaged 436 m² (SD = 367.73) in space and 3.34 meters (SD = 0.41) in height. Gyms with two instructors (n = 10) showed an increase in space to 626 m² (SD = 244.45) but slightly reduced average height (3.2 meters, SD = 0.35). Centers with three instructors (n = 5) had an average space of 546 m² (SD = 150.27) and an average height of 3.0 meters (SD = 0.65). Facilities with four instructors (n = 10) were the most spacious, averaging 715 m² (SD = 231.00) and 3.74 meters in height (SD = 0.59).

Table 2 presents the descriptive statistics of the mean, standard deviation, minimum and maximum of gym height and gym space according to fitness centers with one, two, three and four fitness instructors.

No_Instructors		N	Minimum	Maximum	Mean	Std. Deviation
Gyms- 1 Fitness Instructor	Gym_Space_m2	5	80.0	1000.0	436.000	367.7363
	Gym_Height_m	5	3.0	4.0	3.340	.4099
	Valid N (listwise)	5				
Gyms- 2 Fitness Instructors	Gym_Space_m2	10	210.0	1000.0	626.000	244.4586
	Gym_Height_m	10	3.0	4.0	3.200	.3496
	Valid N (listwise)	10				
Gyms- 3 Fitness Instructors	Gym_Space_m2	5	400.0	800.0	546.000	150.2664
	Gym_Height_m	5	2.2	4.0	3.000	.6481

	Valid N (listwise)	5				
Gyms- 4 Fitness Instructors	Gym_Space_m2	10	450.0	1200.0	715.000	231.0002
	Gym_Height_m	10	3.0	5.0	3.740	.5948
	Valid N (listwise)	10				

Instructor Age Demographics

Instructor age varied across centers. In facilities with one instructor, the average age was 38.3 years (SD = 10.88). This declined to 32.4 years (SD = 7.45) in gyms with two instructors, 27.9 years (SD = 5.28) in gyms with three, and rose again to 34.2 years (SD = 9.34) in centers with four instructors. This pattern suggests that smaller centers may rely on more experienced staff, while mid-sized centers possibly attract younger professionals.

Table 3 indicates the descriptive statistics of the mean, SD, maximum and minimum of age instructors in fitness centers with one, two, three, and four fitness instructors.

	N	Minimum	Maximum	Mean	Std. Deviation
Age_Instructors_Gyms 1	30	22.0	58.0	38.300	10.8855
Age_Instructors_Gyms 2	25	20.0	53.0	32.440	7.4503
Age_Instructors_Gyms 3	15	21.0	39.0	27.867	5.2762
Age_Instructors_Gyms 4	9	23.0	50.0	34.222	9.3378

Gender Distribution

Gender distribution among instructors revealed a predominance of male staff across all gym types. In centers with one instructor, 83.3% were male and 13.3% female. Among two-instructor gyms, males accounted for 50% and females 33.3%, with the remainder unreported. For gyms with three instructors, the male-to-female ratio was balanced at 23.3% each, though a large proportion of data was missing. In four-instructor gyms, male and female instructors each represented 13.3%, again with considerable missing responses. These figures reflect ongoing gender imbalances in the fitness industry, consistent with findings from previous studies (Kirk & Gorely, 2000).

Table nr 4 reveals the frequency and percentages of men and women instructors in fitness centers with one, two, three, four fitness centers.

		Gender Instructors							
		Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
		Gyms 1 Instructors		Gyms 2 Instructors		Gyms 3 Instructors		Gyms 4 Instructors	
Valid	Men	25	83.3	15	50.0	7	23.3	4	13.3
	Woman	4	13.3	10	33.3	7	23.3	4	13.3
	Total	29	96.7	25	83.3	14	46.7	8	26.7
Missing	System	1	3.3	5	16.7	16	53.3	22	73.3

Discussion

The findings of this study provide a foundational assessment of fitness center infrastructure and personnel distribution in Tirana. The average gym size of over 600 m² indicates substantial spatial investment by private owners, aligning with trends observed in other urban capitals where demand for structured fitness environments is growing (IHRSA, 2022). Gym height, a proxy for comfort and air circulation, also averaged above the functional minimum recommended for safe physical training (Buchheit & Laursen, 2013).

The relationship between the number of instructors and gym size reflects the operational scaling capacity of facilities. Larger spaces tend to employ more staff, which may be a result of higher client loads or diversified services (e.g., group classes, personal training). These results parallel observations in studies conducted in Western Europe, where fitness centers increasingly adopt multi-specialist models (Thompson, 2023).

One of the most striking findings is the male dominance among fitness instructors. This gender imbalance may reflect cultural factors, recruitment biases, or social expectations surrounding physicality and authority in gym settings (Papadimitriou, 2010). While some gender parity was noted in gyms with more instructors, the overall data suggests a need for policies that promote female participation in fitness careers, consistent with global calls for gender equity in sports professions (UNESCO, 2018).

Age data further supports a nuanced view of staffing. Smaller gyms appear to employ older, potentially more experienced instructors, while larger facilities rely on younger personnel. This may reflect cost-saving strategies or the preferences of younger job seekers. However, client satisfaction and safety are often associated with instructor expertise, suggesting a need for balanced age distribution and continuous professional development (De Lyon et al., 2017).

Conclusion

This study contributes to the limited body of literature on fitness infrastructure in Southeastern Europe by providing empirical evidence on gym characteristics and staffing in Tirana. While the city's fitness sector appears vibrant, inequities in space allocation and gender representation persist. Policymakers and industry leaders should consider incentivizing gym development in underserved neighborhoods, encouraging inclusive hiring practices, and standardizing instructor training. Future research should explore user satisfaction, accessibility barriers, and comparative urban analyses.

Practical Implications

The results are relevant for municipal planners, public health officials, and gym managers. Understanding the spatial and human dynamics of fitness centers allows for more targeted interventions to promote health equity and increase participation. With growing awareness of physical inactivity's costs, Tirana's fitness sector has an opportunity to become a proactive partner in national health strategies.

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LITERATURE REVIEW ON COMBINED STRENGTH AND ENDURANCE TRAINING'S IMPACT ON VO2MAX ENHANCEMENT

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ABSTRACT

Background: Maximal oxygen uptake (VO2max) is a primary indicator of aerobic endurance and cardiovascular efficiency. Traditionally, endurance-based training programs have been considered the gold standard for improving VO2max. However, increasing evidence has shown that resistance training, particularly when structured in a circuit format, can also lead to significant cardiovascular and metabolic improvements. The potential for circuit resistance training (CRT) to improve VO2max is particularly relevant for populations with low baseline aerobic fitness, including the elderly and sedentary individuals.

Aim of Study: The aim of this review is to synthesize current literature on the effects of combining strength and endurance training on VO2max, with a particular focus on circuit resistance training methods. The review targets studies conducted on both young and older adults to assess the generalizability of CRT's efficacy across different populations.

Methods: A systematic literature review was conducted using databases such as Google Scholar, Medline, Inspire, and PubMed. Keywords included 'VO2max', 'resistance training', 'circuit training', 'aerobic capacity', and 'cardiovascular fitness'. From an initial pool of 600 articles, 10 were selected based on inclusion criteria related to population, intervention type, and outcome relevance. An additional 15 peer-reviewed articles were included to enhance the theoretical foundation and contextual interpretation of findings.

Results: Analysis indicates that CRT is effective in improving VO2max, especially in populations over the age of 60, and those with low initial aerobic capacity. Younger individuals show varying degrees of VO2max improvement, which appear to be dependent on initial fitness levels and program duration. CRT interventions demonstrated improvements in resting heart rate, blood pressure, and muscular endurance in addition to VO2max. The evidence supports that concurrent training approaches may lead to superior adaptations compared to endurance training alone.

Conclusion: This literature review concludes that combining strength and endurance training, particularly through circuit training formats, is a viable and efficient method to improve VO2max across various age groups. CRT provides dual benefits by enhancing both muscular and cardiovascular systems, offering a time-efficient and effective strategy for fitness enhancement and preventive health.

Keywords: VO2max, Resistance training, circuit weight training, cardio-vascular, aerobic fitness, strength training,

Introduction

Maximal oxygen consumption (VO2max) is widely recognized as a key marker of aerobic capacity, reflecting the body's ability to uptake, transport, and utilize oxygen during incremental exercise (Bassett & Howley, 2000). Traditionally, it has been believed that only endurance training significantly enhances VO2max (Wilmore & Costill, 2004). However, an emerging body of research has challenged this paradigm by demonstrating the potential benefits of resistance training—especially circuit-based formats—on cardiovascular function and VO2max (Ozaki et al., 2013; Lovell et al., 2009). The

physiological improvements conferred by resistance training may extend beyond muscular strength and hypertrophy, reaching into areas of cardiac output, stroke volume, and arterial compliance (Steele et al., 2012). Circuit resistance training (CRT) in particular has gained attention due to its time-efficiency and combined focus on both muscular and aerobic systems (Petersen et al., 1988). These effects are particularly important in aging populations, where the natural decline in both muscle mass and cardiovascular fitness contributes to increased morbidity and mortality (Arenas et al., 2013; Fragala et al., 2019). This review investigates the impact of combining endurance and strength training—especially CRT—on improving VO2max across a spectrum of age and fitness levels. By synthesizing experimental evidence, the study seeks to determine whether CRT represents a viable alternative or adjunct to traditional aerobic conditioning in health promotion and athletic performance.

Methodology

This literature review adopted a structured search strategy to identify and analyze relevant studies examining the impact of combined strength and endurance training—particularly in circuit training formats—on VO2max. Electronic databases used for the search included Google Scholar, PubMed, Medline, Inspire, and ScienceDirect. Search terms were selected to encompass a wide array of relevant concepts, including 'VO2max', 'resistance training', 'circuit training', 'cardiorespiratory fitness', 'combined training', 'aerobic capacity', and 'endurance training'.

Initial screening yielded approximately 600 studies. Inclusion criteria were: (1) peer-reviewed articles published between 1988 and 2024, (2) studies involving human participants aged 18 years or older, (3) interventions that included either resistance training, endurance training, or a combination thereof, and (4) studies that reported VO2max or other cardiorespiratory variables as outcomes. Exclusion criteria included: animal studies, review articles without experimental data, and studies not available in English.

After applying inclusion and exclusion criteria, 25 studies were selected for full-text review. Of these, 10 core studies met all criteria and were synthesized in the results section. An additional 15 relevant sources were included to strengthen the theoretical framework and contextual interpretation. The quality of selected studies was appraised based on sample size, intervention duration, control group presence, and the use of valid VO2max measurement protocols such as treadmill or cycle ergometer graded exercise tests (GXT) with respiratory gas analysis (Howley et al., 1995; Midgley et al., 2007).

The methodological rigor of the included studies varied, but priority was given to randomized controlled trials (RCTs) and longitudinal cohort designs, particularly those comparing CRT interventions to traditional aerobic training or sedentary controls.

Results

The studies included in this review demonstrate consistent evidence supporting the efficacy of combined resistance and endurance training—especially in a circuit training format—in improving VO2max. CRT has been particularly effective among older adults, where baseline VO2max levels are typically low (Ozaki et al., 2013; Lovell et al., 2009). For example, Lovell et al. (2009) reported a significant reduction in resting systolic blood pressure and increased submaximal exercise capacity following 16 weeks of CRT in men aged 70–80 years. These outcomes indicate improvements in cardiovascular efficiency resulting from resistance-based interventions.

Younger adults showed more variable results. Among individuals aged 20–40 with moderate fitness levels, improvements in VO2max depended on initial values and training parameters. Ozaki et al. (2013) found that only 3 of 17 studies involving younger populations reported statistically significant VO2max gains. The key factor appeared to be the initial aerobic capacity; participants with lower baseline

VO2max experienced the greatest improvements. This trend supports the hypothesis that CRT yields the greatest benefits for individuals with low to moderate fitness levels.

Several studies confirmed that CRT stimulates both muscular and aerobic adaptations. Petersen et al. (1988) showed a 9.5% increase in VO2max among participants who underwent high-velocity CRT over 5 weeks. These gains were associated with increased oxygen extraction efficiency and stroke volume, highlighting the cardiovascular impact of resistance-based training. Similarly, Gotshalk et al. (2004) demonstrated sustained VO2 usage during CRT, with heart rate elevated to >80% of maximum in final exercise intervals, indicating cardiovascular stress sufficient to elicit aerobic adaptations.

Baye et al. (1998) emphasized that CRT can surpass traditional jogging in improving cardiovascular health, particularly when implemented with progressive overload and minimal rest intervals. Burdette and Garrison further supported this claim by highlighting the metabolic demands and caloric expenditure associated with CRT routines, which lead to fat loss and improved VO2max outcomes. Shaw et al. (2005) reported statistically significant VO2max gains in young adults after 8 weeks of structured CRT, further affirming its application across varied age groups.

Collectively, the results indicate that CRT, particularly with minimal rest and progressive overload, can effectively improve VO2max. These improvements are more pronounced in older adults and those with initially low cardiorespiratory fitness, but also evident among younger populations under appropriate conditions.

Discussion

The findings of this review support the growing consensus that circuit resistance training (CRT) can be a viable alternative or complement to traditional endurance training for improving VO2max. This is a particularly important conclusion given the rising need for time-efficient training methods that yield multifaceted health benefits. CRT not only enhances muscular strength but also elicits sufficient cardiovascular stress to stimulate aerobic adaptations (Petersen et al., 1988; Gotshalk et al., 2004).

One notable observation is the age-dependent variability in CRT effectiveness. Older adults consistently demonstrate significant gains in VO2max, likely due to their lower baseline fitness and greater capacity for measurable improvements (Ozaki et al., 2013; Arenas et al., 2013). These adaptations are critical in mitigating age-related declines in functional capacity, sarcopenia, and cardiovascular risk factors (Fragala et al., 2019). In contrast, younger adults with moderate to high baseline fitness may experience diminished returns unless the CRT protocol is sufficiently intense and frequent (Shaw et al., 2005).

Physiologically, CRT may improve VO2max through multiple mechanisms: increased mitochondrial density, enhanced stroke volume, improved arterial compliance, and optimized oxygen extraction (Steele et al., 2012; Midgley et al., 2007). These mechanisms, coupled with the muscle-building benefits of resistance training, suggest that CRT can simultaneously address muscular and cardiovascular deficiencies, making it an ideal strategy for both health maintenance and athletic conditioning.

The implications of these findings extend into clinical and public health contexts. CRT could serve as a cornerstone intervention in preventing cardiovascular disease, improving quality of life in aging populations, and supporting weight loss efforts. Furthermore, it provides an accessible and scalable solution in resource-limited environments where equipment and time are constrained.

Conclusion

In summary, this review highlights that combined strength and endurance training, particularly in a circuit resistance format, is an effective means of improving VO2max. The evidence is strongest for

older adults and individuals with low baseline fitness, though younger individuals may also benefit under appropriate protocols. CRT offers a time-efficient, dual-benefit training model that can support health, performance, and disease prevention. Future research should focus on optimizing CRT protocols across age groups, determining the minimum effective dose, and comparing CRT with other concurrent training strategies in clinical and athletic populations. As CRT continues to gain recognition, it may shift the paradigm of cardiovascular conditioning beyond traditional aerobic exercise.

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SELECTION BIOMATERIALS FOR APPLICATION AS BONE GRAFTS

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ABSTRACT

The materials for bone grafts must be biocompatible, bioactive, and safe for clinical application. The biocompatibility is a function of its application. Based on the origin, the biomaterials can be classified as autogenous, allogeneic, xenogeneic, or synthetic. Based on the host tissue interaction, biomaterials can be classified as bioinert, bioabsorbable, or bioactive. The best biomaterial for bone graft is autogenous bone. However, autogenous bone has limitations in terms of availability and donor site morbidity. Synthetic bone substitutes, such as hydroxyapatite, tricalcium phosphate, biphasic ceramics, bioactive glasses, and polymers, have been widely used as alternatives to autogenous bone. The selection of a biomaterial must balance its structural and biological properties, its suitability for the specific bone defect, and the patient's physiology. This work analyzes and compares the properties and biocompatibility of several biomaterials used as bone grafts. The biocompatibility will be highlighted based on applications and success rates.

Keywords: bone grafts, bone substitutes, biomaterials, biocompatibility

INTRODUCTION

Bone regeneration remains one of the foremost challenges in contemporary medicine and dentistry, particularly in reconstructive contexts involving fractures, traumatic bone defects, tooth loss, pathological conditions, and implant rehabilitation. Owing to the limited spontaneous regenerative capacity of bone tissue in certain clinical scenarios, the use of bone grafts and their substitutes has become essential for restoring the structure and function of compromised bone.

Autologous bone grafts, harvested from the patient’s own body, are widely regarded as the gold standard, as they simultaneously provide osteogenic, osteoconductive, and osteoinductive properties. Nevertheless, their use is restricted by the limited volume available, the need for additional surgical procedures, postoperative pain, and donor site morbidity—limitations that become more pronounced in the treatment of large defects.

To overcome these drawbacks, alternative grafting materials have been developed and integrated into clinical practice, including allografts (from human donors), xenografts (of animal origin), and synthetic substitutes such as bioactive ceramics, polymers, and composites. Each of these options presents distinct advantages and limitations in terms of biological response, safety, cost, mechanical performance, and clinical predictability.

The selection of an optimal biomaterial for grafting requires a thorough evaluation of fundamental properties, including biocompatibility, osteoconductivity, osteoinductive potential, structural integrity, porosity, bioresorbability, and volumetric stability. Additionally, factors such as ease of surgical handling, commercial availability, and risk profile are critical considerations influencing material choice.

Despite significant advances in tissue engineering—such as the incorporation of growth factors, bioactive scaffolds, and mesenchymal stem cells—no commercially available biomaterial currently fulfills all the ideal criteria to ensure efficient, safe, and cost-effective bone regeneration.

Within this framework, the present article aims to provide a critical review of the various types of bone grafts and their substitutes, based on recent scientific evidence, with emphasis on selection criteria, limitations, desirable properties, and emerging trends in biomaterial development for bone regeneration. This analysis seeks to support more evidence-based clinical decision-making and to guide future research directions in the field.

2. LITERATURE REVIEW

2.1 Biomaterial Concepts

Biomaterials are defined as substances specifically engineered to interact with living systems in order to fulfill a designated tissue or organ function, with the potential to replace the roles of extracellular components (1).

A central role of biomaterials is to serve as a scaffold, maintaining cells in place and preserving the cellular and tissue organization established over time. This can be achieved through the presentation of specific physical architectures or binding domains. Among these, the presence of cell adhesion motifs within scaffolds is a critical parameter that has been extensively explored. Given their recognized benefits, natural substances rich in adhesion motifs—such as collagen, gelatin, and fibronectin—are frequently employed as biomaterials. Alternatively, synthetic materials, with their well-defined and controllable composition, have been utilized and subsequently coated with adhesion proteins such as laminin to promote cellular interaction.

Another important parameter is the scaffold architecture itself (1). Although not as widely studied as cell adhesion motifs, scaffold architecture has gained increasing recognition because (i) it offers an additional dimension of control that complements the traditional use of chemical and biological molecules to influence cell fate, and (ii) it is reasonable to expect that scaffolds should provide a spatial framework that mimics host tissue architecture, thereby enabling successful tissue regeneration and integration.

Biomaterials can also be engineered in the form of microparticles or nanoparticles to deliver a therapeutic payload while simultaneously presenting a functionalized surface capable of interacting with specific cells and tissues. These carriers—sometimes referred to as “Trojan Horse” systems—are particularly advantageous for targeted delivery, enhancing transport efficiency and site-specific therapeutic action (1).

Broadly, any synthetic or natural material designed to replace or restore a specific physiological function qualifies as a biomaterial. They can be classified according to their origin (autologous, allogenic, xenogenic, or alloplastic), composition (metals and alloys, ceramics and bioglasses, polymers, or composites), or interaction with the biological environment (bioinert, bioresorbable, or bioactive) (2).

2.2 Desirable Properties in a Biomaterial

The mechanical properties of bone graft materials can significantly influence their ability to maintain space (7). The mechanical characteristics of autogenous bone particles vary widely and are determined by the harvesting site and the patient's age (7). Lyophilization has been shown to reduce the mechanical strength of bone tissue by approximately 20% (7). Bovine-derived mineralized xenografts exhibit an elastic modulus comparable to that of mandibular cortical bone, whereas nonporous bulk alloplastic materials such as hydroxyapatite (HAp) and tricalcium phosphate (TCP) possess considerably higher elastic moduli than other bone substitutes (7). Notably, compressive strength is influenced more by the granule size than by the intrinsic mechanical properties of the material itself (7).

2.2.1 Biocompatibility

The single and indispensable property a material must possess is **biocompatibility**. Within this concept, several other properties are encompassed, depending on the type of biomaterial employed and its intended application. Biocompatibility is not an isolated event; rather, it involves multiple mechanisms of interaction between the material and host tissues. It refers to the ability of a material to perform its intended function, which depends not only on its mechanical properties but also on its interactions with biological tissues. The definition centers on the host's **appropriate response** to a specific application.

Biocompatibility has been defined as *"the ability of a material to perform with an appropriate host response in a specific application"* (7). Traditionally, in the context of bone grafts, materials are classified as **biotolerant**, **bioinert**, or **bioactive** (7).

- **Biotolerant implant materials** remain in the body encapsulated by fibrous tissue, eliciting a tissue reaction.
- **Bioinert implant materials** are in direct contact with adjacent bone tissue without eliciting any chemical reaction.
- **Bioactive implants** establish chemical bonds with surrounding bone tissue, promoting the direct deposition of bone matrix onto the implant surface.

This conceptual classification is based on histological observations of local effects after implantation into bone tissue (7). In terms of their relationship, bioinert materials are completely independent, whereas biotolerant and bioactive materials partially overlap. **Calcium phosphate–based bone substitutes** currently available on the market fall within this overlapping region. **Polymethylmethacrylate (PMMA)** is a typical example of a biotolerant material (7).

Cytocompatibility is a critical factor within the broader concept of biocompatibility and should be evaluated through in vitro cell culture experiments. For instance, PMMA—although classified as biotolerant—exhibits excellent mechanical properties, with high space-maintaining capacity and guaranteed volume stability, yet is well known for its pronounced cytotoxicity (7).

2.2.2 Injectable Biomaterials

Injectable biomaterials are most commonly formulated as hydrogels that transition from a liquid phase to a semisolid phase, or as suspensions of microparticles. While the initial fluidity that enables injectability is advantageous for minimally invasive delivery, it often limits the ability of these biomaterials to retain predefined architectural features, such as pore orientation.

Recent advances have led to the development of injectable cryogels with shape-memory properties, demonstrating the feasibility of injectable biomaterials that can still present a predetermined architecture. Such systems have already been employed for the delivery of cells and molecules in the context of cancer vaccines (1).

Ideally, minimally invasive implantation of biomaterials should not only offer injectability but also allow for real-time monitoring through an imaging modality. This capability can provide essential

information on various aspects of the injection process, including injection rate, injected volume, and the precise location of the biomaterial. Furthermore, tracking the fate of injected biomaterials enables the assessment of their integration into surrounding host tissues, while simultaneously monitoring the repair status of target tissues over time (1).

2.2.3 Immunomodulation

When polarized toward the M1 phenotype, macrophages produce reactive oxygen intermediates and amplify pro-inflammatory responses, which often result in impaired tissue healing or scar tissue formation. In contrast, when polarized toward the M2 phenotype, macrophages secrete anti-inflammatory cytokines, inhibit fibrotic tissue formation, and promote pathways conducive to tissue repair. The recruitment or implantation of M2 macrophages has been shown to be beneficial (1).

2.2.4 Bioabsorption / Controlled Resorbability

Ideally, the material should undergo gradual degradation and be replaced by newly formed bone, in accordance with the natural timeline of bone remodeling (6).

The term “bioabsorption” has been widely used in the field of polymers and biomaterials, although it remains poorly defined. Several synonyms—including “bioresorption,” “biodegradation,” and “bioerosion”—have also been employed in the literature (7).

Favorable bioabsorption of bone substitutes should involve the replacement of the implanted material by newly formed bone tissue through the physiological remodeling process—thus reflecting “regeneration” rather than mere “reconstruction” (7). Bioabsorption during the bone formation phase is closely associated with space-maintaining capacity and biocompatibility, and it is predominantly mediated by the passive chemical dissolution of the bone substitute (7).

2.2.5 Grain Size

A bone graft must meet specific requirements to achieve its intended purpose. First, it must present interconnected porosity with adequate pore size, allowing diffusion of osteogenic cells, nutrients, and waste exchange throughout the biomaterial. The minimum pore size is approximately 100 μm; however, pores larger than 300 μm are recommended to enable vascularization and new bone formation (6).

Multinucleated giant cells resembling osteoclasts tend to preferentially resorb smaller particles (<1 mm), both in autogenous bone and in bone substitutes such as bovine-derived bone mineral. However, larger particles of bone substitutes may yield greater overall bone augmentation (7). Larger particles also tend to persist longer within newly formed bone, due to the extended time required for dissolution or remodeling. These findings suggest that, compared with smaller particles (<1 mm), larger particles (>1 mm) provide greater mechanical resistance as space-maintaining nodules, and that this space-maintaining ability is more critical for early bone formation than the balance between resorption and bone deposition (Figure 1).

With regard to pore size, diameters of at least 100 μm are required to ensure adequate nutrient diffusion for cell survival (7). Pore sizes of 200–350 μm provide optimal conditions for new bone ingrowth (7). Alloplastic calcium phosphate bone substitutes can be manufactured in various forms, ranging from bulk dense structures to highly porous scaffolds. Greater porosity is associated with faster and more extensive bone ingrowth and replacement (7).

Moreover, pore space directly influences the flow of blood and interstitial fluid within local bone tissue (7). Since blood and interstitial fluid transport oxygen and nutrients to the local tissue, they are essential for bone regeneration. Increased pore size, porosity, and interconnectivity of the scaffold facilitate blood perfusion, interstitial fluid exchange, cellular infiltration, and neovascularization within the material (7). However, excessive pore size and porosity can also compromise the mechanical strength of the scaffold.

Thus, an optimal balance between porosity, space-maintaining capacity, and volume stability must be achieved (7).

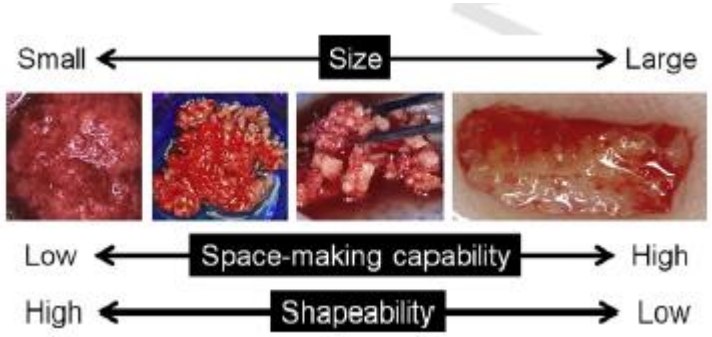


Figure 1: Yamada et al. (2017) (7)
Relationship between material size, space-maintaining capacity, and moldability. The images depict autogenous bone particles or blocks. Larger autogenous bone particles are associated with greater space-maintaining capacity but reduced moldability. This relationship applies to all bone substitutes.

A bioactive matrix, or scaffold (whether physical or chemical), facilitates the colonization and ingrowth of new bone cells and angiogenesis through capillary extension, as a result of its three-dimensional architecture, which provides the appropriate framework for bone formation. This matrix supports and promotes fibrovascular growth, the migration of host progenitor cells into the scaffold, the adhesion of osteoblasts, and the subsequent formation of new bone (5,6,11).

2.2.7 Osteogenesis

Osteogenic grafts contain living bone-forming cells. They must be capable of producing new bone through the activity of osteoblasts or progenitor cells present within the graft material (5,8).

In osteogenic pathways, bone formation is enhanced by progenitor cells derived from the graft that survive harvesting and transplantation. These cells are able to differentiate into osteoblasts, which provide the primary driving force for the osteogenic potential of a graft. Importantly, osteogenesis also requires angiogenesis and the ingrowth of mesenchymal stem cells (MSCs) to support bone tissue development (4).

2.2.8 Osteoinduction

Osteoinduction refers to the presence of a growth factor–rich environment capable of inducing the differentiation of host progenitor cells into bone-forming cells. This property reflects the ability of a biomaterial to promote the differentiation of mesenchymal stem cells into osteoblasts, thereby enhancing both bone integration and regeneration (5,6). The ability of a graft to actively promote bone formation by facilitating the colonization and differentiation of osteoblasts. (9,10)

2.2.9 Structural Integrity

The structural strength of the graft material must encompass compressive strength, as well as torsional and shear resistance. In addition, osteointegration capacity is essential, defined as the ability of the graft to integrate and form a direct bond with the host bone (5,6).

2.2.10 Adequate Mechanical Properties

The graft material must exhibit sufficient compressive strength and appropriate elasticity to ensure stability and support functional load-bearing when required. These mechanical properties should allow for gradual resorption and substitution by new bone, while maintaining the structural integrity necessary during the healing process (6).

3- Classification of grafts

3.1 Natural vs. Synthetic Biomaterials

Natural-origin biomaterials tend to be non-toxic, but they often trigger immune responses. In contrast, synthetic biomaterials are generally non-immunogenic; however, depending on the choice of raw material and purification process, they may contain toxic residues (1).

Another critical factor is the degradation properties of these biomaterials. For drug and protein delivery, it is desirable that degradation occurs at a rate equal to or slower than the release of the therapeutic payload, with complete degradation over time. Similarly, for cell transplantation applications, biomaterials must persist long enough to provide structural support until transplanted or host-recruited cells are able to produce and organize their own extracellular matrix with sufficient robustness (1).

It is also essential that degradation by-products are safely metabolized or excreted. Early advances in biomaterials engineering for drug and protein delivery specifically addressed this issue, leading to the development of synthetic polymers such as poly(lactic-co-glycolic acid) (PLGA) (1). While synthetic biomaterials offer promising alternatives to natural materials, they face the challenge of controlling variability in biological outcomes, which may depend on their composition and can affect resorption dynamics, as well as inflammatory or repair responses (2).

Bone Graft vs. Bone Substitute

The distinction between bone grafts and bone substitutes lies primarily in their origin, composition, and biological function.

- Bone Grafts: biological materials, usually of natural origin, employed to fill or reconstruct bone defects.

1. Autografts: harvested from the patient.
2. Allografts: obtained from a human donor.
3. Xenografts: derived from another species (commonly bovine or porcine).

Key characteristics:

- May contain viable cells (particularly in autografts).
- Can present osteogenesis, osteoconduction, and osteoinduction.
- Applied in both structural defects and regenerative surgeries.

- Bone Substitutes: synthetic or processed materials (natural or artificial) designed to mimic bone tissue in reconstructive procedures. Examples include:

0. Calcium phosphates (e.g., hydroxyapatite, β-tricalcium phosphate).
1. Biodegradable polymers.
2. Bioactive glasses.

Key characteristics:

- Do not contain viable cells.
- Typically osteoconductive, acting as a scaffold.
- Emphasis on biocompatibility, moldability, and controlled resorption.

3.2 Bone Grafts

Bone is the second most commonly transplanted tissue after blood (6). Bone grafts are used to restore both function and aesthetics of tissue lost due to disease, trauma, or congenital defects.

A bone graft is defined as a living tissue capable of promoting bone healing, transplanted into a bone defect either alone or in combination with other materials. In contrast, a bone substitute refers to a natural or synthetic material, often consisting only of a mineralized bone matrix without viable cells, yet capable of achieving the same purpose.

Bone grafts and substitutes have been employed in the medical field for centuries; however, their use in dentistry has significantly increased in recent years, primarily due to advances in implantology (8).

Bone regeneration in the human body has been extensively studied over the last century, with a wide variety of purposes, approaches, and surgical materials. Biomaterials may be classified according to their origin (autologous, allogenic, xenogenic, or alloplastic), their composition (metals and alloys, ceramics and bioglasses, polymers, or composites), or their interaction with the biological environment (bioinert, bioresorbable, or bioactive) (2).

The main function of bone grafts is to provide mechanical support while stimulating osteoregeneration, ultimately aiming for complete bone replacement (8).

3.2.1 Autologous Bone Grafts

Autologous bone grafts are considered the gold standard for the regeneration of bone defects, as they are harvested from the patient's own body, minimizing the risk of immunological rejection. It is the only one with osteogenic properties, as it reuses the osteogenic cells from the bone graft itself. Furthermore, they possess the three fundamental properties required for bone formation: osteoconduction, osteoinduction, and osteogenesis. However, their use is often limited due to the morbidity associated with graft harvesting, such as the need for an additional surgical site, increased risk of infection, and restricted availability of donor bone (3,4,5,6,7,8,9,12,13).

Different types of autologous bone grafts have been defined depending on several factors (2, 9,14,):

1. The architecture of the graft (cortical, cancellous, or cortico-cancellous).

2. Its embryonic origin (intramembranous or endocondral).

3. The source of donor site (intra-oral or extraoral).

4. The morphology of the graft (particulate or block).

5. The type of block (onlay, inlay, or veneer).

In defects of two or more bony walls, particulate bone grafts harvested from intra-oral sites are usually employed in combination with barrier membranes following the principles of guided bone regeneration. In large-flat or one-wall defects, mono-cortical block autografts are usually indicated because they can preserve and maintain the space more appropriately (9,15).

According to Baldwin et al. (2019) (4), autografts can be subdivided into cancellous, cortical, or corticocancellous grafts, and it has been demonstrated that vascularized grafts are stronger than non-vascularized grafts. Non-vascularized grafts tend to undergo local necrosis and resorption at the graft-host interface, with concomitant revascularization during the first six weeks. In contrast, vascularized grafts undergo direct bone healing, providing greater initial mechanical strength. Despite this initial discrepancy, studies in canine graft models have shown that after six weeks both types of grafts present similar mechanical resistance and become histologically indistinguishable within one year (4).

Cancellous bone grafts may contain relatively few osteoblasts, but they preserve progenitor cells with osteogenic potential, thereby retaining the ability to form new bone (5).

Cortical bone grafts, on the other hand, are valuable for maintaining structural support while also providing osteoconduction and some degree of osteoinduction. Cortical grafts ensure robust structural support during the first six weeks after transplantation, but they are prone to fractures, delayed osteointegration, resorption, and remodeling. Both cortical and cancellous grafts should be stabilized with fixation during the healing process (5).

Bone marrow, considered a subset of autologous grafts, is particularly useful due to its osteogenic and osteoinductive potential. Bone marrow aspirate (BMA) can be readily harvested from the anterior iliac

crest via a percutaneous approach. BMA is highly cellular, providing access to stem cells with osteogenic potential, as well as growth factors that promote an osteoinductive environment.

3.2.2 Allogeneic Grafts

By definition, an allograft is bone tissue harvested from one individual (living or deceased) and transplanted into another genetically different individual of the same species (6,7,8). This type of graft demonstrates good osteoconductive properties and may also be osteoinductive. However, since they are devitalized (and often sterilized) primarily through processes such as decalcification, deproteinization, irradiation, and/or lyophilization, they lack viable cells and present reduced osteoinductive properties. The absence of osteogenic potential is a clear limitation (3,6).

Fresh-frozen allografts, despite preserving more of the natural bone architecture, present disadvantages such as the risk of bacterial or viral contamination, immune reactions, long-term failure, and potential disease transmission (3,6,8).

Furthermore, processed allografts exhibit significantly reduced mechanical strength due to preparation methods such as high-dose irradiation and lyophilization, which completely removes water from the bone and compromises its mechanical resistance (3,4).

Despite these limitations, allografts represent a favorable alternative due to their convenience, availability, and reduced donor-site morbidity compared to autografts (4).

Allografts can be prepared as cortical, cancellous, or corticocancellous grafts, and are available in various forms, including powder, chips, wedges, pins, dowels, or structural blocks. However, complications associated with their use include graft fracture, poor integration with surrounding host bone, infection, increased risk of bacterial contamination, and non-union (5).

Given the disadvantages of both autografts and allografts, alternative grafting options have been increasingly explored over the past decade in an attempt to overcome their limitations (3,4,6,8,9).

3.2.3 Xenogeneic Grafts

Xenogeneic grafts involve the transplantation of bone tissue between different species (6,8). They generally exhibit good osteoconductivity but often have low resorbability. The use of xenotransplants presents several biological challenges, including the risk of disease transmission (e.g., prions and retroviruses), immune responses from host tissues after implantation, absence of viable cells, and reduced osteoinductive properties due to manufacturing processes (6).

The most common sources of xenograft materials in dentistry are deproteinized bovine bone or porcine bone, derived from peritoneum or pericardium (8). Bovine bone is processed to produce a porous hydroxyapatite (HA) material, containing only the inorganic components of the original bone. The resulting porous structure closely resembles human bone and can provide mechanical support while promoting bone consolidation through osteoconduction. The porous architecture also offers a large surface area and facilitates angiogenesis, enhancing new bone growth (8).

Bovine-derived grafts are recognized as the xenogeneic graft most similar to human bone, second only to autologous grafts. However, like allografts, sterilization and cleaning procedures can lead to deterioration of both mechanical and biological performance (6).

A promising xenogeneic material currently under investigation is chitosan, a natural polymer derived from crustacean exoskeletons composed of glucosamine and N-acetylglucosamine. Chitosan can stimulate bone regeneration by providing a structure that supports osteoblastic activity, mineralized bone matrix formation, and induces the differentiation of mesenchymal stem cells (MSCs) into osteoblasts in various in vitro environments (8). Recent studies have also shown that the favorable biological

properties of silk allow its use as a membrane for guided bone regeneration (GBR), despite its limited mechanical strength (8).

Both allogeneic and xenogeneic grafts avoid concerns related to limited tissue availability and exhibit high osteoinductive and osteoblast-stimulating properties; however, potential immune reactions and the risk of disease transmission remain important considerations (6).

As Yamada and Egusa (2018) (6) concluded in a recent review: *"Autologous bone remains the gold standard and accelerates initial bone formation to a greater extent than bone substitutes. However, autologous bone is only effective under favorable recipient conditions and therefore requires supplementation with bone substitutes for augmentation in more challenging recipient scenarios. The biocompatibility of current bone substitute materials should be further improved."*

3.2.4 Synthetic Grafts

Advances in surgical treatment and medical research have produced a wide range of potential substances for bone graft substitution.

Bone graft substitutes include synthetic calcium phosphate and calcium sulfate materials. These grafts provide advantages in terms of structural support and compressive strength and are designed with a porous structure capable of supporting the formation of new, healthy three-dimensional tissue (4,6). Their goal is also to provide clinical efficacy while reducing potential risks compared to the gold standard (6). Considerations in selecting bone grafts and substitutes include their characteristic capabilities, availability, patient morbidity, immunogenicity, potential disease transmission, and cost variability (5). Any discussion of bone grafts and substitutes must begin with the objectives of bone replacement (5). The interaction between the biomaterial and the host bone is essential for graft success (6).

The following properties are considered critical for bone grafts: osteogenesis, osteoinduction, osteoconduction, structural integrity, and bioabsorption (5,8).

Basic properties of bone substitutes necessary for bone formation in tissue engineering: scaffolds are defined as three-dimensional porous solid biomaterials designed to perform some or all of the following functions during tissue formation:

1. Promote cell–biomaterial interactions, cell adhesion, and extracellular matrix formation.
2. Allow sufficient transport of gases, nutrients, and regulatory factors to support cell survival, proliferation, and differentiation.
3. Biodegrade at a controlled rate, matching the tissue regeneration rate.
4. Induce minimal inflammation or toxicity in vivo (7).

Commonly available synthetic bone grafts include calcium phosphate (CaP) and calcium sulfate (CaS) compounds. CaP ceramics and cements are osteoconductive and exhibit resorption rates dependent on their structure. Ceramics are brittle and have low tensile strength, but provide structural support through compressive resistance.

The primary advantage of synthetic grafts lies in their osteoconductive composition, conferred by calcium phosphate ceramics (CaP), particularly tricalcium phosphate (TCP). This material exhibits a structure and porosity similar to human bone, promoting bone formation by serving as a scaffold for osteogenic cells under the action of osteoinductive growth factors (4).

CaP cement, when hardened in vivo, allows for compressive filling of bone defects. Biomechanical studies have demonstrated that TCP use in fractures, such as in the tibial plateau, provides greater

stability, higher load resistance, and reduced subsidence compared to autologous grafts. Prospective clinical trials confirm its safety and efficacy (4).

I. Hydroxyapatite (HA)

The rationale for using hydroxyapatite (HA) is not only related to its matrix being similar to that extracted from animal bone and teeth, but also to its **ion exchange during degradation**, which releases calcium and phosphorus ions (16,17) . The release of these ions modifies the local alkaline phosphatase activity, attracting osteoprogenitor cells that promote bone formation. However, simply applying calcium and phosphorus at the site will not induce new matrix synthesis, as the release would be too rapid.

Precipitated hydroxyapatite obtained by the wet chemical method exhibits characteristics similar to those of bone and dental tissue, in contrast to hydroxyapatite synthesized at high temperatures (17). Pure HA crystallizes in a monoclinic form with space group P21/b; however, above 250 °C, an allotropic transition from the monoclinic to the hexagonal form occurs, with space group P63/m. Certain impurities, or partial substitutions of hydroxyl groups by chloride or fluoride ions, stabilize the hexagonal form at room temperature. For this reason, natural HA single crystals generally exhibit a hexagonal conformation (17). Its density is 3.16 kg/m³, with lattice parameters a = b = 0.9423 nm and c = 0.6875 nm (17).

Figure 2 (17) illustrates the arrangement of a unit cell of HAp.

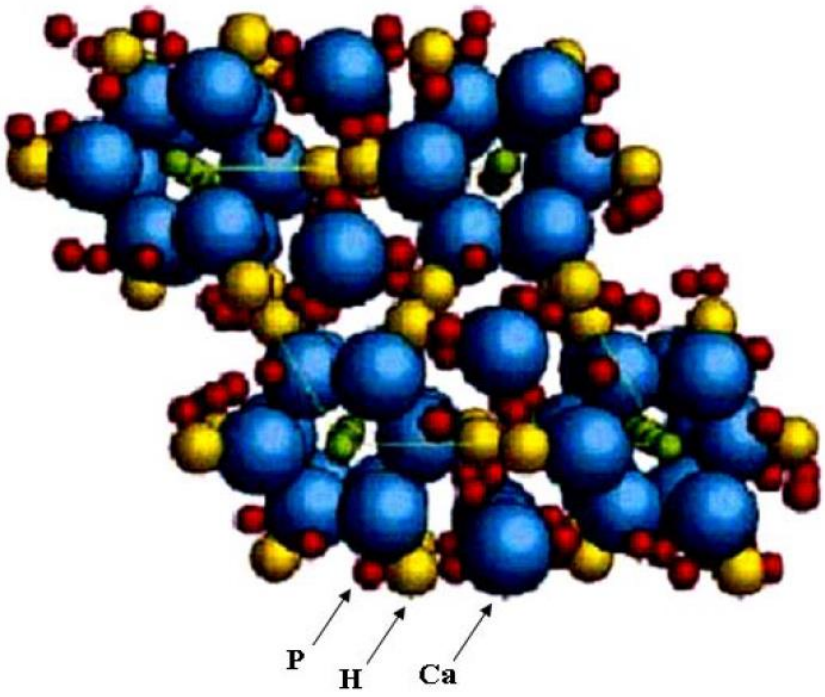


Figure 2 – Crystal lattice of hydroxyapatite

As a graft material, hydroxyapatite can be obtained through deproteinization of bone tissue or by hydrothermal treatment of corals. It can also be produced by synthetic processes such as aqueous solution precipitation or solid-state reactions. The synthesis method adopted for obtaining hydroxyapatite may lead to the presence of additional calcium phosphate phases, which can compromise osteoconduction. When present, these phases can be detected by X-ray diffraction.

In dentistry, hydroxyapatite is employed to prevent bone loss following the extraction of one or several teeth, as well as to regenerate areas affected by bone resorption. HA with very fine granules promotes a rapid release of ions, resulting in the formation of non-mineralized tissue without mechanical strength. Conversely, HA with larger particle sizes undergoes slower degradation, allowing sufficient time for osteogenesis. Therefore, hydroxyapatite induces bone formation through the release of calcium and phosphorus, which interact with the extracellular matrix.

HA with very fine granules results in a rapid ion release, which fails to form mineralized bone tissue and lacks mechanical strength. In contrast, HA with larger particle sizes degrades more slowly, allowing sufficient time for osteogenesis. Therefore, hydroxyapatite induces bone formation through the controlled release of calcium and phosphorus, interacting with the extracellular matrix.

Hydroxyapatite (HA) is the main component of the bone mineral phase. Its chemical composition closely resembles the inorganic component of bone, enabling its use as a bone graft material. HA has a hexagonal crystalline structure that is unstable, allowing ion exchange. Consequently, its composition may fluctuate among mineral salt precursors, such as calcium phosphate and tricalcium phosphate (TCP), in vivo. The ion organization within the crystal lattice influences properties such as thermal stability, solubility, and bioactivity, making HA a widely used material in bone regeneration and dentistry (5,8).

Mineral compounds resemble bone precursors, and their inherent porosity makes them excellent osteoconductive and osteointegrative agents. Highly porous HA acts as a scaffold, promoting fibrovascular growth, migration of bone-forming cells, and deposition of osteoid on its well-developed surface. Mineralization and remodeling occur, eventually resulting in mature bone replacement. These agents are available in paste, putty, solid matrix, or granule form (5). Ceramic HA is a valid alternative to autologous grafts, avoiding donor site morbidity. HA is extremely porous and interconnected, facilitating fibrovascular invasion and eventual bone replacement. These substances act as bioactive osteoconductive scaffolds and integrate well with host bone.

TCP is more porous, resorbs faster than HA, and is mechanically weaker in compression than HA (5).

II. Beta-Tricalcium Phosphate (β-TCP)

Beta-tricalcium phosphate (β-TCP) is one of the crystallographic forms of TCP, widely used as a bone substitute due to its favorable biological properties. Compared to HA, β-TCP exhibits a faster biodegradation and absorption rate, attributed to its lower calcium-to-phosphorus ratio.

Its main advantages include:

- Ease of handling
- Radiopacity, which allows monitoring of the healing process
- Good osteoconductivity due to macroporosity, promoting osteogenic cell adhesion and fibrovascular growth
- Low immunogenicity and reduced risk of disease transmission

Compared to bovine bone grafts, β-TCP also offers higher resorption capacity. However, despite its interconnected porous structure favoring vascularization, it contributes to low compressive mechanical strength (8).

III. Biphasic Calcium Phosphate Ceramics (HA/β-TCP Ceramics)

Biphasic calcium phosphate ceramics were developed to combine the advantages of the two main phases: high resorption of β-TCP and the excellent osteoconductivity of HA (8). The combination of these components results in a material that promotes faster and more effective bone regeneration compared to HA alone, while offering mechanical properties superior to pure β-TCP.

A major advantage of these ceramics is the ability to modulate biological properties**,** such as resorption and osteoconductivity, by adjusting the HA-to-β-TCP ratio (8). However, despite relative improvements in mechanical strength, biphasic ceramics still exhibit compressive resistance lower than cortical bone **(8).**

The calcium and phosphorus ions released by HA and β-TCP mediate protein adsorption at the site**,** recruiting osteoprogenitor cells and initiating bone synthesis.

IV. Bioactive Glass (BAG)

Bioactive glasses (BAGs) are synthetic silicate-based ceramics composed of a silicate matrix combined with other minerals such as calcium, sodium, phosphorus, and hydrogen (5,8). When implanted, these materials interact with bodily fluids, promoting the release of silicon ions that facilitate the formation of an apatite layer on the material surface, which enhances the adhesion of osteogenic progenitor cells. Desirable properties of BAG include excellent biocompatibility, osteoconductivity, antimicrobial activity, and a porous structure that stimulates tissue vascularization.

Recent studies have shown that the addition of specific ions can further enhance BAG performance. Esfahanizadeh et al. demonstrated that zinc doping reduces biofilm formation by microorganisms associated with periodontal disease. Similarly, Lovelace et al. reported that silver-doped BAG provides controlled ion release with increased antibacterial activity against microorganisms such as *Porphyromonas gingivalis*, *Prevotella intermedia*, and *Aggregatibacter actinomycetemcomitans*, major pathogens in peri-implantitis and gingival disease (8).

In addition, BAG offers practical advantages such as ease of handling and good adaptation to the surgical site, making it widely used in periodontal surgery for bone regeneration. Clinical studies have reported significant improvements in probing depth and clinical attachment levels in patients treated with UniGraft® BAG in infrabony defects. However, its limitations include low mechanical strength and brittle fracture resistance, restricting its use to areas of low functional load or in combination with other graft materials (5,8).

V. Calcium Phosphate Cements (CPCs)

Calcium phosphate cements (CPCs) are widely studied biomaterials for bone regeneration, characterized by biphasic or triphasic systems composed of an aqueous component and a powder component. The powder typically contains sintered calcium phosphate, such as alpha-tricalcium phosphate (α-TCP) and hydroxyapatite (HA). Combining these components produces a moldable paste that sets in situ at room temperature via a self-hardening process, forming hydroxyapatite nanocrystals (8).

CPCs offer several advantages, including excellent biocompatibility, the ability to conform precisely to the bone defect, and predictable replication of native bone composition and structure. They are osteoconductive and available in various formulations for different clinical applications. In situ fixation makes CPCs particularly attractive for minimally invasive procedures or defects with complex geometries.

However, CPCs have important limitations. The absence of a macroporous structure reduces cell adhesion rates, hinders proper fluid exchange, and may compromise long-term bone remodeling. Another critical issue is the risk of incomplete setting, which can trigger an undesirable local inflammatory response, representing a significant drawback for clinical use (8).

VI. Polymers

Synthetic polymers used in bone regeneration are generally divided into degradable and non-degradable categories. Among the most commonly used are polylactic acid (PLA), polyglycolic acid (PGA), polycaprolactone (PCL), and their copolymers, belonging to the class of aliphatic polyesters (8). These

materials offer several advantages, including versatile processing for custom-shaped structures, low immunogenicity, adjustable porosity, controlled resorption, and favorable physicochemical properties.

Despite these qualities, polymers have important limitations in dental clinical applications. Key disadvantages include the release of acidic byproducts during degradation, which may acidify the local microenvironment, affecting cell viability and bone regeneration. Additionally, these materials exhibit limited osteoconductivity and poor cell adhesion, compromising their effectiveness in promoting proper bone integration (8).

VII. Growth Factor-Based Bone Substitutes (GFBSs)

Growth factor-based bone substitutes (GFBSs) represent a promising bioactive approach to bone regeneration, promoting osteoinduction by activating cellular pathways involved in bone formation. Factors such as bone morphogenetic proteins (BMPs), platelet-derived growth factors (PDGFs), and insulin-like growth factors (IGFs) have shown the ability to accelerate regeneration in bone defects (8).

In dental practice, early advances involved autologous concentrates derived from blood, such as plasma rich in growth factors (PRGF), platelet-rich plasma (PRP), and platelet-rich fibrin (PRF), aiming to stimulate bone healing and consolidation (8). However, recent evidence shows controversial results regarding the effectiveness of these concentrates when combined with other graft materials, especially in procedures such as intrabony defect treatment and sinus floor elevation (8).

Since the early 2000s, BMPs — particularly BMP-2 and BMP-7 — have been the only growth factors approved by the FDA for dental applications. These factors have been incorporated into commercial products, such as Osigraft® and Infuse®, to enhance bone graft outcomes. However, Osigraft® production has been discontinued, and Infuse® use has been widely questioned due to associations with serious adverse events, including fatal outcomes, necessitating caution in clinical indication (8).

The main limitation in developing synthetic bone substitutes is the difficulty in producing a porous interconnected structure that is simultaneously mechanically resistant and capable of promoting effective osseointegration and vascularization. Currently, these materials predominantly exhibit osteoconductive properties, limiting bone regeneration primarily to the external surface of the graft (8).

3.3 Bone Morphogenetic Protein (BMP)

Recombinant human bone morphogenetic protein-2 (rhBMP-2), from the TGF-β superfamily, is currently the only BMP approved by the FDA for orthopedic trauma, specifically for the treatment of tibial diaphyseal fractures stabilized with intramedullary rods within 14 days post-injury. Studies have demonstrated that rhBMP-2 use can significantly increase consolidation rates in traumatic lower extremity fractures. Benefits have also been observed in diaphyseal reconstructions with allografts, including reduced pain and bleeding.

However, rhBMP-2 use is associated with adverse events, such as heterotopic bone formation in up to 59% of cases, and outcomes that, in some cases, do not surpass isolated intramedullary fixation. Its use must therefore be careful and limited, particularly outside approved indications. It is contraindicated in children, pregnant women, women intending to conceive within one year, and patients with a history of cancer (4).

In **Figure 3,** taken from the article **by Håvard Jostein Haugen et al., 2018 (2),** a summary of the main advantages and disadvantages of each type of graft is presented.

Bone graft (BG)	Advantages	Disadvantages
Autologous	• high osteoconductivity • highest degree of biological safety • no risk of immune reaction	Need of an additional surgery
Xenografts	• architecture and geometric structure resemble bone • Well documented • predictable clinical outcome • slow bio-absorbability preserves augmented bone volume	• possible disease transmission and potential unwanted immune reactions • lacks viable cells and biological components • resorption rate is highly variable • reduced future availability due European regulatory changes ?
Natural biomaterials	Similarity to native extracellular matrix	Mechanical properties poor -biodegradability less controllable
Synthetic polymers	• tuneable physicochemical properties • tuneable degradability	• low cell attachment • timing of absorption (alteration of mechanical properties) • release of acidic degradation products
Synthetic bioceramics	• high biocompatibility • osteoinductive properties • chemical similarity with bone • stimulation of osteoblast growth	• high brittleness • low ductility • not predictable absorption
Composite xenohybrid substitutes	• high similarity with human cancellous bone • higher bioactivity • tailored degradation rates • incorporation of active biomolecules	• cleaning and sterilization process partially alters biological performances • limited clinical data

4. Discussion

The selection of the most appropriate type of bone graft or substitute remains a significant challenge in both clinical practice and tissue engineering, and it is widely debated in contemporary scientific literature. Autografts continue to be considered the gold standard, primarily because they simultaneously possess osteogenic, osteoinductive, and osteoconductive properties within a single material. This biological superiority is well highlighted by Bhatt and Rozental (2012), who report that autologous grafts provide the three essential properties for bone regeneration, in addition to excellent biocompatibility and integration capacity with the host bone. However, these grafts present important clinical limitations, including the need for a second surgical procedure, donor site morbidity, and volume restriction, as also discussed by Haugen et al. (2019).

In contrast, allografts represent a relevant alternative, mainly due to their wide availability and the elimination of donor site surgery. Nevertheless, they exhibit reduced osteoinductive potential because of preparation processes such as lyophilization and irradiation, which decrease cellular viability and compromise the protein matrix integrity, as noted by Baldwin et al. (2019). The authors emphasize that the storage and preparation process directly affects osteoinduction and the mechanical strength of the graft. Babiker et al. (2013) reinforce this point, demonstrating that although allografts have mechanical performance comparable to the gold standard, the isolated use of demineralized bone matrix (DBM) exhibits significantly lower strength, highlighting the importance of composition and association with other materials.

Regarding xenografts, their use has been increasing, particularly in dentistry, due to their availability and stable osteoconductive performance. Haugen et al. (2019) report that bovine xenografts dominate the European market due to their favorable cost-benefit ratio, despite immunological concerns and the lack of significant osteoinductive properties. Zhao et al. (2021) also indicate that, despite the growth of the bone substitute market, substantial deficiencies remain, as no current material simultaneously provides low morbidity, low cost, surgical manageability, and optimal biological performance.

In the context of synthetic substitutes, materials such as hydroxyapatite (HA) and β-tricalcium phosphate (β-TCP) are widely employed due to their biocompatibility and osteoconductive structure. However, their lack of osteoinductive activity and high variability in resorption limit their effectiveness in more complex regeneration procedures. Yamada and Egusa (2017) highlight that these materials are effective as scaffolds but do not promote active biological induction. Furthermore, they observe an inverse relationship between bioresorption and volume maintenance, making the precise control of solubility and crystallinity of the material essential.

In Brazilian dental clinical practice, Araújo et al. (2020) report a preferential trend toward the use of ceramic grafts, particularly in procedures such as maxillary sinus elevation and alveolar ridge preservation. The study shows that autologous and xenogeneic grafts remain the most commonly used, with a high degree of practitioner satisfaction, but also highlights practical barriers related to biosafety and the availability of human grafts from tissue banks.

The discussion regarding biomaterial selection criteria is also noteworthy. Haugen et al. (2019) establish that an ideal graft should combine biocompatibility, mechanical stability, controlled resorption, and bioactivity, with bio-hybrid composite materials being identified as promising to achieve this balance. The authors also critique the gap between laboratory innovations and clinical application, given the high production costs and scarcity of clinical trials. Zhao et al. (2021) reinforce this argument by emphasizing the need for bone substitutes that combine biological performance with ease of use and economic feasibility, particularly in developing countries.

Finally, Lim and Spector (2016), although focusing on biomaterial applications in the central nervous system, provide important contributions by pointing out that the success of a biomaterial depends on its

capacity to functionally interact with host tissues, providing structural support and promoting regeneration through specific bioactive signaling. This perspective underscores the necessity of developing biomaterials with active and adaptive functions, which not only occupy the defect space but also efficiently stimulate the local cellular microenvironment**.**

5. Conclusion

Guided bone regeneration using biomaterials remains a field of intense research and clinical application, given the complexity of bone defects and the biological, mechanical, and immunological requirements involved in this process. The analysis of the evaluated studies demonstrates that, although autografts remain the gold standard due to their capacity to simultaneously provide osteogenesis, osteoconduction, and osteoinduction, their clinical limitations—such as donor site morbidity, volumetric restriction, and increased surgical time—drive the search for viable alternatives.

Allografts and xenografts offer logistical advantages and greater availability; however, they carry immunological risks and reduced regenerative potential due to processing methods. Conversely, synthetic bone substitutes have significantly advanced in terms of surface engineering, pore control, and bioactivity, although most still do not match the biological performance of natural options, being largely limited to osteoconductive function.

The literature indicates that no currently available material simultaneously exhibits all the desirable characteristics of an ideal bone graft, highlighting the need for integrated approaches that combine structural scaffolds, stem cells, and bioactive biomolecules. In this context, tissue engineering emerges as a promising tool, providing hybrid solutions capable of promoting more efficient and personalized osteoregeneration.

It is concluded that the choice of graft type should be based on a careful assessment of the biomaterial's biological and physicochemical properties, the patient's specific clinical needs, and the available scientific evidence. The continuous advancement of biomaterial technologies, combined with a deeper understanding of the mechanisms underlying bone regeneration, will be essential for the development of more effective, safe, and accessible bone substitutes, capable of overcoming current limitations and optimizing clinical outcomes in reconstructive surgery and implant dentistry.

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INSURANCE LITERACY FROM THE PERSPECTIVE OF INSURANCE COMPANY MANAGERS: THE CASE OF ANKARA PROVINCE

SİGORTA ŞİRKET YÖNETİCİLERİ PERSPEKTİFİNDEN SİGORTA OKURYAZARLIĞI: ANKARA İLİ ÖRNEĞİ

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ABSTRACT

Financial literacy is commonly defined as the ability to manage money effectively, while insurance literacy refers to the ability to understand and utilize insurance products, interpret policy coverage, recognize their benefits and limitations, and possess basic knowledge of the insurance sector. The level of insurance development in a country reflects its overall economic progress. However, insurance is not a subject formally taught in schools; rather, it is often learned through real-life experiences such as purchasing compulsory policies or exploring insurance options independently. Despite its limited public appeal, insurance plays a critical role in economic stability and risk management. Therefore, enhancing individuals' awareness and literacy regarding insurance is crucial. This study aims to explore the current state of insurance literacy in Turkey from the perspective of insurance company managers. Through in-depth, semi-structured interviews conducted with managers of insurance companies in Ankara, the study seeks to understand the literacy level of both employees and customers. Findings reveal a significant gap in insurance knowledge among both groups. While financial literacy is vital, it is insufficient alone; insurance literacy must also be cultivated. The research emphasizes the necessity of collaborative educational efforts by both private insurance companies and public institutions, starting from early ages. It also acknowledges that economic constraints are a substantial factor limiting insurance adoption, alongside literacy deficits.

Keywords: Financial Literacy, Insurance Literacy, Customer Awareness, Insurance Sector, Agency Perspective

ÖZET

Finansal okuryazarlık genellikle parayı etkili bir şekilde yönetebilme yetisi olarak tanımlanırken, sigorta okuryazarlığı; bireyin sigorta ürünlerini doğru şekilde anlayabilmesi, poliçe kapsamlarını yorumlayabilmesi, avantaj ve dezavantajlarını değerlendirebilmesi ve sigortacılık sektörü hakkında temel bilgiye sahip olması anlamına gelir. Bir ülkedeki sigortacılık sektörünün gelişmişlik düzeyi, genel ekonomik kalkınmanın da bir göstergesidir. Ancak sigorta, okul ortamında öğretilen bir konu değildir; genellikle zorunlu sigortaların yapılması ya da bireysel araştırmalarla öğrenilen bir alandır. Toplumun yalnızca sınırlı bir kesiminin ilgi gösterdiği bu alan, ekonomide önemli işlevlere sahiptir. Bu nedenle bireylerin sigorta bilinci ve okuryazarlık düzeylerinin artırılması büyük önem taşımaktadır. Bu çalışma, Türkiye'de sigorta okuryazarlığının mevcut durumunu Ankara ilinde faaliyet gösteren sigorta şirketi

yöneticilerinin bakış açısıyla incelemeyi amaçlamaktadır. Yarı yapılandırılmış derinlemesine mülakat yöntemiyle elde edilen bulgular hem çalışanların hem de müşterilerin sigorta konusundaki bilgi düzeylerinin yetersiz olduğunu göstermektedir. Finansal okuryazarlık tek başına yeterli değildir; sigorta okuryazarlığı da eş zamanlı olarak geliştirilmelidir. Bu noktada, sadece özel sektörün değil, kamu kurumlarının da özellikle erken yaşlarda başlayacak eğitim faaliyetleriyle sürece dahil olması gerekmektedir. Ayrıca sigorta yaptırma oranlarının düşüklüğünde yalnızca bilgi eksikliği değil, ekonomik yetersizliklerin de önemli bir etken olduğu gözlemlenmiştir.

Anahtar Kelimeler: Finansal Okuryazarlık, Sigorta Okuryazarlığı, Müşteri Bilinci, Sigorta Sektörü, Acente Perspektifi

1. Giriş

"Risk" kelimesi Fransızca kökenli olup, "zarara uğrama tehlikesi" anlamına gelmektedir. Sigorta ise, önceden ödenen bir prim karşılığında bir kişinin veya bir varlığın ileride karşılaşabileceği zararların telafi edilmesini amaçlayan bir sistemdir ve bu kapsamda sigorta şirketleriyle yapılan sözleşmeler temelinde işlerlik kazanır.

Sigorta sektörü, sanayi, ekonomi, tarım ve diğer birçok faaliyet alanındaki risklere karşı koruma sağlayan önemli bir yapıdır. Bu yönüyle yalnızca bireyleri değil, aynı zamanda ülke ekonomisini de güvence altına alır. Sigortacılığın gelişimi, ekonomik kalkınmanın ve toplumsal refahın önemli bir göstergesi olarak kabul edilmektedir. Son yıllarda Türkiye sigorta sektörüne olan yabancı sermaye ilgisi de bu gelişimi desteklemekte, özellikle genç nüfusun fazla oluşu bu alanda potansiyel bir pazar oluşturmaktadır. Ancak mevcut durumda, sektörün hala ilkel bir görünüm sunduğu da dikkat çekmektedir.

Sigorta bilinci, toplumun sosyal gelişmişlik düzeyiyle doğrudan ilişkilidir. Bu nedenle, toplumsal düzeyde sigorta okuryazarlığının artırılması gerekmektedir. Eksikliklerin tespit edilmesi ve bu doğrultuda politika üretilmesi oldukça kritik bir öneme sahiptir. Bireylerin finansal okuryazarlık düzeylerinde meydana gelecek her artış, dolaylı olarak sigorta sektörünün gelişimine de katkı sağlayacaktır. Bu bağlamda, finansal okuryazarlık ile sigorta sektörü arasındaki etkileşim dikkatle ele alınmalıdır.

Sigorta şirketlerinin sunduğu poliçeler ve teminatların, acente çalışanları tarafından müşterilere doğru ve anlaşılır bir şekilde aktarılması gerekmektedir. Çünkü yaşanan birçok finansal kriz veya bireysel mali sorunlar, finansal okuryazarlığın ne kadar hayati olduğunu ortaya koymaktadır. Bu kapsamda kamu ve özel sektör kuruluşlarının sigorta ve finansal okuryazarlığın öneminin farkına vararak gerekli eğitim ve bilgilendirme çalışmalarını desteklemesi gerekmektedir.

Bu çalışmada öncelikle finansal okuryazarlık kavramına değinilecek, ardından sigorta okuryazarlığına ilişkin literatür taramasına yer verilecektir. Daha sonra araştırmanın yöntemine ve saha verilerine ilişkin bulgular aktarılacak; son bölümde ise ulaşılan sonuçlar ve öneriler sunularak çalışma tamamlanacaktır.

2. Kavramsal Arka Plan

Finansal okuryazarlık, bireylerin finansal kararlar alabilme yetkinliğini ifade eder. Bu kavram, bireylerin gelirlerini, harcamalarını, borçlarını ve yatırımlarını etkili biçimde yönetebilmesini, finansal ürün ve hizmetleri anlayarak bilinçli tercihler yapabilmesini içerir (Lusardi & Mitchell, 2011; OECD, 2016). Finansal okuryazarlığın temelinde; bilgiye dayalı karar alma, geleceği planlama ve riskleri değerlendirme yetkinlikleri yer alır (Atkinson & Messy, 2012). Küreselleşme, teknolojik gelişmeler ve finansal ürün çeşitliliğindeki artış, bireylerin finansal bilgi düzeylerini artırmalarını zorunlu hale getirmiştir (Bahadır, Şahin & Ergin, 2014; Huston, 2010).

Günümüzde finansal okuryazarlık yalnızca bireysel refahın artmasına değil, aynı zamanda ülke ekonomisinin sağlıklı işleyişine de katkı sağlamaktadır (Remund, 2010). Bireylerin finansal sistem içerisindeki yerini doğru konumlandırabilmesi ancak bu sistemin işleyişine dair temel bilgilere sahip olmasıyla mümkündür (Öztürk & Demir, 2015). OECD'nin 2018 raporuna göre, finansal okuryazarlığı yüksek toplumlarda borçlanma eğilimi daha dengelidir ve tasarruf oranları daha yüksektir (OECD, 2018).

Finansal bilgi eksikliği yalnızca az gelişmiş ya da gelişmekte olan ülkelerin değil, gelişmiş ülkelerin de karşı karşıya kaldığı temel sorunlardan biridir (Curto, Lusardi & Mitchell, 2011). Bu durum, yalnızca bireysel yatırımcıların değil; şirketlerin, yöneticilerin ve dolayısıyla ülkelerin ekonomik güvenliğini etkileyebilecek bir tehdit oluşturmaktadır (Baştürk, 2016; Lusardi & Tufano, 2015). Özellikle finansal krizler döneminde, şirketlerin ve hatta üst düzey yöneticilerin dahi riskli yatırımlardan kaçınamadıkları görülmüştür (Klapper, Lusardi & Panos, 2013).

Finansal okuryazarlık düzeyleri demografik özelliklere göre de farklılık göstermektedir. Araştırmalar, erkeklerin kadınlara göre; yüksek eğitim düzeyine sahip bireylerin ise düşük eğitimlilere göre daha yüksek finansal okuryazarlığa sahip olduğunu göstermektedir (Lusardi & Mitchell, 2011; Chen & Volpe, 1998). Türkiye'de yapılan çalışmalar da benzer şekilde yaş, cinsiyet, eğitim ve gelir düzeyinin finansal bilgiye erişim ve kullanım davranışlarını etkilediğini ortaya koymuştur (Yağlı, 2015; Kartal, 2017).

Sigorta okuryazarlığı, bireylerin sigorta sektörüne ilişkin temel kavramlara, teminat içeriklerine, poliçe türlerine, avantaj ve dezavantajlara ilişkin bilgi düzeylerini ifade eder (Baştürk, 2016). Sigorta hizmetlerinin soyut ve karmaşık yapısı nedeniyle toplumun büyük bir kesimi bu hizmetleri anlamakta zorlanmaktadır (Ünal & Serdar, 2020; SEGEM, 2011). Bu nedenle sigorta okuryazarlığını artırmaya yönelik eğitim ve bilinçlendirme faaliyetleri özel bir öneme sahiptir (Kılıç, 2020).

Sigorta okuryazarlığı yalnızca tüketicilerin değil, sigorta şirketi çalışanlarının ve acentelerin de doğru hizmet sunabilmesi açısından kritik rol oynamaktadır (Korkmaz & Koç, 2018). Eğitimlerin yalnızca satış odaklı değil, ürün bilgisi, teminat kapsamı, hak ve sorumluluklar gibi konuları da içermesi gerektiği vurgulanmaktadır (SEGEM, 2011). Ayrıca, sigorta okuryazarlığının finansal okuryazarlıkla entegre bir şekilde ele alınması gerektiği birçok çalışmada ifade edilmektedir (Ünal & Serdar, 2020; Yağlı, 2015).

Finansal okuryazar bireyler, temel finansal kavramları anlama, bütçe yapma, borç yönetimi, sigorta ve yatırım ürünlerini değerlendirme ve bilinçli kararlar alabilme becerilerine sahip olmalıdır (Remund, 2010; Atkinson & Messy, 2012). OECD ve Dünya Bankası'nın ortak çalışmaları, finansal eğitimin erken yaşlardan itibaren eğitim müfredatına dahil edilmesinin bireysel ve toplumsal fayda sağladığını göstermektedir (OECD, 2016).

Son yıllarda finansal ve sigorta okuryazarlığı kavramları yalnızca bireylerin bilgi düzeylerini ölçen araçlar olmaktan çıkmış, davranışsal ekonomi ile birleşerek bireylerin karar alma süreçlerine dair daha derin analizler sunar hale gelmiştir (Willis, 2008; Lusardi, 2019). Finansal okuryazarlığın, bireyin sadece bilgiyi bilmesi değil, bu bilgiyi günlük yaşamında etkili şekilde kullanabilmesi olarak değerlendirilmesi gerektiği birçok çalışmada vurgulanmaktadır (OECD, 2020; Fernandes et al., 2014).

Dijitalleşme, bireylerin finansal ürün ve hizmetlere erişimini kolaylaştırırken, finansal hatalara düşme riskini de beraberinde getirmiştir (Marcolin & Abraham, 2006). Bu bağlamda dijital finansal okuryazarlık, bireylerin mobil bankacılık, kripto paralar ve fintech uygulamaları gibi alanlarda bilinçli hareket edebilmesini ifade eden yeni bir alt alan olarak öne çıkmaktadır (Lai & Tan, 2009; Mende et al., 2022).

Sigorta okuryazarlığı özelinde ise, pandeminin ardından sağlık, seyahat ve hayat sigortalarına yönelik farkındalığın arttığı ancak poliçe içerikleri, istisnalar ve yasal haklara dair bilgi eksikliklerinin devam

ettiği belirtilmektedir (Özdemir, 2021; Aydın & Uyar, 2022). Ayrıca sigorta ürünlerinin finansal kapsayıcılığın bir parçası olarak değerlendirilmesi gerektiği ve düşük gelir gruplarının sigorta sistemine entegrasyonunun teşvik edilmesinin önemli olduğu da vurgulanmaktadır (Churchill & Matul, 2012; Roth et al., 2007).

Güncel yaklaşımlar, finansal ve sigorta okuryazarlığının klasik "bilgi ölçme" anlayışından çok daha öteye geçerek, bireyin davranışsal, dijital ve sosyal faktörlerle birlikte değerlendirilmesi gerektiğini ortaya koymaktadır. Bu durum, özellikle kamu politikalarının ve eğitim programlarının yeniden tasarlanmasını gerekli kılmaktadır (Kaiser & Menkhoff, 2017; Gallery et al., 2011).

Finansal ve sigorta okuryazarlığı alanında yapılan akademik çalışmalar, bireylerin ekonomik davranışlarını yönlendirmede bu kavramların kritik rol oynadığını göstermektedir. Lusardi ve Mitchell (2011), bireylerin tasarruf, borç ve yatırım gibi konularda doğru kararlar alabilmeleri için finansal bilgi düzeylerinin yüksek olması gerektiğini savunmuşlardır. Chen ve Volpe (1998), üniversite öğrencilerinin finansal bilgi düzeylerini analiz etmiş ve çoğunun temel kavramlara yeterince hâkim olmadığını ortaya koymuştur. Yağlı (2015), Türkiye'de finansal okuryazarlığın demografik değişkenlere göre farklılık gösterdiğini ve kadınların daha düşük bilgi düzeyine sahip olduğunu belirtmiştir. Ünal ve Serdar (2020) ise sigorta okuryazarlığının bireylerin sigorta kullanım eğilimlerini artırdığını ve güven düzeyini etkilediğini ifade etmişlerdir. Klapper, Lusardi ve Panos (2013) ise gelişmekte olan ülkelerde yapılan bir çalışmada, finansal okuryazarlığın yetersizliğinin bireylerin kriz dönemlerinde ciddi zarar görmesine neden olduğunu göstermiştir.

3. Araştırmanın Amacı ve Problemi

Bu araştırmanın temel amacı, bireylerin hem finansal hem de sigorta okuryazarlığı düzeylerinde mevcut durumun analiz edilmesi ve sigorta sektörü çalışanlarının bu alandaki yeterliliklerinin değerlendirilmesidir. Araştırma, sigorta sektöründe faaliyet gösteren yöneticilerin perspektifinden sigorta okuryazarlığının mevcut durumunu ortaya koymayı ve bu duruma yönelik çözüm önerileri geliştirmeyi hedeflemektedir.

Sigorta okuryazarlığı düzeyi, yalnızca bireylerin finansal karar alma süreçlerini değil, aynı zamanda sigorta hizmetlerinden etkin biçimde yararlanma kapasitelerini de doğrudan etkilemektedir. Ancak mevcut durum değerlendirildiğinde hem bireylerin hem de sektörde görev yapan çalışanların sigorta ürünlerine ilişkin bilgi düzeylerinin yeterli olmadığı görülmektedir. Bu durum, sigorta bilincinin düşük olmasına, poliçelerin içeriğinin tam olarak anlaşılamamasına ve dolayısıyla sektöre olan güvenin azalmasına neden olmaktadır.

Araştırma kapsamında ele alınan temel problem, sigorta sektöründe çalışanların sigorta okuryazarlığına yönelik bilgi düzeylerinin ne ölçüde yeterli olduğudur. Ayrıca bu eksikliklerin giderilmesine yönelik olarak ne tür eğitimlerin verildiği, hangi stratejilerin izlendiği ve gelecekte nasıl bir yol haritası izlenmesi gerektiği de değerlendirilmiştir. Bu bağlamda, finansal okuryazarlık ve sigorta okuryazarlığı kavramlarının birlikte ele alınması, sigorta sektörünün sürdürülebilirliği ve gelişimi açısından önem arz etmektedir.

Çalışma, bu sorun alanlarına ışık tutarak, kamu kurumları, sigorta şirketleri ve eğitim kurumları açısından politika ve uygulama geliştirme sürecine katkı sağlamayı amaçlamaktadır. Aynı zamanda bireylerin sigorta bilinci ve finansal farkındalığını artırmaya yönelik stratejilerin oluşturulmasına akademik bir temel sunmaktadır.

4. Araştırmanın Yöntemi

Bu araştırma, nitel bir yaklaşım benimsenerek gerçekleştirilmiştir. Sigorta okuryazarlığı konusunun derinlemesine incelenmesi ve sigorta sektörü yöneticilerinin konuya dair algılarının anlaşılabilmesi amacıyla yarı yapılandırılmış mülakat tekniği kullanılmıştır. Bu yöntem, özellikle katılımcıların kendi

deneyim ve gözlemlerine dayalı olarak detaylı bilgi sunmalarına olanak tanıması bakımından tercih edilmiştir.

Araştırmanın evrenini, Türkiye'nin başkenti Ankara'da faaliyet gösteren sigorta acenteleri oluşturmaktadır. Örneklem seçiminde amaçlı örnekleme yöntemi tercih edilmiş ve bilgi zenginliği açısından uygun olduğu düşünülen sekiz sigorta acentesi yöneticisiyle birebir görüşmeler gerçekleştirilmiştir. Bu yöneticiler, birden fazla sigorta şirketiyle anlaşmalı çalışan, aynı zamanda farklı müşteri profilleriyle doğrudan temas hâlinde bulunan saha uzmanlarıdır.

Mülakatlarda katılımcılara toplamda on temel soru yöneltilmiş; bazı sorular, alt başlıklara ayrılarak detaylandırılmıştır. Yöneltilen sorular aracılığıyla hem müşterilerin hem de çalışanların sigorta okuryazarlığı düzeyleri, sigorta ürünlerinin anlaşılma düzeyleri, bilgilendirme faaliyetlerinin yeterliliği ve sigorta bilincini artırmaya yönelik mevcut ve gelecekteki uygulamalar hakkında bilgi toplanmıştır.

Toplanan veriler, betimsel analiz yöntemi kullanılarak analiz edilmiştir. Betimsel analiz, elde edilen verilerin önceden belirlenmiş temalar doğrultusunda sistematik biçimde değerlendirilmesini sağlar. Bu yöntemde, katılımcıların verdikleri yanıtlar anlamlı bir bütün oluşturacak biçimde tematik olarak düzenlenmiş ve ilgili bulgular açık, anlaşılır bir şekilde sunulmuştur.

Araştırma süreci boyunca, katılımcıların gönüllülük esasına göre çalışmaya dâhil edilmesine özen gösterilmiş; verilerin gizliliği ve etik kurallar titizlikle gözetilmiştir.

5. Araştırmanın Bulguları

Bu bölümde, Ankara ilinde faaliyet gösteren sekiz sigorta şirketi yöneticisiyle gerçekleştirilen yarı yapılandırılmış mülakatlar sonucunda elde edilen veriler betimsel analiz yöntemiyle değerlendirilmiştir. Görüşmeler aracılığıyla hem sigorta okuryazarlığının mevcut durumu hem de sektörel gelişim için öneriler ortaya konulmuştur. Bulgular, yöneticilere yöneltilen on temel soru çerçevesinde tematik başlıklar hâlinde aşağıda sunulmaktadır.

5.1. En Sık Satılan Poliçeler ve Müşteri Bilgi Düzeyi

Yöneticilere, kurumlarında en çok hangi sigorta poliçelerinin satıldığı ve müşterilerin bu poliçeleri ne derece bildiği sorulmuştur. Cevaplar doğrultusunda en çok talep gören sigorta türlerinin trafik sigortası, kasko, DASK (Doğal Afet Sigortaları Kurumu) ve sağlık sigortası olduğu görülmüştür. Bu ürünlerin yaygın tercih edilmesinin başlıca nedeni, zorunlu olmaları ya da toplumsal farkındalık düzeyinin görece daha yüksek olmasıdır.

Ancak müşterilerin, satın aldıkları poliçelere dair bilgi düzeylerinin oldukça düşük olduğu tespit edilmiştir. Katılımcıların büyük çoğunluğu, sigorta yaptıran bireylerin poliçe kapsamı, teminat şartları ve hakları konusunda yeterli bilgiye sahip olmadıklarını belirtmiştir. Bu durum, sigorta okuryazarlığı düzeyinin müşteri bazında düşük olduğunu göstermektedir.

5.2. Acente Personelinin Bilgilendirme Sorumluluğu

Tüm katılımcılar, acente çalışanlarının poliçe satışı sırasında müşterileri bilgilendirme görevlerini yerine getirdiğini ifade etmiştir. Ancak bilgilendirme sürecinin etkinliği, çalışanların bilgi düzeyi ve iletişim becerilerine bağlı olarak farklılık gösterebilmektedir. Bu bağlamda, bilgilendirme yapılmakla birlikte müşterinin bu bilgiyi ne ölçüde anladığı ve içselleştirdiği belirsizliğini korumaktadır.

5.3. Sigorta ve Finansal Okuryazarlığın Sektöre Etkisi

Yöneticilere, müşteri sigorta okuryazarlığı ve genel finansal bilgi düzeylerinin sigorta şirketleri açısından avantaj mı yoksa dezavantaj mı oluşturduğu sorulmuştur. Katılımcıların çoğunluğu, bu durumun sigorta şirketleri için avantaj sağladığı görüşündedir. Özellikle fiyatlandırma ve ürün çeşitlendirme süreçlerinde müşteri bilincinin artmasının, satış sürecini kolaylaştırdığı ifade edilmiştir.

Ancak iki katılımcı, yüksek bilinç düzeyinin hasar taleplerinde sigortalı lehine baskı oluşturabileceğini ve bunun şirket açısından dezavantaj doğurabileceğini belirtmiştir.

5.4. Finansal Okuryazarlık ve Sektörel Katkılar

Tüm katılımcılar, finansal okuryazarlığın artmasının sigorta sektörüne olumlu katkı sağlayacağı konusunda hemfikirdir. Bu katkıların başında, poliçe satışı süreçlerinin daha verimli yürütülmesi, fiyatlandırma açıklamalarının daha kolay yapılabilmesi ve ürünlerin daha doğru değerlendirilmesi yer almaktadır. Ayrıca bazı yöneticiler, tanıtım ve satış ekiplerine duyulan ihtiyacın azalacağını dile getirmiştir.

5.5. Sektördeki Bilgi Eksikliği

Katılımcıların tamamına yakını, sigorta sektöründe hem bilgilendirme hem de finansal okuryazarlık alanlarında eksiklikler bulunduğunu ifade etmiştir. Bazı yöneticiler ise bilgilendirmenin yapıldığını ancak bireylerin bu bilgileri anlamada güçlük yaşadığını vurgulamıştır. Bu durum, yalnızca bilgiyi sunmanın yeterli olmadığını, aynı zamanda bireylerin bu bilgiyi anlayabilecek altyapıya sahip olmalarının önemini ortaya koymaktadır.

5.6. Acente Personelinin Sigorta Okuryazarlığı

Yöneticilerin çoğu, acente çalışanlarının sigorta okuryazarlık düzeyinin %50 oranında yeterli olduğunu ifade etmiştir. Bu oran, sektör çalışanlarının yarısının teknik bilgi eksikliği yaşadığını göstermektedir. Yalnızca bir yönetici, çalışanlarının gerekli bilgi ve donanıma sahip olduğunu; bunun da ilgili bölümlerden mezuniyet ve SEGEM sınavı başarılarına dayandığını belirtmiştir.

5.7. Eğitim Uygulamaları ve Planlamaları

Katılımcıların büyük çoğunluğu, acente personeline çeşitli eğitimler verildiğini ancak bu eğitimlerin ürün odaklı olduğunu ve finansal okuryazarlık içeriği taşımadığını dile getirmiştir. Eğitimlerin genellikle genel müdürlükler tarafından yürütüldüğü belirtilmiş, yalnızca bir yönetici kişisel bilgi birikimini çalışanlarına aktardığını ifade etmiştir. Bununla birlikte, katılımcıların çoğu gelecekte bu yönde kapsamlı eğitim planları yapmayı düşündüklerini belirtmiştir.

5.8. Sigorta Yaptırmama Nedenleri

Katılımcıların çoğu, bireylerin sigorta yaptırmama nedeninin öncelikli olarak finansal yetersizlikten kaynaklandığını ifade etmiştir. Altı katılımcı, sigorta okuryazarlığının bu kararlarda etkili olmadığını, temel sebebin maddi imkânsızlık olduğunu belirtmiştir. Ancak iki katılımcı, sigorta bilinci ve bilgi eksikliğinin bu kararda etkili olduğunu ifade etmiştir. Bu durum, sigorta yaptırmama davranışının çok boyutlu nedenlere dayandığını göstermektedir.

5.9. Teknolojik Uygulamalar ve Sigorta Okuryazarlığı

Katılımcıların büyük çoğunluğu, sigorta şirketlerinin mobil uygulamalarına sigorta okuryazarlığına yönelik bölümler eklenmesinin olumlu sonuçlar doğuracağını düşünmektedir. Bu tür uygulamaların özellikle genç kullanıcılar için daha etkili olacağı, sade ve görsel ağırlıklı içeriklerle dikkat çekici hâle getirilmesi gerektiği ifade edilmiştir. Ancak iki katılımcı, bu tür uygulamaların ilgi çekmeyeceği ve beklenen etkiyi yaratmayacağı görüşündedir.

5.10. Akademik Çalışmalar ve Proje Önerileri

Tüm yöneticiler, sigorta okuryazarlığı alanında yapılan akademik çalışmaların sektöre önemli katkılar sağlayacağı görüşündedir. Katılımcılar, sigorta eğitiminin üniversite derslerine entegre edilmesi, sektörle ilgili televizyon programlarının hazırlanması ve acente sistemleriyle ilgili uygulamalı dershanelerin kurulması gibi önerilerde bulunmuşlardır.

5.11. Gelecek Öngörüleri

Katılımcıların çoğu, önümüzdeki yıllarda sigorta okuryazarlığının artmasıyla birlikte sigorta poliçelerinin kapsamının daha iyi anlaşılacağını, daha bilinçli tüketicilerin ortaya çıkacağını ve sigortalı nüfusun artacağını öngörmektedir. Sigortanın yalnızca araç ya da konut gibi yüksek değerli ürünlerle sınırlı kalmayacağı, ev eşyaları, halı, kilim gibi daha düşük maliyetli eşyaların da sigorta kapsamına alınacağı öngörülmektedir.

6. Sonuç ve Öneriler

Bu araştırma, Ankara ilinde faaliyet gösteren sigorta şirketi yöneticilerinin perspektifinden Türkiye'de sigorta okuryazarlığı düzeyini değerlendirmeyi ve bu konuda farkındalık yaratmayı amaçlamıştır. Elde edilen bulgular, ülkemizde sigorta okuryazarlığının genel olarak yetersiz seviyede olduğunu, bu durumun hem bireylerin sigorta tercihlerini hem de sektörün gelişimini doğrudan etkilediğini ortaya koymuştur. Görüşme yapılan acente yöneticileri, sigorta poliçesi satın alan müşterilerin önemli bir kısmının poliçelerin kapsamı, teminat yapısı, hak ve sorumluluklar hakkında yeterli bilgiye sahip olmadığını ifade etmiştir. Bu durum, sigortanın yalnızca zorunlu hâllerde başvurulan bir hizmet olarak algılandığını ve bilgi eksikliğinin sigorta sistemine olan güveni zayıflattığını göstermektedir.

Sigorta okuryazarlığı eksikliği sadece müşteri tarafında değil, sektörde görev yapan bazı acente personelleri açısından da dikkat çekmektedir. Eğitim düzeyi yüksek olan personelin daha bilinçli ve açıklayıcı bir hizmet sunduğu, ancak sektörde bilgi seviyesi düşük çalışanların da varlığını sürdürdüğü anlaşılmaktadır. Bu bağlamda sigorta şirketlerinin, çalışanlarına verdiği eğitimlerin yalnızca ürün satışına odaklanmaktan öteye geçmesi, finansal ve sigortacılıkla ilgili genel bilgi düzeyini artıracak şekilde planlanması gerektiği sonucuna ulaşılmıştır. Ayrıca bu eğitimlerin merkezden gelen standart içeriklerle sınırlı kalmaması, yerel koşullara ve değişen müşteri profiline göre esneklik taşıması önem arz etmektedir.

Sigorta yaptırma oranlarının düşük olmasında yalnızca bilgi eksikliği değil, ekonomik koşulların da belirleyici bir unsur olduğu görülmektedir. Görüşülen yöneticilerin büyük bir kısmı, bireylerin sigorta yaptırmama nedenlerinin temelinde maddi yetersizliklerin yattığını ifade etmiştir. Bununla birlikte bazı yöneticiler, sigorta bilincinin eksik olmasının da bu durumu derinleştirdiğini vurgulamıştır. Bu noktada hem ekonomik erişimi kolaylaştıracak mikro sigorta çözümlerinin geliştirilmesi hem de bireylerin bilinç düzeyini artırmaya yönelik yaygın eğitim faaliyetlerinin yürütülmesi büyük önem taşımaktadır.

Teknolojik gelişmelerin sigorta okuryazarlığını artırma potansiyeli üzerinde de durulmuştur. Görüşülen yöneticilerin çoğu, mobil uygulamalar ve dijital platformlar aracılığıyla sigorta bilincinin artırılabileceğini, ancak bu tür içeriklerin sade, anlaşılır ve görsel destekli bir biçimde sunulması gerektiğini belirtmiştir. Özellikle genç kuşağın teknoloji kullanımının yüksek olması, dijital tabanlı bilgilendirme araçlarının etkisini artırabilecek bir fırsat olarak değerlendirilmektedir.

Araştırma sonucunda ulaşılan ortak bir diğer kanaat ise sigorta okuryazarlığına yönelik akademik çalışmaların sayısının artırılması ve bu alanda geliştirilecek projelerin sektörün gelişimine önemli katkılar sağlayacağı yönündedir. Üniversitelerde bu konuda dersler açılması, kamu kurumları tarafından yürütülecek eğitim kampanyalarının desteklenmesi ve sektöre yönelik medya içeriklerinin yaygınlaştırılması, toplum genelinde sigorta bilincinin artırılmasında etkili olacaktır.

Finansal okuryazarlık ve sigorta okuryazarlığı, bireylerin sağlıklı finansal kararlar alabilmesi için temel öneme sahiptir. Bu araştırmada, finansal ve sigorta okuryazarlığının bireylerin ekonomik refahı üzerinde ne kadar belirleyici bir rol oynadığı vurgulanmıştır. Lusardi ve Mitchell (2011), finansal okuryazarlığın yüksek olduğu bireylerin tasarruf etme, borç yönetimi ve yatırım kararlarını daha etkili bir şekilde alarak, finansal kriz dönemlerinde bile daha az zarar gördüklerini belirtmişlerdir. Bu doğrultuda, finansal okuryazarlığın artırılması, bireylerin hem kişisel hem de toplumsal düzeyde ekonomik güvenliğini sağlamada kritik bir rol oynamaktadır.

Baştürk (2016) sigorta okuryazarlığının finansal okuryazarlıkla olan güçlü ilişkisini ve sigorta sektörüne olan etkilerini ortaya koymuş ve sigorta okuryazarlığının artırılması gerektiğini vurgulamıştır. Sigorta okuryazarlığı sadece tüketiciler için değil, aynı zamanda sigorta sektöründe çalışan profesyoneller için de büyük bir öneme sahiptir. SEGEM (2011), sigorta sektöründe çalışanların eğitimlerinin, müşterilere doğru hizmet sunabilmeleri adına son derece önemli olduğunu ifade etmektedir. Bu bağlamda, sigorta okuryazarlığının artırılması amacıyla sektördeki profesyonellere yönelik eğitim programları geliştirilmesi önerilmektedir.

Ayrıca, finansal okuryazarlığın artırılması, bireylerin gelecekteki finansal ihtiyaçlarına yönelik planlama yapabilmelerini sağlamaktadır. Yağlı (2015) tarafından yapılan bir çalışmada, finansal okuryazarlığı yüksek bireylerin, emeklilik gibi uzun vadeli finansal hedeflerine daha iyi ulaşabildikleri belirtilmiştir. Bu bulgu, finansal okuryazarlık seviyesinin artırılmasına yönelik çeşitli eğitim ve bilinçlendirme çalışmalarının gerekliliğini ortaya koymaktadır.

Finansal ve sigorta okuryazarlığının artırılmasına yönelik çeşitli stratejiler önerilmektedir. Bunlar arasında, eğitim kurumlarında finansal okuryazarlık derslerinin zorunlu hale getirilmesi, devletin finansal okuryazarlık kampanyaları düzenlemesi ve sigorta sektörü ile iş birliği içinde eğitim programlarının hazırlanması yer almaktadır. Ayrıca, demografik özelliklere bağlı olarak finansal okuryazarlık düzeyleri farklılık göstermektedir. Bu nedenle, farklı yaş gruplarına, eğitim seviyelerine ve ekonomik durumlara uygun özelleştirilmiş eğitim programları geliştirilmesi önerilmektedir.

Sonuç olarak bireylerin finansal ve sigorta okuryazarlık düzeylerinin artırılması yalnızca bireysel refahı değil, aynı zamanda sektörel verimliliği ve ulusal ekonomik gelişimi de olumlu yönde etkileyecektir. Bu bağlamda, kamu kurumları, özel sektör ve akademik çevrelerin iş birliği içerisinde politika geliştirmesi ve sürdürülebilir çözümler üretmesi gerekmektedir. Sigorta bilincinin yaygınlaştırılması, bireyleri olası risklere karşı daha hazırlıklı kılarken, sigorta sektörünün de daha sağlıklı ve güven temelli bir yapıya kavuşmasına katkı sağlayacaktır.

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CONSTRUCTING VIRTUAL IDENTITY ON SOCIAL MEDIA: A QUALITATIVE INQUIRY INTO DISSOCIATIVE IDENTITY DISORDER

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ABSTRACT

This study aims to examine the processes of online identity formation influenced by digital technologies and their possible effects on dissociative identity disorder (DID). In today's world, where digitalization has become widespread, the anonymity, freedom of expression, and multiple interaction opportunities offered by social media platforms provide a basis for individuals to develop multiple identities and perform different self-presentations in virtual environments. This situation emerges as an issue that needs to be carefully addressed, especially for individuals experiencing psychological problems related to identity integrity. The theoretical framework of the study is shaped around key concepts such as identity, virtual identity, social media use, and dissociative identity disorder. The research was conducted within the scope of qualitative methodology; in the data collection process, in-depth semi-structured interviews were carried out with three participants selected through purposive sampling. The data obtained regarding participants' social media experiences were analyzed using content analysis, and the emerging themes were presented descriptively in the form of case studies. In addition, the study was supported by an extensive literature review. In this context, the relationships between the formation of virtual identities, social media usage habits, and individuals' psychological responses were analyzed. The findings revealed that social media has both supportive and triggering effects on DID; these effects were shaped around themes such as online identity construction, social comparison, emotional fluctuations, and community support. The study aims to raise awareness of the psychological effects of social media use, to provide guiding information for healthcare professionals, educators, and relevant experts, and to highlight the importance of conscious social media use and psychosocial support mechanisms.

Keywords: Social Media, Identity, Virtual Identity, Dissociative Identity Disorder, Qualitative Research

INTRODUCTION

Digital technologies have made social media an integral part of the daily lives of millions of people. These technologies have caused communication forms to rapidly integrate within an interactive network (Castells, 2008: 440). Online platforms, which have become an inseparable part of everyday life, stand out as powerful tools that individuals use to construct, express, and share their identities. One of the most visible individual and social outcomes of this transformative process, which creates profound effects in every field, is identity (Zinderen, 2021: 71). Social media has transformed not only forms of communication but also identity construction processes; this transformation has made it important to examine the reflections of psychological conditions such as dissociative identity disorder (DID) in online environments (Tuğtekin & Dursun, 2021: 147–149).

The anonymity, freedom of expression, and multidimensional interaction environment offered by social media platforms enable individuals to develop virtual identities. This situation presents both opportunities and risks, especially for individuals living with DID. While being able to transition between different identities online may provide relief in terms of emotional expression and social connection, it can also lead to conflicts with one's real identity, inner distress, and problems in social relationships.

For individuals with DID, social media can offer a safe and free space to express themselves, share emotional experiences, and connect with communities that have similar experiences. However, the complexity of online identities may also pave the way for trust issues and conflicts in relationships. In this context, online identity construction processes emerge as an important factor to be considered in studies on DID (Atak, 2020: 199).

This study examines the relationship between virtual identity construction on social media and DID through a qualitative approach. Semi-structured interviews were conducted with participants selected through purposive sampling, and their social media usage habits, forms of virtual identity construction, and the psychological effects of these processes were evaluated through content analysis. Within this framework, the study aims to examine the relationship between social media and DID in order to understand individuals' online identity experiences.

CONCEPTUAL FRAMEWORK

The theoretical foundation of the research is built upon the concepts of social media, identity, virtual identity, and DID. In this section, the concept of social media, which plays a central role in individuals' online interaction and content production processes, is explained. Subsequently, the concept of identity, which refers to the process of self-definition and positioning within a social context, is addressed, and the phenomenon of virtual identity, which emerges in digital environments and often carries characteristics different from one's real identity, is evaluated. Finally, Dissociative Identity Disorder (DID), a serious psychological condition characterized by multiple self-states and associated with traumatic experiences, is defined in order to clarify the context on which the research focuses.

Social Media

Developed as a product of Web 2.0 technologies, social media has become an inseparable part of everyday life and has paved the way for the emergence of new concepts (Zinderen & Çolak, 2022: 78). Social media is defined as internet-based platforms that enable individuals to come together in virtual environments. From a broader perspective, these platforms provide web-based services that allow users to create open or semi-open profiles, connect with others, and share various types of content (Olgun, 2015: 485–486). These online platforms create spaces for social bonding through new-generation communication devices that are easily accessible and rapidly disseminated. In other words, social media can be defined as online environments where individuals interact with one another by sharing their emotions, thoughts, observations, and experiences (Aydoğan & Kırık, 2012).

Social media is regarded as a space where individuals can express themselves, demonstrate their social presence, and fulfill their social needs (Işık & Kaptangil, 2018: 698). These platforms function as social tools open to collective use, enabling individuals to come together by forming communities and groups or by actively participating in existing ones. In this sense, social media can be defined as a widespread and accessible communication technology through which individuals share content with the aim of influencing others. Moreover, social media represents a structure that allows individuals to move beyond being mere consumers of content to become content producers, thereby reflecting the democratization of knowledge (Bekaroğlu, 2011).

Social media users have become increasingly active on various platforms in order to reach wider audiences for different purposes. With the widespread use of social networks and applications, as well as the facilitation of consumption, individuals have been able to reach large numbers of people and share their ideas through these platforms. Today, there are many social networking sites addressing different needs. Users join these platforms, produce content, and spend significant amounts of time in these environments (Kabakçı & Köker, 2017: 49).

Beyond its entertainment function, social media is considered the broadest ground for socialization and an important tool for self and identity construction (Işık & Kaptangil, 2018: 698). Therefore, today, social media has gone beyond being merely a tool of information and communication, becoming instead a domain that transforms identity construction processes, social belonging, and forms of cultural interaction. By sharing their experiences, observations, and ideas, users take on the role of both content producers and interpreters. This transforms communication from a one-way flow of information into a dynamic process based on mutual interaction and participation. Thus, social media has become not only a technological tool in interpersonal communication but also a central element of social interaction, identity expression, and cultural sharing.

Identity

Identity is shaped by the way an individual defines themselves and by the distinctive characteristics that determine this definition. This process is related both to the answer a person gives to the question "Who am I?" and to how others perceive them (Bilgin, 2007: 161). The different qualities of individuals make their identities unique, while the meaning attributed to identity highlights differences between people. Identity can be subjected to a process of classification, in which both the individual's self-perception and society's perception play a determining role (Aşkın, 2010: 214–215). Furthermore, identity develops within the life process as a source of meaning and experience for the individual and can undergo change over time (Castells, 2006: 12). In this respect, identity differentiates the individual based on lived experiences and makes them distinct from others (Zinderen, 2021: 75).

The emergence of identities is considered the product of a process. According to Hall (1998: 70–72), identity is not a static phenomenon but a continuously reproduced process of construction. Identity construction is a multidimensional process shaped by the interaction of various elements such as history, culture, social conditions, and individual experiences (Castells, 2006: 14). Therefore, individuals' identities are shaped not only by personal experiences but also by their network of social relations (Zinderen, 2021: 75).

From a psychological perspective, identity is closely related to self-perception and the integrity of personality. In this sense, personality is regarded as a regulatory structure that ensures harmony among identities (David, 1996: 21). Through the identities they hold, individuals adapt to the social environment, and some of these identities become more decisive in their lives and sense of belonging. Identity is approached as a structure that exhibits subjective integrity, coherence, and continuity (Aşkın, 2010: 215–216).

Virtual Identity

Virtual identity refers to technologically mediated or mentally processed identities that exist or are simulated within computers, computer networks, and other digital media environments (Jin, 2012). Virtual identities often emerge in anonymous, pseudonymous, or alternative forms. In this respect, virtual identity is defined as a representation created by the individual in the online environment, which may sometimes be entirely different from their real identity. These identities can vary across different social media platforms and are frequently reproduced through visual, linguistic, and cultural codes. The continuous transformation of the internet and communication technologies has led to the

conceptualization and definition of virtual identity in different ways within the literature (Şimşek, 2020: 11–20).

Virtual identity is considered a concept in which people's offline presentations change in line with the dynamics of the internet. Users constantly shape their identities on online platforms through visual and textual codifications, and in this process, virtual identities play an important role in meeting the need for social visibility. In this sense, virtual identity, with its dynamic and multidimensional structure, provides individuals the opportunity to acquire different identities in different spaces and to participate in various communities (Nagy & Koles, 2014).

People construct virtual identities for a wide variety of purposes. Therefore, this process is based on different reference points for each individual (Van Kokswijk, 2007). The factors influencing the construction of virtual identity may vary depending on the characteristics of the environment in which it takes place (Nagy & Koles, 2014). In this respect, the concept of virtual identity holds critical importance in understanding how individuals express themselves and reconstruct their social positions in digital environments.

Dissociative Identity Disorder (DID)

DID is defined as a psychological disorder characterized by the individual's transition between multiple identities or self-states, associated with severe childhood traumatic experiences as well as the interplay of complex developmental and cultural factors (Dorahy, Brand, Şar, et al., 2014; Soner & Aykut, 2017: 130–132). This disorder causes the individual to fragment their sense of self, thoughts, emotions, or behaviors, leading to the experience of distinct identities or self-states. These identities are often independent from one another, and transitions between them may occur automatically or in ways that are not remembered by the individual. This condition is frequently linked to the inability to recall traumatic childhood experiences and the fragmentation of personality as a coping mechanism against such experiences.

Symptoms include memory loss, identity alteration, personality disturbances, anxiety, depression, self-harming behaviors, memory gaps, lack of communication between identities, and emotional fluctuations. These symptoms significantly affect the individual's daily life and make social relationships difficult. DID often leads to challenges in forming emotional bonds with oneself and others.

In the treatment process, the primary aim is to help the individual understand and cope with their traumatic experiences and to establish a more unified sense of self. Approaches such as cognitive-behavioral therapy focused on the individual, dialectical behavior therapy, and observational therapy may be employed. In addition, by ensuring a safe therapeutic environment, support is provided for the individual to develop communication and harmony among different self-states. Defined as a complex psychological condition, DID seriously affects the individual's quality of life. Therefore, accurate diagnosis and an effective treatment plan are crucial for helping individuals cope with this challenging condition (Soner & Aykut, 2017: 130–132).

METHOD

This research was conducted within the framework of a qualitative research design using the case study approach (Yıldırım & Şimşek, 2018; Creswell, 2013). Semi-structured interviews were carried out with three participants diagnosed with DID, selected through purposive sampling (Patton, 2002). The limited number of participants was due to the focus of purposive sampling in qualitative research on providing in-depth understanding rather than broad generalizations. The interviews conducted with three participants yielded rich data aligned with the research aim; similar themes were repeatedly observed,

and at this point, data saturation was considered to have been achieved. In addition, the scope of the study, accessibility conditions, and ethical considerations also made this number appropriate.

To protect the identities of the participants, coding was used (P1, P2, P3), and the interviews were conducted online (via Zoom) during March–April 2025. The research was carried out with the approval of the Ethics Committee and informed consent obtained from the participants.

During the data collection process, a semi-structured interview form was used to explore participants' social media usage habits, forms of virtual identity construction, and the psychological effects of these processes (Yıldırım & Şimşek, 2018). The interviews were audio recorded and transcribed. The data obtained were analyzed through a descriptive approach using content analysis (Miles & Huberman, 1994). In the analysis process, coding and theme development steps were followed, and the findings were presented in the form of case studies. This methodological approach allowed for a multidimensional evaluation of the connections between individuals' online identity experiences and DID.

FINDINGS AND ANALYSIS

In this section, the data obtained are presented through case examples in line with descriptive analysis. The participants' experiences show similarities with what is defined in the literature as DID. DID is characterized by the individual experiencing themselves in multiple self-states and is often associated with traumatic past experiences (Soner & Aykut, 2017). This condition leads to fragmentation in the perception of identity and significantly complicates daily life.

The participants' statements overlap with symptoms of DID, such as memory gaps, intense anxiety, depressive moods, and difficulties in social relationships. For instance, one participant stated that they frequently experienced "temporal disconnections" and could not remember what they had done during those moments. Another participant reported sudden transitions between different emotional states, emphasizing that this became particularly evident in their use of social media.

At this point, social media emerges in participants' experiences both as an element that makes transitions between identities visible and as a kind of escape space. Participants expressed that they continued their identity fragmentation in digital environments by creating different accounts or reflecting different identities through the same account. This finding is consistent with Millard's (2020) study, which shows that social media facilitates the expression of different identities by providing a sense of anonymity and freedom.

Furthermore, participants reported that the continuous presentation of online identities in an "idealized" manner increased their levels of anxiety and stress. This aligns with findings in the literature suggesting that social media can increase the risk of self-esteem problems and depression among individuals (Büyükçorak & Dinç, 2020; Şener & Yiğit, 2021).

For individuals living with DID, social media functions both as a stage for identity and as a space of psychological tension. As demonstrated by participants' experiences, the conflict between virtual and real identities deepens internal tensions and highlights the impact of this condition on mental health.

Case Examples

The participants' statements were grouped under similar themes, and each theme was explained through case examples supported by descriptive findings.

P1 is a male university student who expresses himself through different identities on social media platforms. During the interview, his statement, *"Sometimes I forget who I am; on Instagram I am a completely different person, while on TikTok I confront myself"* clearly reflects his inner conflict. While he gains appreciation from his social circle through the energetic posts he shares on Instagram, he posts

more melancholic and self-questioning content on TikTok. This dual mode of expression has led to inconsistency in his self-perception and has increased his social isolation. According to the interview notes, these identity transitions have made it difficult for him to maintain friendships, ultimately leading to loneliness. Psychological evaluations indicated that the identities he constructs through social media weaken his real sense of self and reinforce existing DID symptoms.

P1's experience reflects the theme of self-fragmentation and social isolation, as his different identity performances on social media have weakened his friendships and led to loneliness.

P2 is a young woman who simultaneously lives two different worlds on social media. During the interview, she stated, *"My professional profile is very serious, while my artistic identity is completely free."* On Facebook, she presents the image of a disciplined businesswoman, whereas on YouTube, she exhibits a creative and artistic persona. This situation has caused her to be perceived differently across various circles and has triggered an identity crisis in her real life. The participant reported experiencing inconsistencies in her relationships with family and friends. According to the interview notes, while her social media interactions fragment her sense of self, they also provide her artistic identity with a space of escape and expression.

P2's case illustrates the theme of identity duality and freedom of expression; for her, social media both creates a fragmented sense of self and enables her to freely express her artistic identity.

P3 is a young man who simultaneously carries two contrasting identities on social media. On Instagram, he shares content about sports, healthy living, and motivation, while on Twitter, he presents a humorous and critical persona. During the interview, he stated, *"Sometimes I post tweets making fun of my fitness-focused self, which means I contradict myself."* These conflicting identities have led to different perceptions across various circles: his colleagues perceive him as a disciplined athlete, whereas his friends see him as a witty personality. According to the therapist's evaluation, these opposing identities weaken his sense of inner cohesion; however, his humorous side provides him with psychological relief.

P3's experience highlights the theme of conflicting identities and psychological relief; while the opposing identities challenge his inner sense of unity, his humorous persona offers him a source of comfort.

Social media functions as a space where participants can express different identities. They stated that through these platforms, they were able to make various aspects of themselves visible, showcase their interests, and connect with similar communities. This finding overlaps with the literature, which emphasizes social media's potential to provide individuals with social support, grant freedom of expression, and foster awareness (Güney, 2020). Particularly for individuals with DID, online communities can offer an environment of support and understanding.

At the same time, social media may also serve as a field of competition and conflict between different identities. Participants expressed that constant social comparisons increased their anxiety, while negative comments led to emotional difficulties. Adopting different identities through separate accounts may reinforce self-fragmentation, which is one of the core characteristics of DID. The literature similarly underlines that online identities may increase self-esteem problems and the risk of depression among individuals (Büyükçorak & Dinç, 2020; Şener & Yiğit, 2021).

The findings of the descriptive analysis demonstrate that social media functions both as a stage for identity and as a space of psychological tension for individuals with DID. Based on participant experiences, there exists a duality between the freedom of expression afforded by social media and its effects that deepen identity fragmentation. In this respect, considering both the positive and negative aspects of online experiences is of critical importance for understanding DID.

CONCLUSION

This study examined the effects of social media use on individuals living with DID. The findings demonstrate that while social media plays a liberating role by offering individuals the opportunity to express their different identities, it also reinforces identity fragmentation and increases psychological tension.

Social media provides interaction with communities that share similar experiences and offers psychological support; however, it may also heighten individuals' levels of anxiety and stress through constant social comparisons, negative feedback, and identity conflicts. This dual effect creates a critical area of tension in the digital experiences of individuals with DID. Thus, in the context of DID, social media functions both as a stage for identity and as a space of psychological tension. Participant experiences reveal that the conflict between online identities and real selves deepens internal tensions, while at the same time providing a platform for social support and expression.

In line with the findings of this study, the following recommendations emerge:

- Encouraging participation in online support groups,
- Seeking professional psychological support,
- Practicing social media detox,
- Developing educational programs for healthy digital habits.

Overall, the interaction between social media and DID is complex and multidimensional. However, through conscious use, strong support mechanisms, and healthy digital practices, the negative effects of this interaction can be mitigated. In this way, individuals living with DID can use online environments in a more balanced and healthy manner without undermining their sense of identity integrity.

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MALÇ UYGULAMALARININ YABANCI OT YÖNETİMİNDEKİ ROLÜ: KALINLIK, TÜR VE UYGULAMA ZAMANININ ETKİSİ

THE ROLE OF MULCH APPLICATIONS IN WEED MANAGEMENT: EFFECTS OF THICKNESS, TYPE, AND TIMING

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ÖZET

Yabancı otlar, tarımsal üretimde verim ve kalite kayıplarına neden olan en önemli etmenlerden biridir. Günümüzde yaygın olarak kullanılan kimyasal mücadele yöntemleri kısa vadede etkili sonuçlar sağlasa da, uzun vadede çevresel kirlenme, toprak sağlığının bozulması ve insan sağlığı açısından riskler doğurmaktadır. Bu bağlamda, çevre dostu, ekonomik ve sürdürülebilir yabancı ot yönetimi stratejilerine olan ihtiyaç giderek artmaktadır. Malçlama uygulamaları, bu amaçla öne çıkan kültürel kontrol yöntemlerinden biri olarak dikkat çekmektedir. Fakat malç uygulamaları malç kalınlığı, kullanılan malç materyalinin türü (organik veya inorganik) ve uygulama zamanı, yabancı otların çimlenme ve gelişimi üzerinde farklılıklar göstermektedir. bundan dolayı bu çalışmada, malçın kalınlığı, türü (organik/inorganik) ve uygulama zamanının yabancı otların çimlenme ve gelişimleri üzerindeki etkileri literatür bulguları doğrultusunda değerlendirilmiştir. Kullanılan malç türü önemli bir rol oynar. Saman, odun yongaları, kompost ve ürün artıkları gibi organik malçlar biyolojik olarak parçalanabilir ve zamanla toprak sağlığını iyileştirebilir. Ancak, etkinlikleri ayrışma oranlarına, malzeme yoğunluğuna ve yerel iklim koşullarına bağlı olarak değişebilir. Plastik filmler ve peyzaj kumaşları da dahil olmak üzere inorganik malçlar, daha homojen ve uzun süreli yabani ot baskılaması sağlar, ancak çevresel atık sorunlarına yol açabilirler. Malçlamanın etkinliği, uygulanan malzemenin kalınlığından büyük ölçüde etkilenir; daha kalın katmanlar genellikle daha iyi yabancı ot kontrolü sağlar, özellikle de ışık şiddetini sınırlayarak ve yabancı ot çıkışını engelleyerek. Zamanlama da bir diğer önemli hususdur. Çoğu araştırma, erken uygulamanın (tercihen yabani otlar çıkmadan önce) yabani otların ilk oluşumunu önleyerek malçlamanın faydalarını en üst düzeye çıkardığı konusunda hemfikirdir. Geç uygulamalar genellikle zaten filizlenmiş yabani otların kontrolünde daha az etkilidir, ancak yine de daha fazla büyümeyi baskılayabilir. Bu inceleme, uygun malç türünü seçme, optimum kalınlıkta uygulama ve uygulama zamanlamasını doğru bir şekilde ayarlama gibi entegre bir yaklaşımın, yabani ot yönetiminde malçlamanın etkinliğini artırabileceğini vurgulamaktadır.

Anahtar Kelimeler: İnorganik malç, Kültürel mücadele, Malçlama, Organik malç, Sürdürülebilir tarım, Yabancı ot kontrolü

ABSTRACT

Weeds are one of the most significant factors causing yield and quality losses in agricultural production. While currently widely used chemical control methods provide effective short-term results, they pose risks to environmental contamination, soil health, and human health in the long term. In this context, the need for environmentally friendly, economical, and sustainable weed management strategies is increasing. Mulching practices are attracting attention as one of the most prominent cultural control methods for this purpose. However, mulch applications vary in terms of mulch thickness, type of mulch material used (organic or inorganic), and application time on weed germination and growth. Therefore,

this study evaluated the effects of mulch thickness, type (organic/inorganic), and application time on weed germination and growth based on literature findings. The type of mulch used plays a significant role. Organic mulches such as straw, wood chips, compost, and crop residues are biodegradable and can improve soil health over time. However, their effectiveness may vary depending on decomposition rates, material density, and local climatic conditions. Inorganic mulches, including plastic films and landscape fabrics, provide more uniform and long-lasting weed suppression but can lead to environmental waste issues. Mulch effectiveness is greatly influenced by the thickness of the applied material; thicker layers generally provide better weed control, particularly by limiting light intensity and inhibiting weed emergence. Timing is also important. Most studies agree that early application (preferably before weeds emerge) maximizes the benefits of mulching by preventing initial weed establishment. Late applications are generally less effective in controlling weeds that have already emerged but can still suppress further growth. This review highlights that an integrated approach, including selecting the appropriate mulch type, applying the optimal thickness, and correctly timing the application, can increase mulching effectiveness in weed management.

Keywords: Inorganic mulch, Cultural control, Mulching, Organic mulch, Sustainable agriculture, Weed control

1.GİRİŞ

Tarımsal üretimde ürünlerin kalite ve verimini etkileyen başlıca faktörler arasında iklim koşulları, hastalık ve zararlılar ile yabancı otlar yer almaktadır (Swinton and Van Deynze, 2017). Yabancı otlar; su, ışık ve besin gibi temel kaynaklar için kültür bitkileriyle rekabete girerek büyüme ve gelişmeyi olumsuz etkiler, ürün kayıpları ve verim düşüşüne yol açar (Tepe, 1998; Gharde et al., 2018). Bunun yanı sıra kalite parametrelerini de olumsuz etkiledikleri bildirilmektedir (Jabran and Chauhan, 2018). Yabancı otların zarar düzeyi türlere göre değişmekte; bazıları yalnızca belirli ürünlerde sorun oluştururken bazıları birçok kültür bitkisinde verim kaybına neden olabilmektedir (Güncan, 2014). Ayrıca bu kayıplar, coğrafi bölgelere bağlı olarak farklılık göstermektedir (Güncan, 2016).Yabancı otlar, yüksek tohum üretim kapasiteleri, hızlı büyüme özellikleri ve rizom, yumru veya stolon gibi yapılarla çoğalabilme yetenekleri sayesinde çevreye hızla yayılabilmektedir (Yıldırım ve Ekin, 2003). Bu özellikleriyle kültür bitkilerinin fizyolojik aktivitelerini baskılamakta, verim ve kaliteyi düşürerek ekonomik kayıplara yol açmaktadırlar (Rajcan and Swanton, 2001). Bu nedenle, etkili yabancı ot yönetim stratejilerinin geliştirilmesi ve uygulanması büyük önem taşımaktadır. Günümüzde yabancı otlarla mücadelede mekanik, kimyasal, biyolojik ve entegre yöntemler kullanılmaktadır (Gao and Su, 2024).). Kimyasal yöntemler, iş gücü tasarrufu ve uygulama kolaylığı nedeniyle yaygın kullanılmaktadır. Ancak herbisitlerin aşırı ve bilinçsiz kullanımı; insan ve hayvan sağlığına zarar verme, herbisit direncinin gelişmesi, biyolojik çeşitliliğin azalması, fitotoksisite, ekonomik olarak zararsız türlerin baskın hale gelmesi ve hedef dışı organizmaların etkilenmesi gibi birçok olumsuzluğa yol açabilmektedir (Kitiş, 2011). Bu nedenle agroekosisteme minimum zarar veren, sürdürülebilir kontrol yöntemleri ön plana çıkmaktadır. Sürdürülebilir tarım uygulamaları, çevresel etkileri azaltırken toprak sağlığını korumayı hedefler. Bu kapsamda malçlama, toprak nemini muhafaza ederek su tasarrufu sağlar, erozyon ve besin kaybını azaltır, organik madde birikimiyle toprak yapısını iyileştirir ve mikrobiyal aktiviteyi artırır. Böylece çevre dostu ve kaynak verimliliğini destekleyen bir yöntem olarak önem kazanmaktadır. Malçlama, yabancı ot kontrolünde toprak yüzeyinin ışık geçirmeyen materyallerle örtülmesine dayanır. Bu sayede toprak yüzeyine çıkan yabancı otlar fotosentez yapamaz ve gelişemez. Kimyasal gerektirmemesi nedeniyle çevre dostu bir yöntemdir. Ayrıca toprak neminin korunması, buharlaşmanın azalması, sıcaklık düzenlenmesi, erozyonun önlenmesi gibi faydalar sağlamaktadır. Organik malçlar toprağın besin içeriğini artırır, mikroorganizmaları destekler, kök gelişimini teşvik

eder; bazı durumlarda meyve kalitesini artırarak verimi yükseltir (Kitiş, 2011). Sonuç olarak, yabancı otlarla mücadelede çevreye zarar vermeyen, uygulanabilir ve sürdürülebilir yöntemlerin geliştirilmesi önemlidir. Malçlama bu kapsamda hem yabancı ot kontrolü hem de verim ve kalite artışı için önemli bir potansiyele sahiptir. Bu çalışma, farklı malçlama uygulamalarının kültür bitkilerinde yabancı ot kontrolü ile verim ve kalite üzerine etkilerini araştırarak sürdürülebilir tarım pratiğine katkı sağlamayı amaçlamaktadır

2. MALÇ: TANIMI, TÜRLERİ VE TARIMDAKİ KULLANIM ALANLARI

Malç sözcüğü Almanca kökenli "molsch" kelimesinden türetilmiş olup "kolay çürüyen" anlamına gelmektedir. Malçlama, özellikle sebze yetiştiriciliğinde uzun süredir kullanılan yöntemlerden biridir (Lightfoot, 1994). Toprak yüzeyine farklı materyallerin serilmesiyle nem kaybını azaltmak, yabancı ot yoğunluğunu düşürmek ve ürün verimini artırmak amacıyla uygulanır (Nalayini, 2007; Kader ve ark., 2019). Ayrıca yüzey akışını sınırlandırma, infiltrasyonu artırma, yabancı ot gelişimini baskılama ve buharlaşmayı azaltma gibi etkileri vardır. Malç uygulamaları, kök bölgesinde sıcaklık dengesini koruma, besin kayıplarını azaltma, erozyonu önleme, toprak sıkışmasını azaltma ve fiziksel özellikleri iyileştirme gibi çevresel faydalar sağlamaktadır (Ngouajio ve McGiffen, 2002; Lamont, 2005). Malç materyalleri genellikle organik ve inorganik (sentetik) olmak üzere iki grupta incelenmektedir. Organik malçlar; saman, ağaç kabuğu, otlar, örtü bitkileri (canlı malç), talaş, kompost ve hayvansal gübre gibi materyallerden oluşurken, inorganik malçlarda en yaygın kullanılan materyal polietilen plastiklerdir. Plastik malçlama günümüzde dünya genelinde giderek daha fazla kullanılmakta olup, 1999 yılında 22 milyon hektardan fazla ekili alanda uygulandığı bildirilmiştir (Miles ve ark., 2005). Özellikle kurak ve sıcak bölgelerde ticari ürün yetiştiriciliğinde önemli avantajlar sağlamaktadır (Schahbazian ve Nejad, 2006; Kader ve ark., 2019). Malç uygulamaları, yabancı ot gelişimini sınırlandırmanın yanı sıra buharlaşma kaynaklı su kayıplarını azaltır ve toprağın su tutma kapasitesini artırır. Örneğin saman malçının buharlaşmayı yaklaşık %35 azalttığı belirtilmiştir (Li ve ark., 2013). Organik malçların, su tutma ve infiltrasyon açısından inorganik malçlara göre daha avantajlı olduğu rapor edilmiştir. Hem organik hem de inorganik malçlar, işlenmemiş toprağa kıyasla nemi daha iyi korumaktadır (Arthur ve Wang, 1999). Uygulamada hayvansal atıklar, bitki artıkları ve taşlar gibi çeşitli materyaller kullanılmaktadır (Siipilehto, 2001; Buban ve ark., 1996). Malç tiplerinin toprak sıcaklığına etkileri farklılık göstermektedir. Bazı malçlar güneş ışığını emerek çıplak toprak veya canlı malçlara kıyasla sıcaklığı yükseltirken (Montague ve Kjelgren, 2004), arnavut kaldırımı malçın çakıldan, yaprak malçların ise komposttan daha olumlu etkiler sağladığı rapor edilmiştir. Canlı malçlar, buharlaşma yoluyla soğutma etkisi yaparak yüzey sıcaklığını düşürmekte ancak daha fazla suya ihtiyaç duymaktadır (Montague ve Kjelgren, 2004). İnorganik malçlardan çakıl, beton gibi sert malçlara göre daha iyi sıcaklık düzenlemesi sağlarken (Iles ve Dosmann, 1999), plastik, kumaş veya asfalt gibi sentetik malçların sıcaklığı artırdığı ve ısı kontrolünde yetersiz kaldığı belirtilmiştir (Duncan ve ark., 1992). Benzer şekilde bazı doğal malç türleri de sıcaklık düzenleme konusunda olumsuz etkilere sahip olabilir; örneğin çam kabuğu malçının yüzey sıcaklığını artırarak bitkilerde terlemeyi yükselttiği bildirilmiştir (Zajicek ve Heilman, 1994). Bununla birlikte organik ve canlı malçlar, besin döngüsü ve toprak kalitesi üzerinde olumlu etkiler göstermektedir. Uygun koşullarda ayrışarak bitkilerin yararlanabileceği besin elementlerini serbest bırakırlar. Odun yongaları, saman, yeşil gübreler ve ağaç kabuğu gibi malçların inorganik malçlara göre daha fazla besin sağladığı bildirilmektedir (Ansari ve ark., 2001). Ayrıca organik malçların, mikrobiyal faaliyetleri artırarak toprak ıslahına ve tuzluluğun azaltılmasına katkı sağladığı rapor edilmiştir (Gan ve ark., 2003). Organik ve canlı malçların, çimlenme için uygun koşullar oluşturma bakımından taş veya çakıl malçlardan daha avantajlı olduğu belirtilmiştir (Chalker-Scott, 2007). Yabancı ot popülasyonlarını baskılamada etkili olmakla birlikte malçların, yüzey altında gelişen tüm bitkiler üzerinde benzer etkiye sahip olduğu, dolayısıyla yabancı otlar ile kültür bitkileri arasında seçici bir kontrol sağlamadığı ifade edilmiştir (Chalker-Scott, 2007)

3.MALÇLARIN YABANCI OT KONTROLÜNDEKİ ETKİNLİĞİ

Malç uygulamaları, hem fidanlık hem de tarla koşullarında yabancı ot yoğunluğunu azaltmada etkili bir yöntem olarak öne çıkmaktadır. Ancak, bu azalmanın mekanizması tam olarak açıklığa kavuşturulamamıştır. (Westbrook et al., 2022). Malçsız uygulamalara kıyasla yabancı ot popülasyonunda %92'ye varan bir düşüş bildirmiştir. Toprak yüzeyine serilen malç, ışığın geçişini engelleyerek özellikle küçük tohumlu yabancı ot türlerinin çimlenmesini baskılamaktadır. Farklı malç materyallerinin (15 çeşit) denendiği bir çalışmada, malç türleri arasında belirgin bir farklılık bulunmamış, ancak malç uygulaması ile çıplak toprak arasındaki farkın istatistiksel olarak önemli olduğu gösterilmiştir (Stinson vd. 1990; Mohtisham vd. 2013; Kader vd. 2019). Malç, yabancı otların çıkışını önleyen fiziksel bir bariyer görevi üstlenmektedir. Bununla birlikte, organik malçların parçalanarak toprak yüzeyinden kısa sürede kaybolma eğilimi bulunmaktadır. Bazı organik malzemeler ayrıca allelopatik etki göstererek yabancı otları baskılayan kimyasal maddeler açığa çıkarabilmektedir. Malçın oluşturduğu ortam, yabancı ot tohumlarıyla beslenen yararlı mikroorganizmalar için de elverişli olmaktadır (Chalker-Scott 2007). Canlı malç uygulamaları da ışık, nem, oksijen ve besin maddeleri gibi kaynaklar üzerinde rekabet ederek yabancı ot gelişimini engelleyebilmekte, ayrıca allelopatik etkiler de gösterebilmektedir. Benzer şekilde, bazı örtü bitkileri ve yer örtücüler, yabancı otların çimlenmesini ve toprakta tutunmasını sınırlayıcı rol üstlenmektedir (Griffiths ve Fairhurst 2003). Ancak tarla koşullarında canlı malçların aşırı kullanımı, kültür bitkileriyle kaynak rekabetine yol açabilmektedir (Chalker-Scott 2007). Plastik malçlar ve peyzaj kumaşları yabancı otları baskılamada başarılı olmakla birlikte uzun süre kullanılamamaktadır. Özellikle beyaz ve yeşil plastikler fotosentetik aktif radyasyonu (PAR) geçirdiği için yabancı ot gelişimine izin verirken, koyu renkli malçlar ışık geçirgenliğini engelleyerek popülasyonu azaltmaktadır. Bununla birlikte, bazı dirençli yabancı otlar malçın üzerinde gelişebilmekte ve hatta plastik örtüleri delip çıkabilmektedir (Labrada, 1994). Plastik veya kumaş malçların yenilenmesi ise zaman alıcı, maliyetli ve bazen yetiştirilen ürüne zarar verici olabilmektedir (Rylander, 2019). Genel olarak organik ve inorganik malçların yeterli kalınlıkta uygulanması, yabancı ot kontrolünde etkili bulunmuştur (Stinson vd. 1990). İnorganik malçlar (örneğin taş veya çakıl) 4 cm derinlikte kullanıldığında yabancı ot kolonizasyonunu engelleyebilmektedir (Marble et al., 2015). Ayrıca bu malçlar nemin korunması ve sıcaklığın dengelenmesi gibi olumlu toprak koşulları sağlamaktadır. Işığın tamamen engellenmesi ise ışığa bağımlı tohumların çimlenmesini sınırlamaktadır (Chalker-Scott 2007). Organik malçların yabancı ot kontrolünde farklı etkileri vardır. Kompost, toprak verimliliğini artırmasına rağmen etkili bir yabancı ot baskılama yöntemi değildir (Major ve ark., 2005). Kompost tam ayrışmadığında yabancı ot tohum bankası görevi görebilmekte ve çok yıllık türlerin yerleşimini kolaylaştırabilmektedir. İnce tabaka halinde uygulandığında yabancı ot çimlenmesini artırabilirken, kalın tabakalar bunun tersine çimlenmeyi baskılamaktadır (Rokich vd. 2002). Tarımsal ürün artıkları (Labrada, 1994; Major ve ark., 2005) ve orman ürünleri (Gardiner ve Yeiser 1998) kompostlanmamış halde kullanıldığında yabancı otları azaltabilmektedir. Özellikle talaş, orman ekosistemleri (Arthur ve Wang 1999) ve fidanlık koşullarında (Chalker-Scott, 2007) önerilmektedir. Ancak kalın talaş tabakalarının su ve gaz değişimini sınırlayabileceği bildirilmektedir (Jodaugienė ve ark., 2006). Sonuç olarak, malç uygulamaları toprak yüzeyine ulaşan ışığı azaltarak yabancı otlarda fotosentezi engeller ve bu sayede yıllık yabancı otların kontrolünde etkili olur.

4.MALÇ KALINLIĞININ YABANCI OT KONTROLÜNDEKİ ÖNEMİ

Malç kalınlığı, yabancı ot yönetiminde başarıyı belirleyen temel faktörlerden biridir. İnce malç tabakaları, ışığın toprak yüzeyine ulaşmasını yeterince engelleyemediğinden, küçük tohumlu yabancı otların çimlenmesini sınırlamada yetersiz kalır. Buna karşılık, uygun kalınlıktaki malç, hem ışığı keserek fotosentez sürecini kısıtlar hem de fidelerin toprak yüzeyine ulaşmasını fiziksel olarak engelleyerek yabancı otların gelişimini baskılar (Chalker-Scott, 2007). Kalın malç tabakaları ayrıca toprağın nemini muhafaza eder ve sıcaklık değişimlerini dengeler. Bu durum, kültür bitkileri için elverişli bir ortam

sağlarken yabancı otların büyümesini olumsuz etkiler. Organik malçlar, yeterli kalınlıkta uygulandığında allelopatik etkilerini artırır; malçın ayrışması sırasında salınan bazı kimyasallar, yabancı ot tohumlarının çimlenmesini ve genç bitkilerin gelişimini engeller (Chalker-Scott, 2007). Öte yandan, aşırı kalın malç tabakaları toprak havalanmasını ve su hareketini kısıtlayabilir, kök bölgesinde oksijen eksikliğine yol açabilir ve özellikle talaş gibi organik malçlarda yabancı ot kontrolünden beklenen faydayı azaltabilir (Jodaugienė ve ark., 2006). Bu nedenle malç uygulamalarında tabaka kalınlığının yeterli düzeyde olması ve uygulamanın yetiştirme koşullarına uygun şekilde yapılması kritik öneme sahiptir. Sonuç olarak, malç kalınlığı, yabancı otların baskılanmasında doğrudan rol oynar; ince tabakalar yeterli kontrol sağlamazken, uygun kalınlıktaki malç hem mekanik hem de fizyolojik olarak yabancı otların gelişimini sınırlamaktadır.

5.UYGULAMA ZAMANININ YABANCI OT KONTROLÜNDEKİ ÖNEMİ

Malç uygulamasının zamanlaması, yabancı otların etkin bir şekilde kontrol edilmesinde belirleyici bir faktördür. Toprak yüzeyine uygulanan malç, ışık ve sıcaklık koşullarını sınırlandırarak yabancı ot tohumlarının çimlenmesini ve genç filizlerin gelişimini engelleyebilir. Ancak bu etkinin derecesi, malçlama zamanına bağlı olarak değişiklik gösterir. Erken dönemde yapılan malç uygulamaları, toprakta bulunan tohum bankasındaki yabancı otların çimlenmesini engelleyerek popülasyon yoğunluğunu düşürür. Buna karşın, geç dönemde uygulanan malç, zaten çimlenmiş veya köklenmiş yabancı otların büyümesini sınırlamada daha az etkili olabilir. Hızlı büyüyen yıllık yabancı ot türlerinde, malçlamanın ekim veya dikim ile eş zamanlı yapılması, yabancı ot baskısını maksimum düzeye çıkarır (Chalker-Scott, 2007). İklim ve mevsim koşulları da malçlama zamanının etkinliğini etkileyen önemli unsurlardır. Özellikle kurak veya sıcak dönemlerde malç, toprak nemini koruyarak hem kültür bitkisi hem de yabancı otlar için ortam koşullarını değiştirir. Bu nedenle malçlama zamanlaması, yabancı ot kontrolü ve kültür bitkisi sağlığı açısından dikkatle planlanmalıdır (Westbrook et al., 2022). Sonuç olarak, malç uygulamasının erken dönemde ve uygun mevsimde yapılması, yabancı otların çimlenmesini önlemekte ve popülasyon kontrolünü artırmada en etkili strateji olarak öne çıkar.

7.SONUÇ

Malç uygulamaları, hem organik (örneğin saman, yaprak, odun talaşı) hem de inorganik (örneğin siyah plastik, çakıl) türleriyle toprak nemini koruma, sıcaklık dengesini sağlama ve besin döngüsünü destekleme gibi çevresel faydalar sunmanın yanı sıra, yabancı ot yönetiminde de etkili bir araç olarak öne çıkmaktadır. Malç, yüzeyde oluşturduğu fiziksel bariyer ve ışık engeli sayesinde yabancı ot tohumlarının çimlenmesini ve genç filizlerin büyümesini engeller. Organik malçlar, toprağın mikroorganizma aktivitesini artırarak hem toprak sağlığını destekler hem de bazı yabancı ot türlerinin baskılanmasına katkı sağlar; canlı malçlar ise ekosistemde biyolojik çeşitliliği destekleyerek uzun vadeli sürdürülebilir yabancı ot kontrolüne olanak tanır. İnorganik malçlar ise özellikle yoğun yabancı ot baskısı olan alanlarda uzun süreli koruma sağlar ve fiziksel olarak filizlerin çıkmasını önler. Malçın yabancı ot yönetimindeki etkinliği, malç türü, kalınlığı ve uygulanma yöntemine bağlıdır. Örneğin, 5–10 cm kalınlığında bir organik malç tabakası, çoğu yabancı ot türünü baskılamak için yeterli bir örtü sağlar. Ayrıca malç uygulamaları, kimyasal yabancı ot kontrol yöntemlerinin kullanımını azaltarak sürdürülebilir tarım ve çevresel koruma açısından önemli bir strateji sunar. Sonuç olarak, malçlama, toprak sağlığını korurken yabancı otları da kontrol eden etkili ve sürdürülebilir bir yöntemdir. Malç türü, kalınlığı ve uygulama şekli ise başarısını belirleyen en önemli faktörlerdir.

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TOHUM DORMANSİSİNİN BİYOLOJİK YAPISI VE KIRILMA YÖNTEMLERİ ÜZERİNE GÜNCEL BİR DEĞERLENDİRME

A CURRENT REVIEW ON THE BIOLOGICAL BASIS AND BREAKING METHODS OF SEED DORMANCY

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ÖZET

Tohum dormansisi, olgunlaşmış bir tohumun uygun çevresel koşullar olsa bile hemen çimlenmemesi durumudur. Bu karmaşık ve çok yönlü fizyolojik özellik, birçok bitki türü için hayati öneme sahiptir ve özellikle yabancı otların doğada hayatta kalma ve yayılma stratejilerinin temelini oluşturur. Dünya genelinde yabancı ot tohumlarının %50 ila %90'ı dormansiye sahiptir. Dormansi sayesinde tohumlar, çimlenmek için en uygun zamanı bekler ve böylece çevresel risklerden korunmuş olur. Dormansi ile çimlenme birbirine zıt gibi görünse de, aslında fizyolojik ve genetik düzeyde sıkı bir ilişki içindedir. Dormansinin farklı tipleri vardır ve bu sınıflandırma, tohumun neden çimlenemediğine bağlı olarak yapılır. Günümüzde beş temel dormansi sınıfı kabul edilmektedir: fiziksel, fizyolojik, morfolojik, morfizyolojik ve kombinasyonel dormansi. Her tip, çimlenmenin gerçekleşebilmesi için farklı ipuçları ve yöntemler gerektirir. Dormansinin kırılması için uygulanan yöntemler arasında sıcaklık değişimleri, soğuklama, mekanik müdahaleler, kimyasal uygulamalar ve tohumun suya maruz bırakılması yer alır. Tohum çimlenmesini etkileyen başlıca çevresel faktörler sıcaklık, nem, oksijen, ışık ve toprak özellikleridir. Ayrıca, bitki hormonları olan absisik asit (ABA) ve giberellin (GA), dormansi ve çimlenme arasındaki dengeyi düzenleyerek tohumun çevresel sinyallere uygun yanıt vermesini sağlar. Bu derlemede, yabancı otlarda dormansi ve çimlenme arasındaki ilişkiler, dormansinin temel biyolojik yapısı, sınıflandırmaları, kırılma yöntemleri ve tohum yönetimindeki önemi güncel literatür ışığında değerlendirilmiştir. Bu bilgiler, tarım, ormancılık ve tohum bankacılığı gibi alanlarda uygulama açısından büyük önem taşımaktadır.

Anahtar Kelimeler: Tohum dormansisi, çimlenme, çevresel faktörler, dormansi kırılması, tohum biyolojisi

ABSTRACT

Seed dormancy is a complex and multifaceted physiological condition in which a mature seed does not germinate immediately even under favorable environmental conditions. This trait is vital for many plant species and forms the basis of survival and spread strategies, especially for weeds, in natural environments. Globally, 50 to 90% of weed seeds possess dormancy. Dormancy allows seeds to wait for the most suitable time to germinate, thereby protecting them from environmental risks. Although dormancy and germination may seem opposing processes, they are closely related at physiological and genetic levels. There are different types of dormancy, classified based on the factors preventing seed germination. Currently, five main classes of dormancy are recognized: physical, physiological, morphological, morphophysiological, and combinational dormancy. Each type requires specific cues and methods to overcome dormancy and enable germination. Methods used to break dormancy include temperature fluctuations, cold stratification, light treatments, mechanical scarification, chemical applications, and soaking seeds in water. The main environmental factors affecting seed germination

include temperature, moisture, oxygen availability, light, and soil properties. Additionally, plant hormones such as abscisic acid (ABA) and gibberellins (GA) regulate the balance between dormancy and germination, enabling seeds to respond appropriately to environmental signals. This review evaluates the relationships between dormancy and germinationin weed, the fundamental biological basis of dormancy, its classification, breaking methods, and the importance of seed management based on current literature. This knowledge holds great significance for practical applications in agriculture, forestry, and seed banking.

Keywords: Seed dormancy, germination, environmental factors, dormancy breaking, seed biology

1.GİRİŞ

Bitkilerin tomurcuk, yumru, rizom ve tohum gibi yapılarında metabolik hızın yavaşladığı ve büyüme gibi faaliyetlerin geçici olarak durduğu döneme dormansi (uyku hali) denir. Durgun yaşam olarak da adlandırılan dormansi, bitkiler açısından olumsuz çevre koşullarına ve elverişsiz mevsimlere dayanma stratejilerinden biridir (Akman ve Darıcı, 1998). Özellikle tarımsal alanlarda problem oluşturan birçok yabancı ot türü dormansi sayesinde tohum bankasında uzun yıllar canlı kalabilmekte ve mücadeleyi güçleştirmektedir (Baskin and Baskin, 2014). Dormant durumda bir tohum ölü değildir; yalnızca gelişim faaliyetleri askıya alınmış, adeta "ölü gibi görünen" ama canlılığını sürdüren bir yapıya dönüşmüştür. Dormansi süresince tohum, çevresel koşullar elverişli hâle geldiğinde veya özel sinyallerin etkisiyle yeniden çimlenme yeteneğini kazanır. Bu dönemin süresi türlere ve çevresel koşullara bağlı olarak birkaç günden birkaç yıla kadar değişebilir (Kadıoğlu, 1999). Dormansinin biyolojik önemi, çimlenmenin bitki için en avantajlı zaman ve yerde gerçekleşme olasılığını artırmasında yatar. Bu sayede türler, ekstrem çevresel koşullara karşı daha dirençli hale gelir ve nesillerini sürdürebilme şansını yükseltirler., 1982). Yabancı ot tohumlarının birçoğunda sert tohum kabuğu su girişini engelleyerek fiziksel dormansiye yol açarken, bazılarında ise hormonal denge değişimleriyle fizyolojik dormansi söz konusudur (Baskin and Baskin, 2014). Dormansinin sona ermesine ise dormansinin kırılması denir; bu süreç ya çevresel koşulların elverişli hâle gelmesiyle ya da dış müdahalelerle sağlanabilir. Yabancı ot tohumlarının dormansisini kırmak için doğada soğuklama, ışık etkisi, mekanik skarifikasyon, sıcaklık dalgalanmaları ve mikrobiyal faaliyetler gibi faktörler rol oynamaktadır. Örneğin, *Chenopodium album* tohumlarında ışık ve sıcaklık dalgalanmalarının çimlenmeyi tetiklediği, *Amaranthus retroflexus*'ta ise sıcaklık ve ışığın ortak etkisinin önemli olduğu bildirilmiştir (Benech-Arnold et al., 2000). Dormansi genel olarak iki grupta incelenir: Gerçek dormansi ve yalancı dormansi. Gerçek dormanside genler baskılanmış, enzim sentezi engellenmiş durumdadır ve çevre koşulları uygun hâle getirilse dahi çimlenme gerçekleşmez. Genlerdeki baskılayıcı etkinin ortadan kalkması ya zamanla olur ya da dış müdahalelerle sağlanır. Bu noktada hormon dengesindeki değişim önemlidir; örneğin, büyümeyi engelleyici absisik asit (ABA) ile büyümeyi teşvik edici gibberellik asit (GA_3) arasındaki oranın azalması dormansinin kırılmasını tetikleyebilir (Kucera et al., 2005). Yalancı dormanside ise genetik bir baskılama söz konusu olmayıp yalnızca çevre koşullarının uygunsuzluğu çimlenmeyi engeller. Ortam uygun hâle geldiğinde dormansi kendiliğinden kalkar (Koca çalışkan, 2008). Bu bağlamda tarımda sık rastlanan Echinochloacrus-galli gibi yabancı otların tohumları yalancı dormansi gösterebilmekte ve uygun sıcaklık/nem koşullarında hızla çimlenebilmektedir). Dormansi olgusu yalnızca tohumlarda değil; tomurcuk, yumru ve soğan gibi yapılarda da görülür. Temel amaç, türün veya bireyin ekstrem koşullar altında hayatta kalmasını sağlamak ve çimlenme/gelişme zamanını denetlemektir (Willis et al., 2014). Özellikle çok yıllık yabancı otlarda rizom ve kök parçalarının dormansiye girmesi, kimyasal mücadele sonrası yeniden sürgün vermelerine imkân tanır (Donald, 1994).Tohumsuz bitkilerin sporlarında da görülen dormansi, canlılık fonksiyonlarının minimum düzeyde tutulması sayesinde olumsuz çevresel koşulların geçici olarak atlatılmasını sağlar. Gelişme sürecinde embriyo ve endosperm

yapılarındaki değişimler, dormansi çeşitlerinin farklılaşmasına yol açmış ve türlerin yeni biyomlara uyum sağlayabilme kapasitesini artırmıştır (Finch-Savage and Leubner-Metzger, 2006). Bu durum, yabancı ot popülasyonlarının farklı iklim bölgelerinde uyum kabiliyetini açıklayan en önemli stratejilerden biridir. Bu çalışmanın amacı, farklı çevresel koşulların, özellikle sıcaklık uygulamalarının, tohum dormansisinin kırılmasına etkilerini inceleyerek dormansi mekanizmasının anlaşılmasına katkı sağlamak, dormansiyi etkileyen faktörleri ortaya koymak ve bu süreçlerin bitkilerin çevresel adaptasyon stratejilerindeki rolünü değerlendirmektir. Ayrıca tarımsal üretimde önemli sorunlara yol açan yabancı otların tohum dormansisi ve kırılma yöntemlerinin daha iyi anlaşılması, etkili yabancı ot kontrol stratejilerinin geliştirilmesine katkı sağlayacaktır.

2.DORMANSİNİN BİYOLOJİK YAPISI

Tohumlarda görülen uykuda kalma (dormansi) tipleri, embriyonun gelişim düzeyi ve fizyolojik özellikleriyle ilişkilidir ve bu farklılıklar doğrudan çimlenme sürecini etkiler. Derin fizyolojik dormansiye (deep physiological dormancy, derin PD) sahip tohumlarda embriyolar gelişim göstermediği gibi anormal fide oluşumları da gözlenebilir. Bu tip dormanside gibberellin (GA) uygulaması etkili değildir; çimlenmenin sağlanabilmesi için uzun süreli soğuk (alt tip a) ya da sıcak (alt tip b) tabakalama gerekmektedir (Baskin & Baskin, 2004; Baskin ve ark., 2005). *Acer platanoides* ve *Acer pseudoplatanus* gibi türler bu gruba örnek olarak verilebilir (Finch-Savage ve ark., 1998). Buna karşın, derin olmayan fizyolojik dormansi (non-deep PD) taşıyan tohumlar normal embriyo gelişimine sahiptir ve bu durumda GA uygulaması çimlenmeyi teşvik edebilir. Ayrıca derin olmayan PD, skarifikasyon, kuru depolama sonrası olgunlaşma ya da sıcak/soğuk tabakalama işlemleri ile de ortadan kaldırılabilir (Baskin & Baskin, 2004). Bu tip dormanside çimlenmeye uygun sıcaklık aralığı, türün fizyolojik özelliklerine bağlı olarak zamanla değişir. Örneğin *Arabidopsis thaliana*'da bu aralık düşükten yükseğe doğru genişlerken ,bazı türlerde yüksekten düşüğe doğru daralır. Dormansinin azalmasıyla birlikte tohumların ışık ve GA'ya duyarlılığı da artış gösterir. Morfolojik dormansi (MD), embriyosu yapısal olarak farklılaşmış fakat boyut açısından tam gelişmemiş tohumlarda görülür. Bu tip tohumlar fizyolojik olarak dormansi halinde değildir, ancak embriyonun büyüyüp çimlenmeye hazır hale gelmesi için zamana ihtiyaç vardır. Morfofizyolojik dormansi (MPD) ise hem az gelişmiş embriyo yapısı hem de ek bir fizyolojik engel içerir. Bu nedenle MPD taşıyan tohumlarda dormansinin kırılması için soğuk ve/veya sıcak tabakalama kombinasyonları gerekebilir; bazı durumlarda GA uygulaması da etkili olabilmektedir. MPD'nin sekiz farklı düzeyi rapor edilmiştir ve örnek olarak *Trollius* (Ranunculaceae) ve *Fraxinus excelsior* (Oleaceae) türleri verilebilir (Baskin & Baskin, 2004;). Fiziksel dormansi (PY), tohum veya meyve kabuğunda su geçişini engelleyen palisad hücrelerinin oluşturduğu yapılar nedeniyle ortaya çıkar. Bu tip dormansi, mekanik ya da kimyasal skarifikasyon ile ortadan kaldırılabilir. Fabaceae familyasına ait *Melilotus* ve *Trigonella* cinsleri bu gruba dahildir (Baskin & Baskin, 1998; Baskin, 2003). Son olarak, kombinasyonel dormansi (PY + PD), suya geçirimsiz kabuk yapısı ile birlikte embriyonun fizyolojik dormansiye sahip olduğu durumlarda görülür. Sardunya ve Trifolium bu tip dormansiye sahip türlerdendir (Baskin & Baskin, 2004). Bu sınıflandırmalar, tohumların çimlenme engellerinin anlaşılması açısından büyük önem taşır. Dormansi tiplerinin embriyo gelişimiyle ilişkisi yalnızca ekolojik süreçlerin açıklanmasında değil, aynı zamanda tarımsal üretimde uygun çimlenme stratejilerinin belirlenmesinde de kritik bir rol oynamaktadır.

3.DORMANSİNİN TÜRLERİ

Dormansi, tohumların çimlenmesini sınırlayan doğal bir özelliktir ve bu süreç çevresel faktörlerin (sıcaklık, ışık, nem gibi) yanı sıra absisik asit ve giberellin gibi bitki hormonları tarafından düzenlenir. Bu mekanizma genetik temelli olup, bitki türlerinin yaşam döngüsünde önemli rol oynar. Dormant olmayan tohumlar ise farklı ekolojik koşullarda geniş bir çimlenme yeteneği gösterebilir (Finch-Savage ve Leubner-Metzger, 2006). Baskin ve Baskin (2004) tarafından yapılan tanıma göre, dormant bir tohum

uygun çevresel koşullar (örneğin ışık, sıcaklık, nem) sağlansa bile, dışarıdan özel bir uyarı olmaksızın çimlenemez. Dolayısıyla, bu tür tohumların çimlenebilmesi için önce dormansilerinin kırılması gerekir.

3.1. Fiziksel Dormansi (PY)

Fiziksel dormansi, tohum veya meyve kabuğunda yer alan ve su girişini engelleyen palizat hücrelerinden kaynaklanır. Bu tür dormansiye sahip tohumlarda, çimlenmeyi teşvik edebilmek için çeşitli yöntemler kullanılabilir. Bunlar arasında; mekanik kazıma (örneğin bistüri ile çizilmesi), konsantre sülfürik asitle skarifikasyon, kaynar su uygulaması, yüksek sıcaklıkta inkübasyon (35/20°C veya 40/25°C), etanol veya kuru sıcaklık işlemleri sayılabilir. Ayrıca mekanik veya kimyasal skarifikasyon, yüzeysel fizyolojik dormansiye sahip tohumların çimlenmesini de uyarabilir. Bir türün tohumlarının fiziksel dormansiye sahip olup olmadığını belirlemek için, kazınmış ve kazınmamış tohumların su alımı karşılaştırılır. Kazınmış tohumlar kolaylıkla su emerken, kazınmamış olanlarda yalnızca küçük bir kısmı su alır. Genellikle, PY görülen türlerdeki tohum populasyonlarının çoğu geçirimsizlik nedeniyle su alamazken, az sayıda tohum suyu geçirebilir (Baskin ve Baskin, 2003).

3.2. Morfolojik Dormansi (MD)

Morfolojik dormansiye sahip tohumlarda embriyo genellikle küçük ve tam gelişmemiştir. Bu embriyolar ya farklılaşmamış halde bulunur ya da kısmen gelişmiş olup kotiledonlar ve radikül gibi yapılar ayırt edilebilir. Gelişmemiş ve farklılaşmamış embriyoların çimlenmesi, özel bilgi ve deneyim gerektiren bir araştırma alanıdır (Baskin ve Baskin, 1998). MD, embriyonun boyut bakımından küçük fakat kotiledon ve hipokotil-radikül yapıları belirgin şekilde farklılaşmış olduğu durumlarda görülür. Bu tip embriyolar fizyolojik dormansi göstermediğinden, çimlenme için özel bir dormansi kırma işlemi gerekmez. Ancak gelişimlerini tamamlayıp filizlenmeleri için belirli bir süreye ihtiyaç duyarlar (Finch-Savage ve Leubner-Metzger, 2006).

3.3. Morfofizyolojik Dormansi (MPD)

Morfofizyolojik dormansi, hem yeterince gelişmemiş bir embriyoyu hem de fizyolojik dormansiyi içeren karmaşık bir dormansi tipidir. Bu nedenle, tohumların çimlenebilmesi için dormansi kırma ön işlemlerine ihtiyaç vardır (Baskin ve Baskin, 2004). Çoğunlukla soğuk ve/veya sıcak stratifikasyon uygulamaları, bazen de giberellik asit (GA) uygulaması, embriyo gelişimini ve fizyolojik dormansinin ortadan kalkmasını sağlayarak çimlenmeyi mümkün hale getirir (Finch-Savage ve Leubner-Metzger, 2006).

3.4. Fizyolojik Dormansi (PD)

Fizyolojik dormansi, tohumlarda en yaygın görülen dormansi türüdür. Gymnosperm tohumlarında ve büyük angiosperm gruplarında yaygın olarak bulunur. Ilıman bölgelerdeki tohum bankalarında ve doğal ekosistemlerde en sık rastlanan dormansi tipidir. Dormansinin kırılması sırasında sıcaklık koşulları ve tohumun fizyolojik tepkilerindeki değişimlere bağlı olarak, derin olmayan PD'nin beş farklı tipi tanımlanmıştır (Baskin ve Baskin, 2004).

3.5. Kombinasyonel Dormansi (PY + PD)

Bu dormansi tipinde, tohum ya da meyve kabuğu suya geçirimsizdir (fiziksel dormansi), embriyo ise aynı zamanda fizyolojik dormansi göstermektedir. Literatürde bildirilen örneklerin tamamında fizyolojik dormansi kısmının derin olmayan düzeyde olduğu belirtilmiştir (Baskin ve Baskin, 1998). Tek yıllık kış bitkilerinin bazı türlerinde (örneğin Geranium, Trifolium), olgunlaşan tohumların bir bölümünde embriyolar şartlı dormansi gösterebilir. Bu tür tohumlarda kabuk suya geçirimsiz olmasına rağmen, olgunlaşmadan birkaç hafta sonra kuru depolama koşullarında veya doğal ortamda dormansi kademeli olarak ortadan kalkabilir.

4. TOHUMDA DORMANSİNİN KIRILMASI VE ÇİMLENME

Dormant tohumlar, çimlenme için uygun tüm çevresel koşullar sağlansa bile çimlenemezler; ancak dormansi durumları ortadan kalktıktan sonra çimlenme gerçekleşebilir (Baskin ve Baskin, 2003). Dormansi farklı ekolojik ortamlara uyum sağlamış türlerde değişkenlik gösterebilir ve çimlenmenin başlaması ancak dormansinin kırılmasıyla mümkündür. Çimlenme, dormansisi ortadan kalkmış kuru tohumun su almasıyla başlar, embriyonik eksenin büyümesiyle devam eder ve radikülün tohum kabuğunu aşarak dışarı çıkmasıyla sonlanır (Bewley, 1997a; Finch-Savage ve Leubner-Metzger, 2006). Kuru tohumun su alımı üç aşamada gerçekleşir. Faz 1'de (imbibisyon) hızlı bir su alımı gözlenir. Faz 2'de su miktarı belirli bir seviyede sabitlenir ve artış veya azalış göstermez. Faz 3'te ise su alımı yeniden artar, embriyo ekseni uzamaya başlar ve kabuk (testa ve diğer örtü tabakaları) kırılarak radikül dışarı çıkar (Finch-Savage ve Leubner-Metzger, 2006). Çimlenmenin tamamlanması için embriyodaki hücrelerin büyümesi gereklidir; genellikle radikül çıkışı ve kabuk çatlaması görünür çimlenmenin göstergesi kabul edilir (Bewley, 1997a; Kucera ve ark., 2005). Su alımıyla birlikte, tohum olgunlaşma döneminde sentezlenen ve metabolizmanın yeniden başlaması için gerekli enzimler ve yapılar tekrar aktif hale gelir (Bewley, 1997a). Embriyo hücrelerinde protein sentezi için gerekli bileşenler hazır durumdadır; başlangıçta mevcut ribozomlar kullanılırken, kısa süre içinde yeni ribozomlar ve polizom kompleksleri de oluşturulur (Dommes ve Van de Walle, 1990). Ayrıca, embriyo olgunlaşması sırasında sentezlenmiş ve gelişimle ilgili bilgileri taşıyan bazı mRNA'lar, çimlenmenin erken döneminde geçici olarak kullanılabilir (Comai ve Harada, 1990; Lane, 1991). Çimlenme ilerledikçe ise yeni mRNA'lar sentezlenir ve bunlar büyüme ile hücresel onarım süreçlerinde görev alan proteinleri kodlar (Bewley ve Marcus, 1990). Çimlenme için yalnızca bu sürece özgü bir protein belirleyicisi tanımlanmamış olsa da, belirlenen mRNA'ların çoğunun, depolanan rezervlerin (örneğin endosperm) mobilizasyonu ve dönüşümünde görev alan enzimleri kodladığı düşünülmektedir. Bu mRNA'lar aynı zamanda fide gelişimi sırasında ortaya çıkan postgerminatif süreçlerle de doğrudan ilişkilidir (Bewley, 1997a).

5. YABANCI OTLARDA DORMANSİNİN KIRILMA YÖNTEMLERİ

Yabancı ot tohumlarında dormansi, türlerin toprak tohum bankasında uzun süre canlı kalmasını sağlayan en önemli uyum mekanizmalarından biridir. Dormansi, çimlenmenin çevresel koşullara göre ötelenmesine imkân tanıyarak yabancı ot popülasyonlarının tarımsal alanlarda sürekliliğini garanti altına almaktadır (Baskin & Baskin, 2014). Bu nedenle dormansinin kırılma yöntemlerinin anlaşılması, yabancı ot mücadelesinde etkin stratejiler geliştirilmesi açısından büyük önem taşımaktadır.

5.1. Çevresel Faktörlerle Dormansinin Kırılması

Çoğu yabancı ot türünde dormansi, sıcaklık, ışık ve nem gibi çevresel faktörlerin etkisiyle sona ermektedir. Örneğin *Avena fatua* tohumlarının gelişim döneminde maruz kaldığı sıcaklık ve kuraklık koşulları, daha sonra tohumların dormansi süresini belirlemektedir (Sawhney & Naylor, 1982). *Chenopodium album* ve *Amaranthus retroflexus*'ta gündüz–gece sıcaklık farklılıkları ve ışık, çimlenme sürecini teşvik eden önemli faktörlerdir (Benech-Arnold ve ark., 2000).

5.2. Mekanik ve Fiziksel Yöntemler

Fiziksel dormansi, genellikle tohum kabuğunun geçirimsizliğiyle ilişkilidir. Bu durumda, tohum kabuğunun zımparalanması veya çizilmesi gibi skarifikasyon işlemleri çimlenmeyi kolaylaştırmaktadır. Sert kabuklu yabancı otlarda, örneğin *Malva parviflora* ve *Xanthium strumarium*, mekanik ve sıcak su uygulamalarıyla dormansinin ortadan kaldırılabildiği gösterilmiştir (Michael et al., 2006; Toledo et al., 1993). Ayrıca bazı çok yıllık yabancı otlarda yüksek sıcaklık uygulamalarının çimlenme oranlarını artırdığı rapor edilmiştir. Örneğin, *Cirsium arvense* tohumlarında termal şok uygulamalarının dormansi çözülmesini kolaylaştırdığı belirlenmiştir (Donald, 1994).

5.3. Kimyasal Yöntemler

Dormansi kırılmasında kimyasal uygulamalar da önemli rol oynamaktadır. Özellikle gibberellik asit (GA_3), fizyolojik dormansinin ortadan kaldırılmasında etkin bir hormondur. GA_3 uygulamalarının Avena fatua ve Echinochloa crus-galli gibi problemli türlerde çimlenmeyi artırdığı bildirilmiştir (Adkins et al., 1986; Song et al., 2015). Bunun yanında, potasyum nitrat (KNO_3) ve nitrik asit (HNO_3) gibi kimyasalların uygulanması, sert tohum kabuğunu aşındırarak veya oksidatif etkiyle çimlenmeyi teşvik etmektedir. Örneğin, *Chenopodium album*'da KNO_3 uygulamalarının ışıkla birlikte çimlenmeyi belirgin ölçüde artırdığı ortaya konmuştur (Henson, 1970). Ayrıca absisik asit (ABA) düzeylerinin düşürülmesi ya da etkisinin baskılanması da dormansi kırılmasında kritik bir rol üstlenmektedir (Kucera et al., 2005).

5.4. Biyolojik ve Ekolojik Etkileşimler

Toprak mikroorganizmaları, tohum kabuğunu parçalayarak veya kimyasal yapısını değiştirerek biyolojik skarifikasyon etkisi gösterebilir. Bu durum özellikle sert kabuklu yabancı ot tohumlarında dormansinin ortadan kalkmasını kolaylaştırmaktadır (Chee-Sanford et al., 2006). Ayrıca tarımsal uygulamalar da dormansi kırılmasına katkı sağlamaktadır. Derin toprak işleme gibi yöntemler, gömülü tohumları yüzeye çıkararak ışık ve sıcaklıkla temasını artırır ve bu sayede dormansi çözülerek çimlenme süreci başlar (Cavers and Benoit, 1989).

6. SONUÇ

Dormansi, bitkilerin çevresel koşullara uyum sağlamasında ve nesillerini sürdürebilmesinde kritik bir mekanizma olarak ortaya çıkmaktadır. Tomurcuk, yumru, rizom ve özellikle tohumlarda görülen dormansi, bitkilerin yaşam döngüsünde olumsuz çevresel şartları atlatabilmelerini sağlayan temel stratejilerden biridir. Bu çalışmada özetlenen literatür verileri, tohum dormansisinin biyolojik temelleri, sınıflandırılması ve kırılma mekanizmaları üzerine önemli bilgiler sunmaktadır. Dormansi tipleri (fiziksel, morfolojik, morfofizyolojik, fizyolojik ve kombinasyonel) incelendiğinde, embriyonun gelişim düzeyi, tohum kabuğunun yapısı ve fizyolojik kısıtlamaların türlere göre değişiklik gösterdiği görülmektedir. Örneğin; fiziksel dormansi (PY), tohum kabuğunda su alımını engelleyen yapılar nedeniyle ortaya çıkarken; morfolojik dormansi (MD), embriyonun küçük ve tam gelişmemiş olmasıyla karakterizedir. Morfofizyolojik dormansi (MPD), hem embriyo gelişim eksikliklerini hem de fizyolojik kısıtlamaları içerdiğinden en karmaşık dormansi tiplerinden biri olup, stratifikasyon ve/veya giberellik asit uygulamalarını gerektirir. Fizyolojik dormansi (PD) ise en yaygın görülen tip olup, sıcaklık ve hormonal düzenlemelere duyarlıdır. Kombinasyonel dormansi (PY+PD)'de ise hem kabuk geçirimsizliği hem de fizyolojik kısıtlamalar aynı anda bulunur. Bu çeşitlilik, tohumların farklı ekolojik koşullara uyum sağlayabilmesinde kritik bir rol üstlenmektedir. Dormansinin kırılması ve çimlenmenin başlaması süreci incelendiğinde; çimlenmenin üç aşamalı bir su alımı mekanizması (imbibisyon, plato fazı, radikül çıkışı) ile ilerlediği anlaşılmaktadır. Bu süreçte yalnızca su alımı değil, aynı zamanda metabolik aktivitenin yeniden başlaması da önemlidir. Dormansi süresince askıya alınmış olan enzimler, ribozomlar ve mRNA'lar yeniden aktive olur, yeni proteinler sentezlenir ve embriyonun büyümesiyle radikül tohum kabuğunu kırarak dışarı çıkar. Burada özellikle hormonların (ABA ve GA_3) dengesi, çimlenmenin başlamasında belirleyici faktörlerden biri olarak öne çıkmaktadır. Literatür verileri, dormansi çeşitliliğinin yalnızca ekolojik adaptasyon stratejileri açısından değil, aynı zamanda tarımsal üretimde uygun çimlenme tekniklerinin geliştirilmesi açısından da önem taşıdığını göstermektedir. Tarımsal açıdan değerli birçok türün tohumlarında dormansi, çimlenme oranlarını sınırlayan temel etkenlerden biridir. Bu nedenle, dormansi mekanizmalarının anlaşılması ve uygun kırılma yöntemlerinin (örneğin stratifikasyon, skarifikasyon, sıcaklık uygulamaları, hormon tedavileri) belirlenmesi, hem doğal populasyonların sürdürülebilirliği hem de kültüre alınmış türlerin üretim başarısı için kritik öneme sahiptir. Sonuç olarak, tohum dormansisi; çevresel faktörler, hormonal düzenlemeler ve genetik yapı tarafından kontrol edilen çok boyutlu bir olgudur. Dormansinin biyolojik temellerinin ve kırılma

mekanizmalarının anlaşılması, hem ekoloji hem de tarım bilimleri açısından ileriye dönük araştırmalar için yol gösterici niteliktedir. Gelecekte yapılacak çalışmaların, dormansinin moleküler temellerini daha ayrıntılı aydınlatması ve tarımsal uygulamalara yönelik yeni stratejilerin geliştirilmesine katkı sağlaması beklenmektedir.

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THE IMPACT OF CONSUMER HABITS ON THE E-COMMERCE SECTOR AND THE TRANSFORMATION IN MARKETING STRATEGIES IN THE POST PANDEMIC PERIOD: A COMPARISON OF TRENDYOL, HEPSİBURADA AND AMAZON TURKEY

TÜKETİCİ ALIŞKANLIKLARININ E-TİCARET SEKTÖRÜNE ETKİSİ VE PANDEMİ SONRASI DÖNEMDE PAZARLAMA STRATEJİLERİNDEKİ DÖNÜŞÜM: TRENDYOL, HEPSİBURADA VE AMAZON TÜRKİYE KARŞILAŞTIRMASI

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ABSTRACT

The COVID-19 pandemic has instigated a paradigm shift in consumer behavior, accelerating the adoption of digital channels and fundamentally altering purchasing patterns. This study explores the enduring impact of post-pandemic consumer behavior on the e-commerce sector, with a particular emphasis on the evolving marketing strategies employed by leading e-commerce platforms in Turkey. A comparative analysis is conducted focusing on three dominant market players: Trendyol, Hepsiburada, and Amazon Turkey.

The research begins with a theoretical overview of consumer behavior and purchasing decision models, followed by an in-depth discussion of how the pandemic has disrupted and redefined these processes. Empirical data illustrating the exponential growth of e-commerce during and after the pandemic is presented, providing a foundation for understanding shifts in consumer expectations, preferences, and engagement mechanisms.

Special attention is devoted to the innovative marketing strategies developed in response to this transformation. These include enhanced digital communication, real-time customer interaction, and personalized content delivery. The study examines and contrasts the practical implementations of each platform in areas such as promotional campaigns, customer loyalty programs, last-mile delivery innovations, and data-driven marketing approaches.

Findings suggest that the pandemic served not as a temporary interruption but as a catalyst for lasting behavioral change, prompting a reconfiguration of the e-commerce landscape. In response, firms have significantly intensified their investment in digital infrastructure, user experience optimization, and tailored marketing initiatives to better align with the demands of the "new digital consumer."

This research contributes to the academic discourse on digital consumerism and strategic marketing while offering practical insights for industry stakeholders aiming to navigate the post-pandemic marketplace. The study underscores the necessity for e-commerce enterprises to adopt agile, consumer-centric, and technologically integrated business models in the face of continuous environmental uncertainty.

Keywords: Pandemic, Consumer Behavior, e-Commerce, Digital Marketing

ÖZET

COVID-19 pandemisi, tüketici davranışlarında bir paradigma değişimine yol açarak dijital kanalların benimsenmesini hızlandırmış ve satın alma modellerini kökten değiştirmiştir. Bu çalışma, pandemi

sonrası tüketici davranışının e-ticaret sektörü üzerindeki kalıcı etkisini, özellikle Türkiye'deki önde gelen e-ticaret platformlarının kullandığı gelişen pazarlama stratejilerine odaklanarak incelemektedir. Üç baskın pazar oyuncusu olan Trendyol, Hepsiburada ve Amazon Türkiye'ye odaklanan karşılaştırmalı bir analiz yürütülmektedir.

Araştırma, tüketici davranışı ve satın alma karar modellerine teorik bir genel bakışla başlamakta ve ardından pandeminin bu süreçleri nasıl bozduğu ve yeniden tanımladığı derinlemesine bir tartışmayla devam etmektedir. Pandemi sırasında ve sonrasında e-ticaretin katlanarak büyümesini gösteren ampirik veriler sunulmakta ve tüketici beklentileri, tercihleri ve etkileşim mekanizmalarındaki değişimleri anlamak için bir temel oluşturmaktadır.

Bu dönüşüme yanıt olarak geliştirilen yenilikçi pazarlama stratejilerine özellikle dikkat çekilmektedir. Bunlar arasında gelişmiş dijital iletişim, gerçek zamanlı müşteri etkileşimi ve kişiselleştirilmiş içerik sunumu yer almaktadır. Çalışma, promosyon kampanyaları, müşteri sadakat programları, son mil teslimat yenilikleri ve veri odaklı pazarlama yaklaşımları gibi alanlarda her platformun pratik uygulamalarını incelemekte ve karşılaştırmaktadır.

Bulgular, pandeminin geçici bir kesinti değil, kalıcı davranış değişikliği için bir katalizör görevi gördüğünü ve e-ticaret ortamının yeniden yapılandırılmasına yol açtığını göstermektedir. Buna karşılık, firmalar "yeni dijital tüketici"nin talepleriyle daha iyi uyum sağlamak için dijital altyapıya, kullanıcı deneyimi optimizasyonuna ve özel pazarlama girişimlerine yatırımlarını önemli ölçüde yoğunlaştırmışlardır.

Bu araştırma, pandemi sonrası pazarda yol almayı hedefleyen sektör paydaşlarına pratik içgörüler sunarken, dijital tüketicilik ve stratejik pazarlama konusundaki akademik söyleme katkıda bulunmaktadır.

Anahtar Kelimeler: Pandemi, Tüketici Davranışı, e-Ticaret, Dijital Pazarlama

GİRİŞ

21. yüzyılda dijitalleşme, özellikle internet teknolojilerinin gelişimiyle birlikte ticaret anlayışında köklü dönüşümler yaratmıştır. E-ticaret, bu dönüşümün en somut örneklerinden biri olarak, tüketicilerin ürün ve hizmetlere erişim biçimini değiştirmiştir. İnternet kullanıcı sayısındaki artış, mobil teknolojilerin yaygınlaşması ve güvenilir dijital ödeme sistemleri, küresel ölçekte e-ticaretin hızlı büyümesine imkân sağlamıştır (Laudon & Traver, 2020; Chaffey, 2019).

COVID-19 pandemisi, e-ticaretin yükselişini hızlandıran en önemli faktörlerden biri olmuştur. Sosyal izolasyon ve fiziksel mağazaların kapanması, tüketicileri dijital alışverişe yöneltmiş, bu dönemde Türkiye'de e-ticaret hacmi %66 oranında artış göstermiştir (TÜİK, 2021). Benzer şekilde küresel ölçekte de dikkat çekici büyüme yaşanmıştır (Statista, 2021).

Pandemi sonrası tüketici davranışlarında sağlık, hijyen ve temassız teslimat beklentileri öne çıkmış; dijital kanallarda ürün karşılaştırma, fiyat araştırma ve müşteri yorumlarını inceleme gibi bilinçli alışveriş davranışları yaygınlaşmıştır. Türkiye'nin önde gelen e-ticaret platformları olan Trendyol, Hepsiburada ve n11, bu değişime uyum sağlamak amacıyla dijital altyapılarını güçlendirmiş, veri analitiği ve yapay zekâ tabanlı kişiselleştirilmiş öneriler geliştirmiş, lojistik yatırımlarla hızlı ve temassız teslimat hizmetlerini artırmışlardır (Ticaret Bakanlığı, 2021).

Tüketici Davranışları ve Pandemi Etkisi

Tüketici davranışları, bireylerin mal ve hizmetleri seçme, satın alma, kullanma ve değerlendirme sürecinde sergiledikleri zihinsel, duygusal ve fiziksel faaliyetlerdir (Solomon, 2018). Bu kavram,

yalnızca satın alma öncesi değil, satın alma sırasındaki ve sonrasındaki karar süreçlerini de içerir. Karar verme süreci; psikolojik, sosyokültürel, ekonomik ve durumsal faktörlerden etkilenir (Schiffman & Wisenblit, 2019; Kotler & Keller, 2016). İşletmeler için tüketici davranışlarını anlamak, rekabet gücü açısından stratejik önem taşır.

Tüketici davranışlarını belirleyen faktörler dört başlıkta toplanır:

- **Kişisel faktörler:** Yaş, gelir, eğitim, yaşam tarzı gibi özelliklerdir. Gençler daha çok dijital ürünlere yönelirken, ileri yaş grupları temel ihtiyaçları önceliklendirir (Blackwell, Miniard & Engel, 2006).
- **Psikolojik faktörler:** Motivasyon, algı, tutum ve öğrenme gibi unsurlar tüketim kararlarını etkiler. Maslow'un ihtiyaçlar hiyerarşisi bu duruma açıklık getirir (Solomon, 2018).
- **Sosyokültürel faktörler:** Aile, sosyal çevre, kültür ve sınıf, bireyin kararlarını yönlendirir (Schiffman & Wisenblit, 2019).
- **Durumsal faktörler:** Zaman baskısı, mağaza ortamı, hava durumu gibi anlık etkiler satın alma davranışını değiştirebilir (Kotler & Keller, 2016).

Tarihsel süreçte tüketici davranışları da dönüşüm geçirmiştir. Sanayi Devrimi öncesinde tüketim ihtiyaç temelli iken, seri üretim ve reklamcılıkla birlikte "istekler" ön plana çıkmıştır. Günümüzde tüketiciler yalnızca fiyat ve kaliteye değil, markanın sunduğu deneyime, sosyal sorumluluklarına ve çevre duyarlılığına da önem vermektedir (Belk, 1988). Teknolojinin yaygınlaşmasıyla tüketiciler daha bilinçli hale gelmiş; sosyal medya, uygulamalar ve kullanıcı yorumları karar süreçlerini etkilemiştir (Rahman, Islam & Esha, 2018).

Pandemi Öncesi Tüketici Alışkanlıkları

Pandemi öncesinde tüketiciler hem fiziksel mağazaları hem de dijital platformları kullanıyordu. Ancak Türkiye'de e-ticaretin perakende içindeki payı 2019'da yalnızca %7,5'ti (TÜİK, 2020). Güven unsuru ön plandaydı; marka itibarı, ürün kalitesi ve mağaza güvenilirliği önemliydi. Fiziksel mağazalar, ürünü görme ve deneme imkânı sağladığı için tercih edilmeye devam ediyordu. Bununla birlikte, genç kuşak kolaylık ve çeşitlilik nedeniyle online alışverişe yönelmekteydi (Demir, 2019).

Avrupa ve ABD'de çok kanallı (omnichannel) alışveriş yaygınlaşırken (Verhoef, Kannan & Inman, 2017), Türkiye'de aile yapısı ve kültürel faktörler tüketim kararlarında belirleyici olmaya devam etmiştir. Ayrıca indirim, kampanya ve fiyat odaklı alışveriş yaygındı. Çevre duyarlılığı ve etik tüketim ise özellikle gençlerde önem kazanmaya başlamıştı (Aydın & Korkmaz, 2019).

Pandemi Sürecinde Değişen Alışkanlıklar

COVID-19, tüketici alışkanlıklarında hızlı ve kalıcı dönüşümler yaratmıştır. Karantina ve mağaza kapanmaları fiziksel alışverişi sınırlamış, online kanallar öne çıkmıştır. Türkiye'de e-ticaret hacmi 2020'de %66 artmıştır (TÜİK, 2021). Bu dönemde güvenlik, hijyen ve temassız alışveriş öncelikli hale gelmiş, panik satın alma ve stoklama davranışları gözlenmiştir (Laato, 2020).

Marka tercihlerinde de değişim yaşanmış; güvenilir, hijyenik hizmet veren işletmeler avantaj sağlamış, yerel üreticilere yönelim artmış ayrıca fiyat duyarlılığı yükselmiştir. Sosyal medya, mobil uygulamalar ve influencer pazarlaması tüketici kararlarında daha etkili hale gelmiştir. Evde geçirilen sürenin artmasıyla ev dekorasyonu, teknoloji ve hobi ürünlerine talep yükselmiştir. Pandemi aynı zamanda çevre dostu ve etik değerlere sahip ürünlere ilgiyi güçlendirmiştir (Kantar, 2020).

Dijital Tüketici Profili

Pandemiyle birlikte **dijital tüketici profili** öne çıkmıştır. Dijital tüketiciler bilgiye hızlı ulaşan, ürün karşılaştırması yapan ve sosyal medya ile kullanıcı yorumlarından etkilenen bireylerdir. Özellikle Z

kuşağı ve milenyaller bu gruptadır. Türkiye'de yapılan araştırmalar, influencer'ların karar alma süreçlerinde önemli rol oynadığını göstermektedir (Çelik & Yılmaz, 2020).

Mobil cihazların yaygınlaşmasıyla alışverişlerin çoğu telefonlar üzerinden yapılmaktadır (TÜBİSAD, 2021). Yapay zekâ destekli öneriler, chatbotlar ve kişiselleştirilmiş reklamlar, tüketicilerin deneyimlerini güçlendirmektedir. Bununla birlikte, veri güvenliği kaygıları artmıştır; Türkiye'de tüketicilerin %65'i bu nedenle online alışverişte çekimserdir. İşletmeler bu nedenle güvenilir ödeme sistemleri, hızlı teslimat ve şeffaf veri politikaları geliştirmek zorundadır (Çelik & Yılmaz, 2020).

Türkiye'nin Önde Gelen E-Ticaret Markalarının Pazarlama Stratejileri

Pandemi süreci, Türkiye'de alışveriş alışkanlıklarını köklü şekilde değiştirmiş, tüketicilerin fiziksel mağazalardan dijital platformlara yönelmesini hızlandırmıştır. Bu dönüşüm, yalnızca teknolojik değil, pazarlama stratejilerinde de büyük değişiklikleri beraberinde getirmiştir. Trendyol, Hepsiburada ve Amazon Türkiye, hızlı, güvenli ve kişiselleştirilmiş deneyim sunan stratejileriyle ön plana çıkmıştır. Bu markalar; dijital pazarlama, müşteri deneyimi, lojistik altyapı, kişiselleştirme ve sosyal medya odaklı kampanyalar aracılığıyla kullanıcı bağlılığını artırmaktadır. Türkiye e-ticaret hacmi 2019'da 136 milyar TL iken, 2022'de 800 milyar TL'yi aşmış, bu büyümede pandemi etkisi belirgin olmuştur (Ticaret Bakanlığı, 2023).

Trendyol'un Pazarlama Stratejileri

Trendyol, 2010 yılında Türkiye merkezli olarak kurulan ve Alibaba ile stratejik iş birliği sonrası uluslararası yatırımlar alarak büyüyen bir e-ticaret platformudur. Özellikle pandemi sonrasında gerçekleştirdiği kampanyalar, dijital reklam çalışmaları ve kullanıcı deneyimine yönelik projeler sayesinde Türkiye'nin en çok tercih edilen online alışveriş sitelerinden biri haline gelmiştir. Trendyol'un pazarlama yaklaşımında temel odak noktaları; kişiselleştirme, dijital entegrasyon, sosyal medya iş birlikleri ve mobil deneyimdir.

Kişiselleştirme alanında Trendyol, ileri düzey veri analitiği kullanarak kullanıcıların önceki alışverişleri, inceledikleri ürünler ve davranış kalıpları üzerinden öneriler sunmaktadır. Mobil uygulamadaki ana sayfa, her kullanıcıya özel olarak düzenlenir; sık ziyaret edilen kategoriler, favori markalar ve kampanya zamanlamaları bu algoritmalarla eşleştirilir (ticaret bakanlığı, 2023). Bu yapay zekâ destekli sistem, sadece müşteri memnuniyetini artırmakla kalmaz, aynı zamanda sepet tutarını yükseltir ve tekrar alışveriş oranını artırır.

Sosyal medya ve Influencer iş birlikleri, özellikle genç kullanıcı kitlesi ile kurulan bağı güçlendirmektedir. Instagram, tiktok ve youtube üzerinde binlerce mikro ve makro influencer ile çalışan Trendyol, marka görünürlüğünü artırmakta ve doğal içeriklerle hedef kitlesini yönlendirmektedir. örnek olarak, iş birlikli "haul" videoları, yeni ürün lansmanları ve kampanya tanıtımları bu stratejinin önemli unsurlarıdır. kampanya dönemlerinde sosyal medya etkileşimleri milyonlara ulaşmakta ve platformun dijital görünürlüğünü pekiştirmektedir (trendyol basın bülteni, 2023).

Mobil uygulama yatırımları ve geliştirmeleri de dikkat çekicidir. 2022'de Türkiye'de en çok indirilen alışveriş uygulaması olan trendyol, kullanıcı deneyimini iyileştirmek için sürekli arayüz güncellemeleri ve geri bildirimlere dayalı iyileştirmeler yapmaktadır. hızlı kargo entegrasyonu, sipariş takibi ve anlık kampanya bildirimleri gibi özellikler, kullanıcıların uygulamaya bağlılığını artırmaktadır.

Kampanya yönetiminde Trendyol, agresif bir yaklaşım izlemektedir. "Trendyol günleri", "11.11 alışveriş festivali" ve "black friday" gibi dönemlerde yüksek indirim oranlarıyla geniş kitlelere ulaşmakta; dijital reklamlar ve tv reklamlarıyla da çevrimdışı görünürlüğünü korumaktadır. Ayrıca Trendyol cüzdan, Trendyol yemek ve Trendyol market gibi yan platformlarla ekosistemini genişletmiş ve çapraz satış stratejileriyle kullanıcı bağlılığını güçlendirmiştir.

Trendyol'un pazarlama stratejisi, tüketici verilerini merkeze alan, teknoloji destekli altyapısı ile kişiselleştirmeye ve genç kullanıcı diline odaklanan bir modeldir. Türkiye e-ticaret pazarında lider olmasının temel nedeni, yalnızca geniş ürün çeşitliliği veya lojistik gücü değil, aynı zamanda bu bütüncül dijital pazarlama yaklaşımıdır.

Hepsiburada'nın Pazarlama Stratejileri

Hepsiburada, 2001 yılında kurulan ve Türkiye'nin dijital dönüşümüne öncülük eden en köklü e-ticaret markalarından biridir. pandemi öncesinde zaten geniş bir kullanıcı kitlesine sahip olan platform, covid-19 süreciyle birlikte pazarlama stratejilerinde önemli değişiklikler yaparak rekabet avantajını artırmıştır. markanın stratejisi, temel olarak kullanıcı deneyimi, hızlı teslimat altyapısı, veri odaklı kişiselleştirme ve güven odaklı marka konumlandırması etrafında şekillenmektedir.

Firma, yalnızca ürün satışı yapmakla kalmayıp teslimat, iade, destek ve ödeme süreçlerini kapsayan bütüncül bir deneyim sunmayı amaçlamaktadır. bu doğrultuda kendi lojistik ağı olan "hepsijet"i geliştirmiş ve siparişlerin büyük kısmını 24 saat içinde ulaştırmayı başarmıştır. hızlı teslimat, pazarlama stratejisinde güçlü bir satış vaadi olarak öne çıkmakta, kampanya dönemlerinde verilen taahhüt sürelerinin karşılanması ise marka güvenini pekiştirmektedir (hepsiburada yatırımcı raporu, 2023).

Müşteri ilişkilerini güçlendirmek için veri temelli kişiselleştirme önemli bir araçtır. kullanıcı geçmişi, sepet verileri ve gezinme alışkanlıkları analiz edilerek kişiye özel kampanya ve ürün önerileri sunulmaktadır. site içi davranış analizleri sayesinde anlık kampanya pop-up'ları, mobil bildirimler ve e-posta içerikleri kullanıcıya ulaştırılmakta, bu sayede dönüşüm oranları ve sadakat artırılmaktadır. abonelik modeli "hepsiburada premium" ile müşteri segmentasyonu daha detaylı yapılmakta, seçili kullanıcılara özel indirimler sunulmaktadır.

Sosyal medya ve dijital reklamlar alanında hepsiburada, kurumsal ve güven temelli bir iletişim dili kullanmaktadır. instagram, youtube ve twitter gibi mecralarda aktif olsa da genç kitle odaklı agresif strateji yerine, teknoloji ve aile alışverişine yönelik içeriklerle geniş bir yaş aralığına hitap etmeyi hedefler. reklam çalışmalarında sıkça "güvenilirlik" ve "yerli platform" vurgusu yapılmakta, tüketicide milli aidiyet duygusu pekiştirilmektedir. örnek olarak pandemi döneminde başlatılan "hepsiburada kadın girişimci programı" ve "e-ticaret kadın gücü" kampanyaları, sosyal sorumluluk odaklı pazarlamanın güçlü bir örneğidir.

Dijital pazarlamada programatik reklamcılık yöntemleri kullanılmaktadır. google ads, youtube reklamları ve mobil banner'larla kullanıcı davranışlarına göre yeniden hedefleme yapılmakta; site ziyaretinden sonra farklı platformlarda görülen reklamlar bunun doğrudan sonucudur. içerik pazarlaması kapsamında blog yazıları, teknoloji incelemeleri ve rehber videoları ile seo gücü artırılmakta ve kullanıcıya faydalı bilgiler sunularak marka güveni pekiştirilmektedir.

Müşteri hizmetleri tarafında 7/24 canlı destek, whatsapp ve çağrı merkezi entegrasyonu ile memnuniyet artırılmaktadır. "müşteri memnuniyeti garantisi" kapsamında sunulan iade ve değişim kolaylıkları, alışveriş kararlarında güven unsurunu güçlendirir. kullanıcıların puanlama, yorum ve soru sorma gibi sistemlerle aktif rol alması, organik trafik ve içerik etkileşimini artırmaktadır.

Genel olarak hepsiburada'nın pazarlama yaklaşımı, güven, hız, kullanıcı memnuniyeti ve veri temelli kişiselleştirme üzerine odaklanmaktadır. agresif kampanya dili yerine sade ve güvenilir iletişimle uzun vadeli müşteri ilişkileri kurmayı hedeflemekte, pandemi sonrası artan online alışveriş beklentilerini karşılayarak pazardaki güçlü konumunu korumaktadır.

Amazon Türkiye'nin Pazarlama Stratejileri

Amazon, dünya genelinde e-ticaretin standartlarını belirleyen ve teknoloji odaklı pazarlama stratejileriyle global ölçekte başarı sağlayan bir markadır. Türkiye pazarına 2018 yılında giriş yapan amazon Türkiye, kısa sürede geniş ürün yelpazesi, kullanıcı dostu arayüz ve prime hizmetleriyle dikkat

çekmiştir. ancak yerel rakiplerle rekabet, markayı hem küresel stratejilerini Türkiye'ye uyarlamaya hem de yerel tüketici davranışlarına göre özelleştirmeler yapmaya zorlamıştır.

Amazon'un pazarlama stratejisi üç ana eksen üzerine kuruludur: müşteri merkezlilik, veri temelli kişiselleştirme ve operasyonel verimlilik. Türkiye pazarında da bu stratejiler uygulanmakta, ancak yerel rekabet nedeniyle bazı farklılıklar görülmektedir. lansman döneminden itibaren "güvenilir alışveriş", "hızlı teslimat" ve "koşulsuz iade" gibi değer önermeleri öne çıkarılmıştır. prime üyelik sistemi, platformdaki pazarlama stratejisinin en kritik öğesidir; aylık düşük ücretle sunulan üyelik, hızlı teslimat, ücretsiz kargo, prime video erişimi ve özel indirimler gibi avantajlarla kullanıcı bağlılığını artırmayı hedefler. özellikle pandemi döneminde hızlı teslimat hizmeti büyük bir rekabet avantajı sağlamıştır (amazon.com.tr, 2023).

Amazon Türkiye'nin dijital pazarlamasında öne çıkan unsur, sessiz ama etkili reklam anlayışıdır. agresif kampanya dilinden ziyade algoritma temelli kişiselleştirme ön plandadır. kullanıcıya özel ürün önerileri, sepet hatırlatmaları ve e-posta kampanyaları bu stratejinin temel unsurlarıdır. gelişmiş yapay zekâ algoritmaları, kullanıcıların gezinme davranışına göre ana sayfa, kategori sıralamaları ve öneri listelerini dinamik olarak düzenler. sosyal medya reklamcılığı alanında ise youtube, google ads ve meta platformlarında hedefli kampanyalar yürütülmekte, bilgilendirici ve sade içerikler sunulmakta; yerel influencer iş birlikleri sınırlı düzeyde kalmaktadır. Bu yaklaşım, amazon'un "yüksek teknoloji, düşük gösteriş" anlayışını yansıtmaktadır.

Müşteri hizmetlerinde ise sistematik ve güven temelli bir yaklaşım benimsenmiştir. "koşulsuz iade" politikası ve hızlı dijital destek, kullanıcı memnuniyetini artırmakta, sipariş durumu hakkında anlık bilgilendirme ve tahmin edilebilir teslimat günleri, müşteri bağlılığını güçlendirmektedir. ürün çeşitliliği açısından amazon Türkiye, yerli satıcıları platforma çekmek için "amazon satıcı hesabı" sistemini teşvik etmiş ve binlerce KOBİ'nin satış yapmasını kolaylaştırmıştır. bu sayede pazarlama faaliyetlerinde b2b ve b2c stratejileri eş zamanlı yürütülmektedir. 2023 itibarıyla amazon Türkiye, yerli tedarikçilerle iş birliği yaparak e-ticaretin yerlileşmesine katkı sağlamaktadır.

Amazon Türkiye'nin pazarlama stratejisi, küresel deneyimi yerel pazar dinamikleriyle entegre etme becerisiyle öne çıkar. Düşük maliyetli ama yüksek hizmet kalitesi sunarak marka sadakati oluşturmakta, veri analitiği ve kişiselleştirme ile satış süreçlerini optimize etmektedir. orta ve uzun vadede sürdürülebilir büyüme için, yerel kullanıcıyla daha fazla sosyal etkileşim kuracak stratejilere yönelmesi beklenmektedir.

Karşılaştırmalı Değerlendirme

Pandemi sonrası e-ticaret sektörü, dünya genelinde olduğu gibi Türkiye'de de hızlı bir dönüşüm yaşamış, fiziksel alışverişten dijital platformlara yönelim artmış ve bu süreç bir alışkanlık haline gelmiştir. bu değişim, trendyol, hepsiburada ve amazon Türkiye gibi önde gelen e-ticaret oyuncularının pazarlama stratejilerini yeniden şekillendirmelerini zorunlu kılmıştır. Trendyol, yerli bir girişim olarak doğmuş ve özellikle pandemiyle birlikte hızla büyüyerek genç ve dinamik kullanıcı kitlesine hitap eden bir marka kimliği geliştirmiştir. agresif kampanyalar, sosyal medya etkileşimi ve influencer iş birlikleri, "efsane kasım" ve "trendyol günleri" gibi dönemsel kampanyalar marka bilinirliğini ve alışveriş trafiğini artırmaktadır. ayrıca trendyol cüzdan, trendyol yemek ve trendyol market gibi alt hizmetlerle kullanıcıları kendi dijital ekosisteminde tutmaktadır.

Hepsiburada, 2001'den beri faaliyet gösteren köklü bir marka olarak güven, hizmet kalitesi ve müşteri memnuniyeti temelli bir pazarlama stratejisi izlemektedir. kampanya dönemlerinde "hepsiburada premium" üyelerine özel fırsatlar sunulmakta, uzun vadeli sadakat oluşturulmaya çalışılmaktadır. hızlı teslimat ve sorunsuz iade süreçleri, kendi lojistik ağı hepsijet sayesinde sağlanmakta; kadın girişimcileri destekleyen programlar ve yerli üretici kampanyaları ile toplumsal imaj güçlendirilmektedir.

Amazon Türkiye ise 2018'de pazara giriş yapmış olmasına rağmen küresel marka deneyimi, teknolojik altyapı ve prime hizmetleriyle kısa sürede ciddi kullanıcı kitlesi kazanmıştır. amazon, sessiz ama etkili bir pazarlama yaklaşımı benimser; sistem içi kişiselleştirilmiş öneriler, prime üyelik avantajları ve algoritma temelli ürün yönlendirmeleriyle kullanıcı deneyimini derinlemesine optimize eder. dijital pazarlama görünürlüğü daha az olsa da veri ve yapay zekâ tabanlı kişiselleştirme stratejisi ön plandadır.

Üç markanın stratejileri karşılaştırıldığında; trendyol genç ve kampanya odaklı, hepsiburada güven ve hizmet temelli, amazon ise veri odaklı ve kişiselleştirilmiş deneyim sunan bir yaklaşım izlemektedir. teslimat ve lojistik açısından hepsijet, trendyol'un bölgesel dağıtım merkezleri ve amazon prime sistemleri rekabetin hizmet kalitesi boyutunu belirlemektedir. sonuç olarak, her üç marka da pandemi sonrası değişen tüketici beklentilerine uyum sağlayarak kullanıcı deneyimini merkeze alan stratejiler geliştirmiş, sektördeki konumlarını güçlendirmiştir. türkiye e-ticaret pazarı, yenilikçi ve teknoloji odaklı yapısıyla bu üç güçlü markanın yönlendirmesiyle şekillenmeye devam etmektedir.

- Trendyol, genç ve dijital odaklı kullanıcıları hedefler.
- Hepsiburada, güven, hızlı teslimat ve uzun vadeli müşteri bağlılığı sağlar.
- Amazon Türkiye, kişiselleştirilmiş veri analitiği ve global operasyonel deneyimi ile öne çıkar.

Her üç marka, pandemi sonrası değişen tüketici beklentilerine uygun pazarlama stratejileri geliştirmiş, kullanıcı deneyimini merkeze alarak sadakat yaratmayı başarmıştır. Türkiye e-ticaret pazarı, dinamik ve teknoloji odaklı bir ekosistem olarak şekillenmektedir.

Tablo 1. Karşılaştırma Tablosu

Marka	Odak Noktası	Pazarlama Dili	Hedef Kitle	Lojistik ve Sadakat
Trendyol	Agresif kampanya & genç odaklı	Dinamik, sosyal medya dostu	Genç kullanıcılar	Trendyol Cüzdan ve yan platformlarla ekosistem bağlılığı
Hepsiburada	Güven & hizmet kalitesi	Kurumsal, güven temelli	Geniş yaş aralığı	HepsiJet hızlı teslimat & Premium üyelik
Amazon TR	Veri ve algoritma odaklı	Sade, bilgi temelli	Her yaş, küresel deneyim	Prime hizmetleri & KOBİ entegrasyonu

SONUÇ

Bu çalışmada, pandemi sonrası Türkiye'de tüketici davranışlarında meydana gelen köklü değişimler ve e-ticaret sektörüne etkileri incelenmiştir. Pandemi süreci, fiziksel temasın azalması, evde geçirilen sürenin artması ve sağlık kaygıları gibi faktörlerle tüketicilerin alışveriş alışkanlıklarını değiştirmiştir. Bu değişim, dijital altyapı yatırımlarını hızlandırmış ve online alışverişe güveni artırmıştır. Tüketiciler artık hızlı teslimat, güvenilir ödeme, kolay iade ve kişiselleştirilmiş hizmet gibi kriterleri ön planda tutmaktadır. Bilgiye erişim ve dijital okuryazarlığın artması, çevrimiçi satın alma kararlarını etkileyen temel unsurları oluşturmuştur.

Trendyol, Hepsiburada ve Amazon Türkiye'nin pandemi sonrası pazarlama stratejileri incelendiğinde, her markanın dijitalleşmeye hızlı uyum sağladığı, müşteri deneyimini geliştirdiği ve rekabet avantajı için yenilikçi yöntemler benimsediği görülmüştür. Trendyol, sosyal medya ve kampanyalara dayalı dinamik bir stratejiyle genç kullanıcıları hedeflerken; Hepsiburada daha güven odaklı ve kurumsal bir

yaklaşım benimsemiştir. Amazon Türkiye ise global deneyimini Türkiye'ye uyarlayarak Prime üyelik ve veri odaklı kişiselleştirme ile farklı bir müşteri deneyimi sunmaktadır. Bu değişimler, e-ticaret sektöründe yalnızca ticari bir dönüşüm değil, tüketici alışkanlıklarında kalıcı bir evrimi göstermektedir.

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THE IMPACTS OF SELF-DIAGNOSING MENTAL HEALTH DISORDERS THROUGH SOCIAL MEDIA IN YOUNG ADULTS

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ABSTRACT

In recent years, mental health challenges have garnered significant and warranted attention beyond clinical settings. However, this increased awareness has coincided with a concerning trend among the younger generation: the informal adoption of psychiatric diagnoses, such as ADHD, Autism Spectrum Disorder, and Bipolar Disorder, as colloquial terms. This phenomenon presents several key issues. Firstly, individuals may prematurely identify as having a mental illness without professional consultation, potentially influencing their internal dialogue and subconscious, thereby inducing unnecessary psychological distress. Secondly, and more critically, this mindset can lead to the justification of maladaptive behaviours by attributing them to purported mental health conditions. This not only perpetuates existing societal stigmas but also trivializes genuinely debilitating psychiatric diagnoses.

To investigate the impact of this trend on the daily lives of young adults and its influence on help-seeking behaviours, a quantitative study was conducted. Online surveys were distributed to a diverse cohort of university students (aged 18-25) across various faculties in Tbilisi, Georgia. The collected data, processed using Google Forms and Excel, was integrated into a comprehensive literature review. Our analysis revealed contrasting patterns in the perception and management of mental health concerns. Notably, a clear correlation was observed between social media awareness campaigns and an increased propensity for seeking professional help.

The interplay between social media and mental health represents a potent force that, when appropriately understood and strategically leveraged, can serve as a valuable asset in preventative strategies and management planning for the aforementioned psychiatric conditions. This underscores the critical importance of ensuring the accessibility of only reliable and evidence-based resources online.

Keywords: Self-diagnosis, Social Media, Mental Health

THE RELATIONSHIP BETWEEN PSYCHOLOGICAL RESILIENCE AND JOB STRESS: THE CASE OF KAHRAMANMARAŞ SOCIAL SERVICE WORKERS

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ABSTRACT

Psychological resilience is a concept related to coping and being successful in the face of adversities that people may encounter even under very difficult conditions. Job stress is associated with the physiological and psychological adverse reactions that occur in the body of employees in the face of the difficulties they experience in their work. This study aims to determine the effect of psychological resilience on job stress in professional social workers. It was examined whether there is an increase or decrease in work stress in social service employees working in Kahramanmaraş Provincial Directorate of Social Services according to their psychological resilience levels. This study is essential in understanding the effect of psychological resilience levels and work stress of social service employees in a city that has experienced earthquakes, which are expressed as the disaster of the century, and whose effects continue from the moment of the quake. In the quantitative research, data were collected using a questionnaire. Data were collected from 213 employees working in the Kahramanmaraş Provincial Directorate of Social Services. Firstly, frequency analysis, normality findings, and Cronbach's alpha reliability values were examined in the SPSS programme. Correlation and regression analyses were used to determine the effect of psychological resilience levels of social service employees on job stress. As a result of the research, it was seen that psychological resilience significantly affected job stress. It was concluded that job stress decreases as the level of psychological resilience increases in social service employees. It is recommended that managers of social service workers who continue to work under harsh conditions after the earthquake should develop policies and practices to increase the psychological resilience levels of employees to reduce their work stress.

Keywords: Psychological resilience, job stress, social service workers.

INTRODUCTION

This study aims to investigate the impact of psychological resilience on job stress among professional social workers. It was examined whether there is an increase or decrease in work stress among social service employees working in the Kahramanmaraş Provincial Directorate of Social Services, according to their psychological resilience levels.

PSYCHOLOGICAL RESILIENCE

Individuals generally face a range of obstacles and challenges throughout their lives, encompassing minor inconveniences to significant life events (Fletcher & Sarkar, 2013). Resilience, a phrase originating from ecology, refers to an ecosystem's capacity to recover or prevent damage when disrupted. The term resilience today commonly denotes a psychological significance. Resilience is the capacity to recover or surmount adversity, resulting in favorable outcomes despite encountering a negative incident or circumstance (Vella & Pai, 2019). Resilient individuals can reconstruct their lives

through a 'positive development' of their life project, regardless of external circumstances. They cultivate the capacity to amalgamate sorrow and psychological fragility with personal, familial, relational, and existential resources, successfully augmenting them in accordance with their requirements (Sisto et al., 2019).

JOB STRESS,

An individual's response to a specific stressor is contingent upon numerous personal characteristics. When an individual's stress threshold is exceeded, signs of stress manifest. Physiological stress symptoms can be categorized as short-term manifestations, such as headaches; long-term consequences, such as ulcers, hypertension, or myocardial infarctions; and nonspecific indicators, such as gastric acid production. Psychological responses encompass symptoms such as indifference, amnesia, discontent, impatience, and dissatisfaction. The individual behavioral repercussions of stress may include diminished appetite, fluctuations in weight, alterations in smoking patterns, variations in alcohol intake, and sudden changes in appearance (Lee Larson, 2004: 1120). Job stress is characterized by an employee's recognition or sensation of personal dysfunction stemming from perceived circumstances or events in the workplace, along with the psychological and physiological responses elicited by these distressing, unwelcome, or threatening elements in the employee's immediate work environment (Montgomery et al., 1996). The influence of job stress on the workplace and employees has been examined in recent decades, as it represents a critical factor for any human resource organization. Organizations must ensure the mental and physical well-being of their employees to achieve optimal quality (Singh et al., 2019). Job stress adversely impacts various elements, including workload, turnover intention, job burnout, emotional exhaustion, depersonalization, and diminished personal achievement, which in turn have a detrimental influence on an individual's work-related behaviors (Bakan et al., 2017).

In this study, it is predicted that psychological resilience will increase job stress, and the research hypothesis is formulated as follows:

H1. Psychological resilience has a negative effect on job stress.

Research Model and Hypotheses

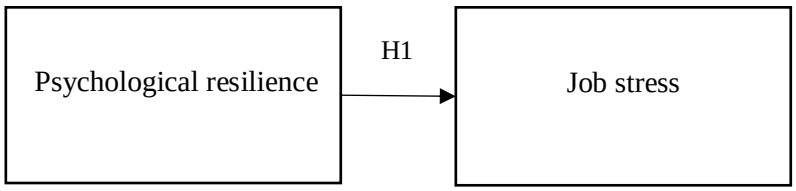


Figure1. Research Model

H1. Psychological resilience has a negative effect on job stress.

RESEARCH METHOD

In the quantitative research, data were collected using a questionnaire. Data were collected from 213 employees working in the Kahramanmaraş Provincial Directorate of Social Services. Firstly, frequency analysis, normality findings, and Cronbach's alpha reliability values were examined in the SPSS programme. Correlation and regression analyses were used to determine the effect of psychological resilience levels of social service employees on job stress.

The Psychological Resilience Scale was developed by Smith et al. (2008) to measure the psychological resilience of individuals. It was adapted into Turkish by Doğan (2015), and validity and reliability studies were conducted. It consists of 6 statements. To measure the statements, the questionnaire was coded as follows: "1. not at all suitable" and "5. completely suitable".

For Job Stress, the Job Stress Scale was developed by Arkun Tatar. (2020). It consists of 20 statements. To measure the statements, the questionnaire was coded as follows: "1. not at all suitable" and "5. completely suitable".

Reliability of the Research

The reliability of the scales was tested using Cronbach's Alpha. Cronbach's Alpha values are given in Table 1. The Cronbach's Alpha coefficients of the variables were 0.759 for psychological resilience and 0.928 for career satisfaction.

Table 1. Reliability Table of Psychological Resilience, Job Stress Variables

Variables	Number of Statements	Cronbach's Alpha
Psychological resilience	6	0,759
Job stress	20	0,928

Table 2 presents the findings on normality. Although various tests are conducted to determine the normal distribution of data in general, in the field of the Social Sciences, normal distribution can be determined by examining skewness and kurtosis values. It is seen that the data are between +1 and -1. According to these findings, it is evident that the kurtosis and skewness values fall within the required range and are typically distributed.

Table 2. Normality Findings for Psychological Resilience, Job Stress

Variables	Mean	Median	Std. Dev.	Skewness	Curtosis
Psychological resilience	3.3375	3.3333	0.77042	-0,106	0.012
Job Stress	2.5350	2.5000	0.84529	0,328	-0.118

FINDINGS

Correlation Analysis

The correlation between psychological resilience and job stress is shown in Table 5. The findings indicate a significant negative relationship between psychological resilience and job stress ($r = -0.387^{**}$, $p < 0.01$).

Table 3. Psychological Resilience, Job Stress Correlation Table

Variables	1	2
1. Psychological resilience	1	
2. Job Stress	$-.387^{**}$	1

** p< 0.01

Regression Analysis

Table 4. Regression Analysis of Psychological Resilience and Career Satisfaction

Variables	***Beta***	***t***	***p***
Psychological resilience (Independent)	-0.387	-6.106	<.001
Job Stress (Dependent)			
R^2: .150 Adj R^2: .146	F: 37.279		p: <.001

The results of the regression analysis on the effect of Psychological resilience on job stress are shown in Table 4. As a result of the simple linear regression analysis conducted to test the hypothesis "H1. Psychological resilience has a negative effect on job stress.", the model is significant (F=37.279; p<0.01) and psychological resilience explains 15% of job stress. As psychological resilience increases, job stress tends to decrease. The findings confirm the hypothesis (H1) of the study.

CONCLUSION

The Cronbach's Alpha coefficient for the reliability of the scales was 0.759 for Psychological resilience and 0.928 for job stress. It was observed that kurtosis and skewness were between the required values (+1, -1) and the data were normally distributed (0,328, -0,118).

According to the research findings, a significant negative relationship exists between psychological resilience and job stress. Considering the level of effect within the scope of the research hypothesis, it was observed that Psychological resilience had a 15% impact on job stress.

According to the study's hypothesis, as psychological resilience increases, job stress decreases. Implementing practices that enhance employees' psychological resilience levels will also reduce their job stress.

One limitation of the study is that it was conducted at a single institution within a single province. It is recommended to continue studying in other provinces and at different institutions.

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THREADS OF THE UNCONSCIOUS: SYMBOLISM AND SPATIAL MEMORY IN CHIHARU SHIOTA'S INSTALLATION THE KEY IN THE HAND

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ABSTRACT

This study analyses Chiharu Shiota's captivating installation, Key in Hand, emphasising its symbolic and spatial techniques for meaning construction. The study utilises art historical frameworks to contextualise the psychological aspects inherent in Shiota's material language, citing Carl Gustav Jung's notion of the collective unconscious. The article employs Jungian theory as a conceptual framework to enhance the interpretive analysis of her work. Key in Hand features hundreds of used keys intricately strung in a dense network of crimson thread, hovering over two miniature wooden boats. The key, as a culturally situated object, conjures associations with memory, transition, concealed recollections, and tales. The crimson thread visually linking each key implies emotional distress, origins, and hidden connections. In Jungian terminology, this picture aligns with archetypes like the threshold and the maternal figure, providing a symbolic realm for examining absence and yearning.

The study interprets Shiota's installation not as a psychological revelation, but as a curated environment where collective and individual memory converge. The work succinctly addresses the themes of the Uncertain Journey, Accumulation, and the Quest for Purpose to highlight Shiota's ongoing exploration of migration, loss, and inner transformation. Recurring motifs create a unique visual language based on quiet, repetition, and emotional intensity.

The study posits that Shiota's installations serve as modern symbolic environments, emphasising spaces where tangible forms convey intangible emotional and psychological conditions. This method highlights the viewers experiential connection with symbols and spatial elements. This work engages with Jung's teachings on unconscious imagery in relation to modern installation art, contributing to interdisciplinary discussions on symbolic meaning, emotional materiality, and inner experience within visual culture.

Keywords: symbolic space, installation art, visual memory, collective unconscious, contemporary art

INTRODUCTION

Chiharu Shiota's installation "Key in Hand," exhibited at the Japan Pavilion at the 2015 Venice Biennale, is a poignant juxtaposition of matter, memory, and metaphor. The work comprises two weathered wooden boats, woven with thousands of old keys donated by people from around the world, beneath a dense canopy of red thread. This striking visual environment invites viewers to step into a suspended landscape where their personal histories intersect with collective memory, and objects function as carriers of the unconscious.

Shiota's works often navigate the contradictions between presence and absence, materiality and transience, life and death. In "Key in Hand," the artist uses red thread as both a connective tissue and a metaphor for the flow of life, transforming everyday objects into symbols of emotion and memory. In the work, the suspended keys, each carrying the invisible weight of the various memories they once unlocked, become intimate archives of lived experiences. This article examines how Key in Hand functions as both a symbolic structure and a site of memory, drawing on Carl Jung's archetypes and Bachelard's "poetics of space," examining how the installation mediates between individual psychological landscapes and the collective human condition. Focusing on the work's psychological,

sensory, spatial, and symbolic dimensions, this analysis aims to reveal how Shiota's immersive environment engages viewers not only visually but also through memory, emotion, and bodily experience.



Figure 1. *Key in Hand*, installation view, Japan Pavilion, 56th Venice Biennale, 2015.

THEORETICAL FRAMEWORK

Chiharu Shiota's Key in the Hand can be examined from three interrelated theoretical angles: modern memory studies, Bachelard's phenomenology of space, and Jungian psychoanalysis. When taken as a whole, these frameworks provide insight into how the installation's spatial memory and symbolism function.

1. Archetypes and Jungian Psychoanalysis

According to Carl Gustav Jung's theory of the collective unconscious, archetypes, archetypal images, and symbols that are common to all cultures and eras have an impact on the individual unconscious. In Key in the Hand, the key serves as a liminal object that represents the preservation of private regions as well as the potential to visit hidden realms. It also serves as a means of entrance, passage, and illumination. Similar to this, the red thread conjures up images of blood, lifelines, and intertwined destiny, bringing to mind East Asian myths like the "red thread of fate." These archetypes, which appear regularly in Shiota's artwork, are dynamic components that enable viewers to project their own stories onto universal shapes rather than being static symbols.

2. The Poetics of Space by Bachelard

Gaston Bachelard highlights the influence of spaces on human memory and consciousness in his 1958 book Poetics of Space. His conception of "home" is similar to the boats in Shiota's installation in that it is a storehouse of dreams and lived experiences. The boats in this piece are viewed as symbolic vessels that hold the accumulated memories of people's life. The exhibition area is transformed into what Bachelard would refer to as a "nest" or "shell," a porous yet protective cage that promotes reflection, by the thick drape of crimson thread. Viewers are able to experience the network's visual intricacy as well as the feeling of being suspended in a memory-filled setting thanks to this spatial design.

3. Embodied Experience and Spatial Memory

In the writings of Yi-Fu Tuan and Edward Casey, the idea of spatial memory examines how our surroundings evoke memory through bodily and sensory contact. The viewer's spatial memory is activated in Key in Hand by the mix of tactile imagination, visual immersion, and physical intimacy. Hanging keys act as memory triggers since they are individually ingrained in a particular household or individual setting. The evocative processes of memory are reflected in the intangible web of stories created by the crimson threads that connect the thousands of keys on the boats. The installation becomes a lived, interactive archive where the past and present converge thanks to this spatial choreography.

By combining these viewpoints, this study places Shiota's work in the intersection of embodied memory, intimate spatiality, and archetypal symbolism. The installation has evolved into a psychological and phenomenological place where unconscious strands are both uncovered and reconstructed, rather than just being an object to be examined.

METHODOLOGY

This study is based on a qualitative and interpretive research approach that integrates art historical analysis, semiotic reading, and phenomenological interpretation. The methodology develops in three interrelated steps:

1. Visual and Spatial Analysis

- Examination of the physical components, spatial arrangement, and lighting in Key in Hand, utilizing high-resolution photographic documentation and video analysis from the 56th Venice Biennale.
- Analysis of material qualities, including texture, density, and thread arrangement; the scale and patina of the keys; and the size and position of the boats.

2. Symbolic Interpretation

- Application of Carl Jung's archetypal theory to focus on and identify symbolic patterns in the objects and their configurations.
- Interpretation of the place of red thread in East Asian culture and cross-referencing with cultural symbolism such as maritime metaphors.

3. Phenomenological and Bodily Reading

- To understand how viewers fully engage with the installation, how they locate and navigate it, Bachelard's poetics of space and spatial memory research (Casey, 2000; Pallasmaa, 2005) was utilized.
- To assess bodily memory, examined how sensory stimuli, posture, and movement within the space contribute to the construction of meaning.

The research is primarily based on visual data obtained from secondary sources and official documents, based on critical reviews, exhibition catalogs, and interviews with the artist. While the analysis is primarily interpretive, it aims to reflect academic rigor through the triangulation of theoretical, visual, and contextual evidence.

ANALYSIS OF ARTWORK

Chiharu Shiota's Key in Hand presents an immersive environment in which every element, material, color, scale, and spatial arrangement, functions as part of a symbolic and evocative system. Exhibited in the Japan Pavilion at the 56th Venice Biennale (2015), the work envelops the viewer in a dense veil of red thread from which over 50,000 keys hang, converging towards two weathered wooden boats placed on the floor. The scale and magnitude of the installation transform the exhibition space into a navigable psychological landscape, both intimate and monumental, immersing the viewer.



Figure 2. Detail views of *Key in Hand*, showing the texture of the red thread canopy and the suspended keys.

1. Materiality and Symbolic Function

The choice of materials is integral to the work's conceptual framework. Red thread, a recurring motif in Shiota's work, is both visually striking and culturally resonant. In East Asian culture, the "red thread of fate" symbolizes invisible human bonds, binding individuals together. In a broader symbolic sense, red is associated with vitality, blood, passion, and life force, thus anchoring the work in bodily and emotional registers. Keys donated by people from around the world serve as physical containers of memory. Each key bears traces of its former function and unlocks spaces of privacy, security, and personal history.

2. Spatial Composition

The installation's spatial design establishes a dynamic relationship between the viewer and the artwork. A web of red threads, occupying a dense space and radiating outward and upward, draws into a web-like matrix evoking nerve pathways, blood vessels, or constellations. The weathered, hollow, and grounded vessels are receivers of the unseen burden of human stories. Placed beneath the canopy, these vessels appear to collect the drifting fragments of memory and "catch" the keys. This vertical layering, extending from top to bottom, creates a symbolic axis between the abstract realm of memory, keys above, boats below, and the concrete container of lived experience.

3. Immersive and Participatory Experience

While the installation is visually dominant, it is not a static object to be passively observed; rather, it encourages concrete participation. Its sheer size compels viewers to physically navigate the space, adjusting their gaze and posture in response to the suspended elements. The proximity of some of the keys, so close they almost touch, heightens sensory awareness and creates a sense of intimacy. The multitude of keys reinforces the collective dimension of memory while preserving individual differences and personal uniqueness.

4. Temporal and Narrative Dimensions

The temporality of the work extends far beyond the duration of the exhibition. Keys, once part of private lives, have been displaced and recon textualized, acquiring new layers of meaning through collective arrangements. The revitalization of objects through spatial redistribution reflects the fragmented, layered, and constantly reassembling processes of memory. Evoking migration, journeys, and the flow of time, the boats reinforce the narrative of transition and transformation. In "Key in Hand," Shiota, through the meticulous arrangement of materials and space, constructs an environment that functions as a symbolic archive, a navigable memory landscape, and a visualization of the complex webs of the subconscious, achieving a rare synthesis of the personal and the universal.

SYMBOLISM IN KEY IN HAND

Symbolism is the fundamental language of Key in Hand, and each element operates on multiple levels of interpretation. Shiota's installation draws on archetypal, cultural, and personal meanings to create a symbolic space between viewers' memories and unconscious associations.

1. Key as Archetype

In Jungian terms, a key is a liminal object that marks the threshold between the known and the unknown, the safe and the vulnerable. Keys provide access, but also protect and conceal. In the installation, thousands of keys, detached from their original locks, stand as a symbol of the unlocking of the unconscious and the release of hidden memories. Each donated key is invisibly linked to its donor's personal history, serving as a reminder of the incomplete spaces it once opened. The accumulation of keys transforms them from individual artifacts into a collective archive, symbolizing human experiences such as memory, privacy, and belonging.

2. Red Thread

In this work, the red thread network functions simultaneously as connective tissue and a visualization of life's intertwined narratives. Culturally, according to East Asian mythology, the "red thread of fate" connects different people regardless of time, space, or circumstances. Psychologically, the red thread appears as a metaphor for the structures that circulate memory and emotion, the blood vessels and nerve pathways of the mind. In Shiota's installation, these threads not only connect the keys but also connect the viewers to the space through the use of the entire space, enveloping them in an interconnected web of memory.

3. Boats as Vessels of Memory

Two old wooden boats placed beneath the suspended keys function as carriers of collective memory. The boats are archetypal symbols of migration and journey, of journey and transition between realms, whether physically, from life to death, from consciousness to unconsciousness, or metaphysically. In Key in Hand, the boats capture the fallen memories embodied by the keys, anchoring the intangible in physical form, evoking the eroded surfaces marked by time, durability, and the carrying of countless invisible burdens.

4. Vertical Axis: Heaven, Earth, and the Unconscious

The spatial arrangement of the elements creates a symbolic vertical axis; the hanging keys and threads create fluid, intangible, and infinite "heavens" of the unconscious, while the boats, firmly planted on the ground, anchor memory in the realm of lived experience. This verticality also reflects spiritual cosmologies and psychological models in which consciousness, while grounded in the body, is connected to a larger, unseen network.

5. The Connection of Personal and Collective Memory

By collecting donated keys from around the world, Shiota aimed to blur the boundaries between individual memory and collective history. The work has become a living archive in which each object retains its personal resonance while contributing to a broader narrative network. Both the work and the audience become part of this network as their own memories are activated by the sensory and symbolic environment.

With these symbolic layers, Key in Hand transcends its physical form, serving as an experiential metaphor for the unconscious, mapping the fragile yet enduring bonds that bind human lives together across time and space.

SPATIAL MEMORY AND VIEWER EXPERIENCE

Key in Hand is not merely an installation to be visually observed and traversed; it is a space to be entered, navigated, and felt. In doing so, it activates what Edward Casey describes as spatial memory, the way memory is shaped, triggered, and embodied through our interaction with space and place. This immersive environment Shiota presents transforms the exhibition pavilion into an evocative architecture in which the viewer becomes both a witness and a participant in a landscape of memory.

1. Embodied Navigation and Perception

When viewers step into the installation with this work, they are immediately immersed in a dense drape of red thread. Their gaze is drawn to the suspended mass of keys, while their bodies instinctively respond to the vertical space, bending, twisting, and slowing their pace. This physical engagement with the environment allows viewers to establish a tangible relationship with the work. It is not only the mind, but also the body, that remembers, that connects the past and the present. The act of walking under the keys becomes symbolic of moving through a field of suspended memories that is both intimate and universal.

2. Sensory Immersion

Shiota's installation is minimal in sound but rich in texture and visual complexity. The monochrome red creates a sensory intensity, while the metallic sheen of thousands of keys captures light and shadow. Materials like wood, metal, and yarn themselves evoke tactile memories, even when not in direct contact. The silence of the space paradoxically amplifies inner voices, encouraging viewers to listen to their inner voices and reflect on their own forgotten rooms, lost keys, and unseen journeys. In this way, the installation functions as a magnificent "memory theater," where interior landscapes are projected onto exterior structures.

3. The Role of Absence and Imagination

The installation is filled with objects, but what haunts the space are the missing and elusive things—the people who once used the keys, the doors they opened, the stories they belonged to. This absence, through creative interaction, encourages viewers to create narratives, project associations, and fill the silences. As Maurice Halbwachs argues in his theory of collective memory, memory is always communicated through social and spatial frameworks. Shiota's works offer such a framework by providing a shared space where private memories and imagined histories can coexist.

4. Memory as a Shared, Layered Phenomenon

Key in Hand does not merely present a fixed or linear memory; it creates a multilayered, polyphonic experience of memory. Each viewer brings their own emotional history to the space, but the space is also surrounded by the invisible presence of others, including those who donate the keys and those who simultaneously experience the installation. Thus, the work becomes a site of collective memory where individual experiences resonate within a much larger human narrative.

5. The Viewer as a Bearer of Meaning

Ultimately, the meaning of Key in Hand is not limited to the gallery space and the viewers. Like the keys themselves, viewers leave the installation transformed, with newly activated memories, emotions, and symbolic associations. In this sense, Shiota's works exhibit a kind of psychological continuity, connecting the temporary exhibition experience to permanent memory. The connections may linger, but what they connect, and their impact, carries forward.

CONCLUSION

Chiharu Shiota's Key in Her Hand is a profound testament to the capacity of installation art to activate the unconscious, evoke spatial memory, and evoke common human emotions through symbolic language. By interweaving thousands of keys in a dense tapestry of red thread, Shiota creates not only a visually incredible and immersive experience but also a psychological and emotional landscape in which viewers confront absence, longing, memory, and connection.

From a Jungian perspective, the keys and red threads function as archetypal symbols resonating with profound psychological meaning. Through Bachelard's theory of intimate spaces and poetic memory, we can see the boats and spatial composition as tools of imagination and emotional resonance. Furthermore, the installation's spatial immersion engages the viewer in not only a psychic but also a bodily experience of memory, emphasizing the role of the environment and sensory perception in shaping memory. Key in Hand invites us all to consider how memory is constructed not only through time, but also through space, shared materials, and symbols. It reminds us that the unconscious is not a static, buried space, but a dynamic realm of connection, interwoven with the objects we hold, the spaces we inhabit, and the stories we carry.

In an age increasingly dominated by digital ephemerality and rapid forgetting, Shiota's work revisits slowness, sensuality, tactility, and contemplation. He offers viewers a space to pause, remember, and feel, to engage their senses. And in doing so, he connects the fragile, the complex, and the beautiful, transforming installation art into a living archive of the human condition.

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TOURISTIC TRAILS AT THE BAPTISM SITE OF JESUS CHRIST (AL-MAGHTAS)

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ABSTRACT

The Baptism Site of Jesus Christ, known as *Al-Maghtas* (Bethany Beyond the Jordan), is one of the most significant religious and archaeological sites in the Christian world, as it is associated with the baptism of Jesus Christ by John the Baptist. Since its discovery and rehabilitation in the 1990s, the site has witnessed remarkable development in its tourism infrastructure, enabling the organization of pilgrim and visitor movement through a carefully designed network of religious and touristic trails. This study aims to provide a detailed presentation of these trails, analyzing their religious, archaeological, and environmental dimensions.

Visitor Center

All visits begin at the Visitor Reception Center, the main gateway to the site. The center includes service and interpretive facilities such as an exhibition hall, models, historical photographs, and informative panels. It also provides internal transportation (shuttle buses) to key points of the site and professional guides who accompany visitors.fig:1 .

1. The Jordan River Trail (The Traditional Baptism Site)

This trail begins at the Visitor Center, where visitors travel by bus along a gravel-paved ecological road heading south, passing through the wilderness (the Wilderness of John the Baptist). Along the eastern side of the road lies the Research Center, established in 1996 and named after John the Baptist, which has been the hub of surveys, excavations, documentation, and publications. The trail then turns west, and after about 1,500 meters, visitors reach a sloping area where modern churches have been built by different Christian denominations in recognition of the authenticity of the baptism site on the eastern bank of the Jordan River.

Continuing by bus for another 700 meters, visitors arrive at the Baptism Square and Pool, constructed during site development on alluvial plains formed by Jordan River floods. These facilities were created to serve pilgrims wishing to perform baptismal rituals. From here, the bus route ends, and a walking trail begins for approximately 1 km, passing by the John the Baptist Church Complex and the Church of the Garment. After 600 meters, the visitor reaches the Jordan River itself—the traditional baptism site—still recognized today. Over time, various shelters were built here, from cement to wooden canopies and palm-frond roofs, culminating in a modern platform for pilgrim baptisms.

This sacred area remains highly revered, allowing pilgrims to touch the flowing waters of the Jordan River, sense the spirituality of the place, and view the western riverbank at the lowest and closest accessible point.

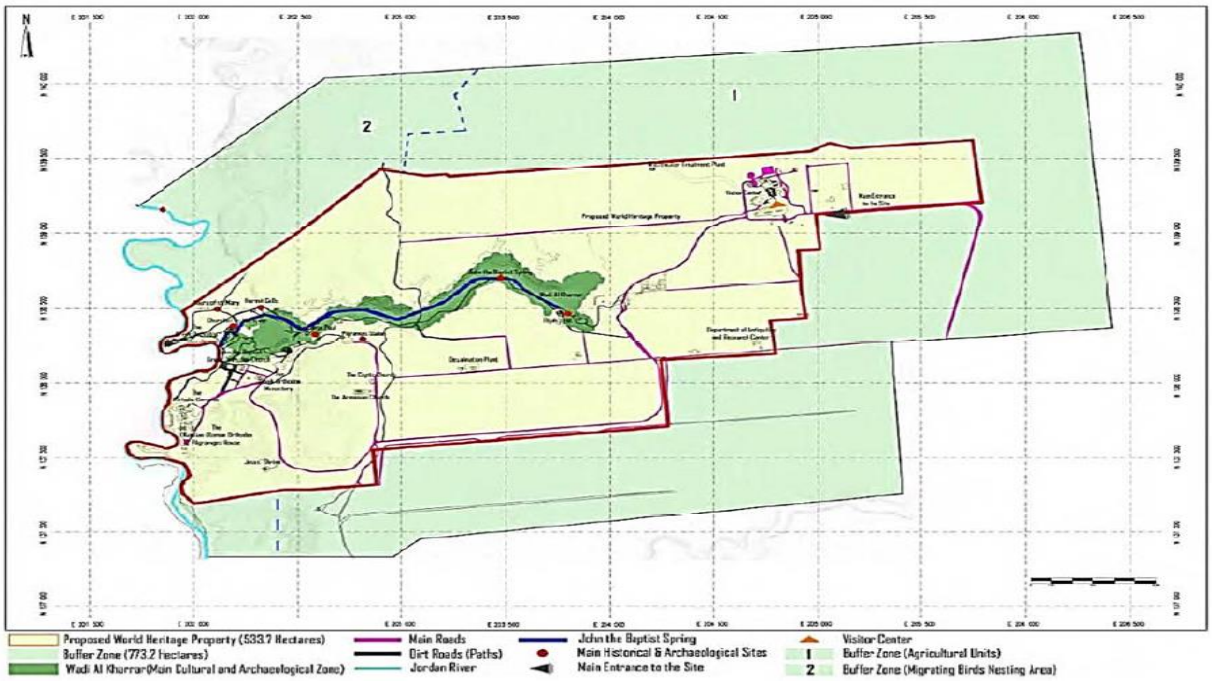


Fig 1: General Plan of the Baptism Protected Area & the Touristic Trails .

2. The Mar Elias Hill Trail (The Upper Area)

This trail consists of caves, Byzantine churches, baptismal pools, cisterns, mosaic floors, monks' cells, wells, aqueducts, drains, walls, buttresses, entry arches, stairways, and ceramic pipelines.

The trail begins at the southern approach to Tell al-Kharrar, where several structures from different eras remain. Visitors first pass the monks' cells, once used by Orthodox monks as lodging and reception rooms for pilgrims entering from the south. The next stop is the Arch Church, notable for its lack of an apse, dating it to the early Byzantine period (5th century AD). Visitors then view the hydraulic system—ceramic pipes that carried water from Wadi Gharrar, 1 km away, supported by filters and manholes for sustainability.

A large cistern follows, still partly intact with traces of plain mosaic on its roof, possibly used for worship. Nearby lies a rectangular prayer hall with a white mosaic floor. Visitors then encounter a cylindrical well for water storage, and remnants of aqueduct piers once used to carry water to the baptismal pools atop the hill.

Entry into Mar Elias Hill is through three arches (from the west), while eastern visitors first encounter a purification pool with stone steps. At the summit, evidence shows Orthodox monks attempted to build places of worship, though never completed. Across the valley to the east, remains of a monastic room are visible. Continuing north, visitors find two baptismal pools designed for rituals, with remnants of their water channels still extant. In the center of the northeastern pool lies a lined well, built after the water system collapsed, intended to reach groundwater directly from the valley.

Further along, visitors descend gradually to the Rotorius Church, identified by a mosaic inscription naming the donor. This early Byzantine rectangular church also lacks an apse. The trail continues past traces of the surrounding defensive wall, toward the western slope, where the Cave Church stands. This church incorporated an ancient cave traditionally believed to have been used by John the Baptist during his wilderness retreat.

Other features include a colored mosaic prayer hall associated with the Rotorius Church, fragments of cave dwellings (notably three caves, symbolically significant), and a triple-arched gate. Outside the wall are supporting buttresses, and archaeological evidence suggests a stairway once led to the valley. At the eastern edge, remains of a hermit's residence can still be seen. Excavation squares south of the Arch Church revealed Roman-period remains, linking the site's earliest use to the era of John the Baptist and Jesus Christ.

3. The Pilgrims' Station and Surroundings (The Central Area)
This trail revolves around the Pilgrims' Station, built atop a rise overlooking the Jordan floodplain and the river itself. The station functioned as a monastery serving pilgrims traveling from west to east or vice versa. It included rooms and halls for prayer, meals, sleeping, and religious study. Attached was the largest baptismal pool at the site, supplied by springs from Wadi Kharrar, with a drainage system and stone stairways for access.

Nearby is a small defensive tower, likely a watchtower. To the north (300 m away) are the monks' caves, carved into limestone cliffs, accessible today by wooden stairs. They consist of small rock-hewn cells with commanding views, historically reached by rope or wooden ladders. Two caves remain visible.

To the southwest (700 m from the station), the ruins of stables are visible, once used to house animals assisting in river crossings. This station reflects the site's historical role as a global pilgrimage hub since the 5th century AD.

4. The John the Baptist Church Complex

Visitors may enter this area either via the ecological trail along the Baptism Spring or via a shaded southern path. The first remains encountered are the stone piers and foundations of the original Baptist Church, destroyed by Jordan River floods and later earthquakes. To avoid flood damage, Byzantine builders reconstructed additional churches nearby. Excavations revealed evidence of two successive churches beneath the visible third church, which features mosaics, marble paving, and a raised platform.

East of the complex, a marble stairway of 22 steps leads down to the Jordan River. At the riverbank, a commemorative chapel was built on the spot where tradition holds Jesus left his garment on a tree before baptism. A square stone base, still extant, once supported a marble column topped by an iron cross, marking the precise baptismal location. Byzantine pilgrims also noted a black marble paving slab at the stair's end—possibly the very place where Jesus and John stood during the baptism.

To the north (500 m away), the shrine of the Coptic saint Mary the Egyptian is located, with remnants of her two simple rooms (for living and worship), ending the visit to this complex.

5. The Environmental Trail – Wadi Kharrar

The Ainon / Baptism Spring Trail

This symbolic trail highlights the spiritual roots of the site. Early pilgrims described six springs here, depicted on the 5th–6th century AD Madaba Mosaic Map. The trail has two phases:

- **Phase One:** Beginning near Mar Elias Hill, it follows a natural path shaded by tamarisk, laurel, and willow trees, with bird songs and the flow of six still-active springs. It passes near the Pilgrims' Station and continues to the Baptism Spring and its large pool. The length is about 1,300 meters.
- **Phase Two:** Known as the "Zor Forest Path," it passes through dense woodland along Wadi Kharrar for about 700 meters, ending at the archaeological remains of the John the Baptist Church Complex. This trail adds ecological and meditative dimensions, often used for spiritual reflection and contemplative walks.

Trail for Visitors with Special Needs
A specially prepared and accessible trail near the entrance leads to modern churches built for various

denominations, including Greek Orthodox, Catholic, Coptic, and Latin communities, reflecting the site's global and ecumenical role.fig:2.

Conclusion

The five main trails at the Baptism Site of Jesus Christ (Al-Maghtas) present a unique integration of religious and archaeological dimensions, guiding visitors through sacred springs, riverbanks, Byzantine churches, and natural landscapes. The inclusion of modern churches and pilgrimage routes highlights the site's global role as a center of spiritual and cultural convergence.

- **Religious Dimension:** Directly tied to the baptism narrative and allowing ritual practice.
- **Archaeological Dimension:** Showcasing continuity from the Byzantine period to modern times.
- **Environmental Dimension:** Preserving the natural character of the river and surrounding wilderness.
- **Touristic Dimension:** Facilitating visitor movement and offering a diverse experience of history, faith, and nature.

Thus, the trails offer an integrated framework for understanding Al-Maghtas as one of the world's most important religious tourism destinations.



Fig 2: The place of Baptism on the Eastern Side of Jordan River

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TRANSPORTATION RISK ASSESSMENT OF MODULAR UNITS FOR POST-DISASTER HOUSING USING EVENT TREE ANALYSIS

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ABSTRACT

Türkiye has been exposed to many destructive earthquakes and natural disasters throughout history due to its location on an active tectonic belt. These disasters not only cause physical destruction but also deepen social and economic vulnerabilities. The Eastern Anatolia Region in particular stands out with its complex fault lines, topographical diversity, and scattered, low-density settlement structure. Most of the settlements in the region are villages and small towns, and the transportation infrastructure is generally inadequate.This study focuses on the proposed solution method in the context of geographical access difficulties and weak infrastructure conditions faced by eastern provinces in the post-disasters, a specially post-earthquake resettlement process. Given the poor road conditions, rugged terrain, and limited resources available for on-site construction, a model based on modular systems with centralized management of construction activities has been proposed. However, the success of this approach depends largely on the transportation process. Due to the damaged transportation infrastructure following the earthquake, the logistics process constitutes the most critical and risky phase of the project. Therefore, the transportation process was addressed in the study using a risk-based approach and systematically evaluated using the Event Tree Analysis (ETA) method. Module slippage, crane failure, securing errors, and damage caused by road-induced vibrations were defined as basic risk scenarios; each was analyzed through modeling. Vehicle type selection was also structured in line with these risk analyses; trucks, medium-sized trucks, and off-road carriers were compared in terms of transportation performance. The findings reveal that logistics planning conducted in the early stages of the process is decisive in terms of safety and time management.

Keywords: Post-disasters reconstruction, Logistics risk assessment, Event Tree Analysis (ETA), Modular housing systems

INTRODUCTION

Türkiye is frequently hit by destructive earthquakes due to its location on active fault lines. The 1999 Marmara Earthquake and the 2023 Kahramanmaraş-centered earthquakes have demonstrated how critical the need for post-disaster shelter is. Among temporary and permanent housing solutions, prefabricated modular units stand out due to their advantages of rapid production and easy installation. However, transporting these units from the factory to disaster zones poses significant logistical risks. While the production and installation advantages of modular systems are frequently discussed in the literature, studies on the risks associated with the transportation process are limited. This study aims to comprehensively assess the risks involved in the post-earthquake transportation of modular units using the ETA method.

MATERIALS AND METHODS

In this study, the Event Tree Analysis (ETA) method was used to identify the risks encountered during the transportation of prefabricated modular units to disaster areas after an earthquake. The methodological framework was developed by considering the general principles of the ISO 31000:2018 risk management standards (ISO, 2018) and the ETA approach recommended in the ISO 31010:2019 risk assessment techniques (ISO, 2019). Additionally, the ASTM D4169 standard (ASTM, 2016) was used as the basis for modeling the vibration and shock conditions encountered during transportation, while the MIL-STD-810H (DoD, 2019) standards were used as a reference framework for environmental durability.

1. Modular System Characteristics

The modules examined in the analysis were assumed to be 2.5 × 6 m in size and weigh approximately 3–4 tons, which are commonly used in the industry. The modules were evaluated based on two types of structural materials:

• Steel construction modules: These offer the advantages of high ductility, low weight, and vibration resistance (Lawson et al., 2012).

• Prefabricated reinforced concrete modules: While they have high compressive strength, they exhibit more brittle behavior against vibrations and impacts (Tam et al., 2015).

This difference was particularly considered in the risk assessment criteria related to vibration-induced damage and road impacts.

2. Process Stages

The risks evaluated in the study were examined in four main stages, from the transportation of the module from the factory to the disaster area:

1. Loading: Loading the module onto the vehicle with a crane at the factory site.

2. Transportation: Transportation by vehicle on city streets, highways, motorways, or mountain/village roads.

3. Unloading: Unloading the module from the vehicle in the disaster area.

4. Positioning: Positioning the module in its final location with the help of a crane prior to assembly.

These processes were examined in an ETA tree, which was initiated by the "error that may occur during loading" defined as the initial event.

3. Risk Criteria

Eight main risk criteria have been identified based on studies related to modular transportation in the literature (Ghosh & Sullivan, 2018; Li & Bilec, 2019; Zeng et al., 2017):

1. Structural damage caused by vibration,

2. Impact/shock caused by road surface,

3. Risk of slipping or overturning,

4. Loosening of connection points,

5. Weather conditions (wind, rain),

6. Vehicle malfunction or accident,

7. Logistical delays,

8. Impact during loading/unloading.

Impact (I) values for each criterion are classified on a scale of 1–5 (ISO 31000, 2018). For example, structural vibration damage is rated 4 (high impact), while the risk of overturning is rated 5 (critical impact).

4. Determination of Probabilities

Probabilities (P) are based on field studies and standard test profiles in the literature:

Vibration and impact probabilities: ASTM D4169 truck vibration profiles are used as a basis. These profiles define three main levels in truck transportation: low (0.40 Grms, 120 min), medium (0.54 Grms, 45 min), and high (0.73 Grms, 15 min) vibration intensities (Lansmont, 2022; KUL Packaging, 2022). The relevant probabilities are scaled using road roughness (IRI – International Roughness Index) values.

Road roughness: According to World Bank and Wirtgen Group data, IRI ≈ 2 m/km for highways, ≈ 3 m/km for urban asphalt, ≈ 6 m/km for roads, and ≈ 15 m/km for village/mountain roads (World Bank, 2005; Wirtgen, 2012). These values have been used as multipliers that increase vibration and impact risks.

• Vehicle types: Transport vehicles are classified as 4-wheel pickup trucks (short, 6.5 m), 6-wheel rigid trucks (9 m), and 8-wheel tractor-trailers (16.5 m). As vehicle length increases, maneuvering difficulty and the magnitude of road impacts increase, especially on mountain and rural roads (NCHRP, 2003). Therefore, additional multipliers have been defined for 8-wheel vehicles on rough roads.

5. Risk Score Calculation

The risk score for each criterion was calculated using the following formula:

R = P x I (Detailed explanation provided in the Calculations section.)

The scores obtained were evaluated in four classes:

Low (0–0.5), Medium (0.5–1.25), High (1.25–2.5), Very High (>2.5).

6. Event Tree Analysis (ETA)

The ETA model consists of three stages:

Loading (L): Probability of impact during loading.

Transportation (T): Combined probability of damage derived from vibration, road impact, overturning, slackening of fastenings, vehicle failure, and weather conditions. This probability was calculated as follows, assuming independence:

Unloading (U): Probability of impact during unloading from the vehicle.

The combination of these three stages is classified as “Smooth,” “Minor damage (single stage),” and “Major damage (two or more stages)” (Zeng et al., 2017).

The initial event is defined as an error that may occur during loading at the production facility. Risks were assessed using the ETA method with probability-impact multiplication.

7. Calculations

7.1) Impact (I) scale (1–5)

Following the ISO 31000 framework, the severity of the results has been classified on a scale of 1 (negligible) to 5 (critical); this type of qualitative–quantitative blended scale, commonly used in construction/logistics applications, is consistent with the ISO 31000 definition of consequence. (ISO 31000 is a guidance document; ISO 31010 is a supporting guidance document for the ETA technique.)

Table 1: Criteria and Impact Table for 6-Wheel Vehicles

Criteria	Impact_1_5	P0_Road_6wheel
Vibration-induced damage (micro cracks/connections)	4	0,30
Road impact/pothole/obstacle shock	4	0,20
Sliding/Overturning (lateral stability)	5	0,05
Loosening/breakage of fastening equipment	3	0,10
Air/environmental effects (rain/wind)	2	0,15
Vehicle failure (tires/suspension/brakes)	3	0,06
Logistical delays/detours	2	0,12
Loading/unloading collisions/impacts	4	0,10

7.2) Probability (P) — Literature-based scaling

Initial values per trip were determined for base probabilities (6 wheels/rigid truck + "Highway/medium asphalt") and scaled according to road roughness (IRI), truck vibration profiles (ASTM D4169), and vehicle configuration (number of wheels/length).

7.2.a) Road roughness (IRI) → vibration/shock factor

From the World Bank–SSATP and other technical guidelines, the following ranges were adopted for good asphalt: IRI≈2 m/km, medium asphalt ≈6 m/km, urban ≈3 m/km, and unpaved rural/mountain roads ≈12–20 m/km. (In this study, 15 m/km was used). Since IRI directly affects the likelihood of vertical vibration and shock, the following road factors were used.

f_vib_road = IRI/6 → Highway 0.33, Highway 1.00, Urban 0.50, Village/mountain 2.50.

f_shock_road (impacts) is scaled more severely: Highway 0.4, Road 1.0, Urban 0.6, Rural/mountain 3.0.

These ranges are consistent with the road's good–poor spectrum and the field classes related to the high roughness of mountain/rough terrain.

Table 2: Road Parameters Table

Road	IRI_m_per_km	f_vib_road	f_shock_road	f_maneuver_road	f_delay_road
Highway (good asphalt)	2,00	0,33	0,40	0,90	0,80
Main Road (medium asphalt)	6,00	1,00	1,00	1,00	1,00
Short Asphalt	3,00	0,50	0,60	1,00	1,10
Village/mountain road (unpaved)	15,00	2,50	3,00	1,80	1,60

7.2.b) Truck vibration profiles (ASTM D4169) Calibration based on environmental severity

Technical summaries shared in the industry for the Truck Profile (Truck Profile) of ASTM D4169 provide Grms levels and time distributions: a typical profile is represented by 0.40/0.54/0.73 Grms (low/medium/high) and 120/45/15 min durations. This aligns with the observation of lower intensity on well-maintained surfaces like highways and more frequent medium–high intensity on rough/rural surfaces. These data were used as a reference for calibrating the initial P0 values within a realistic range when scaling base probabilities according to IRI.

7.2.c) Vehicle configuration and Vehicle–road interaction

Vibration filter/stability: Long combinations and modern tractor–semi-trailers can filter vertical vibration relatively better on smooth surfaces; therefore, for 8 wheels on flat/good roads, f_vib_vehicle_base = 0.90, 6 wheels 1.00 (base), and 4 wheels 1.10 were used.

Interaction on mountain/rural roads: Since coupling/bridging effects can increase in long combinations, an additional multiplier has been defined (f_vib_vehicle_mountain: 1.15 for 8 wheels, 1.05 for 6 wheels, 1.00 for 4 wheels).

Maneuvering/lateral loads (rollover/skidding): Long vehicles experience more off-tracking and maneuvering difficulties on narrow-radius rural/mountain roads, which increases lateral acceleration and rollover risk. NCHRP-505 and AASHTO/FHWA turning-path references explain this trend; additionally, the static rollover threshold (SRT) for heavy vehicles is typically in the ~0.35–0.4 g range; safety margins decrease on narrow–steep roads. Therefore, f_maneuver_road (mountain/road=1.8) is used for lateral risk, and f_roll_base (8 wheels 1.10; 6 wheels 1.00; 4 wheels 0.95) and f_roll_mountain (8 wheels 1.30; 6 wheels 1.15; 4 wheels 1.00) are used on a vehicle-by-vehicle basis.

Table 3: Impact Multipliers Table

Vehicle	**Length_m**	**f_vib_vehicle_base**	**f_vib_vehicle_mountain**	**f_roll_base**	**f_roll_mountain**
4 wheels (short truck/rigid 4x2)	6,50	1,10	1,00	0,95	1,00
6 wheels (rigid truck 6x4)	9,00	1,00	1,05	1,00	1,15
8 wheels (tractor + semi-trailer)	16,50	0,90	1,15	1,10	1,30

7.2.d) Loading/unloading, air, fastening equipment

Loading/unloading damage depends more on production facility applications than road type; therefore, a multiplier that is independent of road conditions and sensitive to vehicle length to a certain extent (platform height/manipulation) was assigned.

Lashing slack was scaled with f_vib_road to be sensitive to vibration.

f_delay_road was increased for rural/mountain roads for weather conditions and delays; environmental profile information on the vibration/shock side was sourced from MIL-STD-810H {Method 514.8 (Vibration)/516.8 (Shock) classifications}.

7.2.e) ETA tree and final state probabilities

ETA 3-stage: Loading (L) → Transport (T) → Unloading (U).

L and U: The "loading/unloading impact" risk was divided into two and distributed between the L and U stages.

T: An upper-bound combined probability was used with an independence approach against the possibility of vibration, road impact, overturning, fastening, vehicle failure, and weather effects not being independent: Eq.(1)

$$P_T = (1 - \prod_i (1 - P_i)\ (i = vibration, impact, overturning, binding, malfunction, air) \quad (1)$$

Current status: Grouped as "No problems", "Minor damage (single stage)", "Major damage (two+ stages)" and probabilities have been calculated from total combinations.

Table 4: Damage and Risk Score Calculation

Road	Vehicle	"L" loading probability	"T" transport damage probability	"U" unloading probability	No Damage	Minor Damage	Major Damage	Total Risk Score
Main Road (medium asphalt)	4 wheels (short truck/rigid 4x2)	0,05	0,63	0,05	0,34	0,61	0,06	3,75
Main Road (medium asphalt)	6 wheels (rigid truck 6x4)	0,05	0,62	0,05	0,35	0,59	0,06	3,67
Main Road (medium asphalt)	8 wheels (tractor + semi-trailer)	0,05	0,61	0,05	0,35	0,59	0,07	3,68
Village/mountain road (unpaved)	4 wheels (short truck/rigid 4x2)	0,05	0,96	0,05	0,04	0,87	0,09	8,01
Village/mountain road (unpaved)	6 wheels (rigid truck 6x4)	0,05	0,96	0,05	0,04	0,87	0,09	8,03
Village/mountain road (unpaved)	8 wheels (tractor + semi-trailer)	0,05	0,96	0,05	0,04	0,86	0,10	8,35
Highway (good asphalt)	4 wheels (short truck/rigid 4x2)	0,05	0,40	0,05	0,54	0,42	0,04	2,18

Highway (good asphalt)	6 wheels (rigid truck 6x4)	0,05	0,40	0,05	0,55	0,41	0,04	2,17
Highway (good asphalt)	8 wheels (tractor + semi-trailer)	0,05	0,40	0,05	0,54	0,42	0,04	2,22
Short asphalt	4 wheels (short truck/rigid 4x2)	0,05	0,49	0,05	0,46	0,49	0,05	2,75
Short asphalt	6 wheels (rigid truck 6x4)	0,05	0,48	0,05	0,47	0,49	0,05	2,73
Short asphalt	8 wheels (tractor + semi-trailer)	0,05	0,48	0,05	0,46	0,49	0,05	2,77

RESULTS

As a result of the ETA model created in this study, risk scores were calculated for different vehicle types (4, 6, and 8 wheels) and different road conditions (highway, urban, highway, and village/mountain roads). The findings indicate that risks vary depending on vehicle type, road surface roughness (IRI value), and module structure (steel or reinforced concrete) parameters.

According to the ETA (Event Tree Analysis) results, the most critical risk stage in the process of transporting modular housing units to disaster areas after an earthquake is the "transportation" phase. In highway (medium asphalt) scenarios, the probability of damage during transportation is between 61% and 63%, while in village/mountain road scenarios, this rate rises to 95%–96%.

When comparing vehicle types, there is no significant difference between 4-wheel trucks (33.5% trouble-free transportation) and 8-wheel tractors (34.8% trouble-free transportation) in highway transportation, while the probability of trouble-free transportation in village/mountain roads has dropped to 3.6–4.1%. This situation demonstrates that road surface roughness (IRI value of 15 m/km) dramatically increases risks associated with vibration and impact.

When total risk scores are examined, scores for all vehicles in highway (medium asphalt) scenarios range from 3.67 to 3.75 and are classified as "high risk." In village/mountain road scenarios, these scores rise to 8.01–8.03, falling into the "very high risk" category.

However, although the probability of "minor damage" occurring during transport is high (59–87%), such damage is generally repairable on site and does not impair the basic functionality of the modules. The probability of "major damage" during loading and unloading remains within the range of 6–9% in all scenarios.

DISCUSSION

The findings of this study show that the risks encountered in the transportation of modular housing systems after an earthquake are largely determined by road conditions and the characteristics of the transport vehicles. The low level of risk on highways is due to the limited vibration and impact effects during transport. In contrast, the dramatic increase in risk scores on rural and mountain roads highlights that the most fragile stage for modules is the rural logistics process. This finding aligns with the work

of Li and Bilec (2019), who emphasized that poor road conditions are the most critical risk factor in modular structure transportation.

When evaluated in terms of vehicle types, it was observed that 8-wheel tractors and semi-trailers offer significant advantages in terms of capacity, but risks increase due to reduced maneuverability on narrow roads. This situation aligns with the findings in the NCHRP (2003) report regarding the negative effects of vehicle length on maneuverability. On the other hand, 4-wheeled vehicles are advantageous on narrow roads and sharp curves despite their low capacity. At this point, 6-wheeled rigid trucks stand out as a "balancing factor" in terms of both capacity and maneuverability.

Module types also have a significant impact on the risk profile. Steel construction modules have been found to be relatively more resistant to vibrations and impacts due to their lighter weight. Prefabricated reinforced concrete modules, on the other hand, carry a risk of cracking and connection loosening, especially under poor road conditions, due to their heavy structure. Ghosh and Sullivan (2018) also found that the risk of structural damage increases during the transportation of heavy prefabricated structures; this result is directly consistent with the findings of our study.

The ETA diagram results show how error chains can trigger each other and lead to major damage. While smooth transportation is likely to occur with a probability of 65–70% in the highway scenario, the probability of major damage exceeds 30% on village and mountain roads. This finding supports the work of Zeng and colleagues (2017), who emphasized the power of the ETA method in modeling complex risk chains, particularly in construction and logistics processes.

Thus, this study not only produced findings consistent with the existing literature but also filled a gap in the literature by comprehensively addressing vehicle types, road conditions, and module types. While transportation risks are typically addressed in the literature in a one-dimensional manner (only road, only vehicle, or only structure type), this study evaluated all three parameters simultaneously and presented a systematic probability model using the ETA method.

The findings indicate that there are significant logistical risks involved in transporting modular housing units. However, these risks take on a different context when compared to the time, labor, and maintenance challenges faced by on-site construction methods in the aftermath of a disaster.

The main challenges faced by on-site construction practices in disaster conditions are summarized as follows (Lawson et al., 2012; Tam et al., 2015):

Time Pressure: Site setup, material procurement, and labor organization can cause significant delays in the aftermath of a disaster. An average residential construction project can take 3–6 months, depending on site conditions. In Turkey, these timeframes are likely to be extended in the aftermath of an earthquake. The suitability of the ground for excavation and construction after an earthquake is an additional process.

Labor Requirements: On-site production requires a large number of skilled workers to be present on-site for an extended period. Access to such labor is often limited in disaster-affected areas.

Maintenance and Quality Control: Manufacturing in a field environment cannot match the quality control standards of a factory environment, which may increase the need for maintenance and repairs in the coming years.

In contrast, modular systems offer the following advantages, as noted in the studies by Ghosh & Sullivan (2018) and Li & Bilec (2019):

Time Efficiency: Modules can be completed in the factory through mass production before arriving at the disaster site; only assembly is required on site. This can reduce the total installation time to a matter of weeks.

Labor Savings: Only crane operators and assembly teams are required on site; labor-intensive construction activities are completed in the factory environment.

Standard Quality: Thanks to factory production, the modules have standard material and workmanship quality.

Therefore, transportation risks do not outweigh the temporal and operational advantages that modular systems offer in the post-disaster resettlement process; on the contrary, with proper planning, these advantages can be preserved while managing risks.

This study highlights that damage risks during transportation are particularly high on rural/mountain roads, but also demonstrates that these risks can be reduced through preventive logistics planning and protective measures. Route selection, module securing techniques, vibration-reducing transportation equipment, and weather-dependent planning can significantly reduce the overall risk.

In this context, one of the most distinctive aspects of the study is its examination of risks in modular housing transportation using a comprehensive ETA approach that considers vehicle type, road conditions, and module type simultaneously. While most studies in the literature address risk factors in a one-dimensional manner, this study systematically reveals the interactions between different parameters within a probability-based model. Additionally, the fact that the study not only identifies theoretical values but also quantitatively analyzes them using an Excel-based computational model can be considered an innovative aspect that directly contributes to practice. With these features, the research contributes methodologically to the academic literature while also providing decision-makers with a practical roadmap for post-disaster housing logistics.

RESULTS

In this study, the transportation processes of modular housing systems for post-earthquake emergency shelter needs were examined in detail, and risks were systematically assessed using the ETA method. The results indicate that the sources of risk during the transportation process are not limited to logistical conditions; vehicle selection, road conditions, module typology, and environmental factors interact to determine the risk profile.

Transportation carried out under highway conditions presents a relatively safe structure. However, considering that the need for reconstruction in post-disaster areas and unsuitable conditions for reconstruction are generally located in rural areas, it is seen that risks on village and mountain roads reach a much more critical level. In particular, the maneuverability of long vehicles is weakened on these surfaces, increasing the risk of impact and overturning. At this point, it is necessary to diversify the vehicle fleet used in module transportation, including not only high-capacity trucks but also shorter vehicles with high maneuverability.

A comparison between steel-framed modules and reinforced concrete prefabricated modules has shown that structural durability is directly related to transportation risks. Steel modules are more resistant to vibrations and impacts due to their lightweight nature, while reinforced concrete modules, due to their heavy structure, carry a higher risk of damage, especially on rough terrain. This situation highlights that steel modules are a more advantageous option for rapid post-disaster settlement solutions. However, the long-term maintenance issues of steel structures, their fire resistance, and their evaluation as temporary housing products should be taken into consideration. Concrete module production should be considered for permanent housing using modular systems. As highlighted in this study, potential transportation damages must be taken into account, additional detailed solutions suitable for concrete system transportation should be developed, and repair costs and durations under field conditions should be minimized.

One of the most important contributions of this study is that it does not merely identify risk factors, but systematically models them within a probability-based analytical framework. Thanks to the ETA method, risks are quantified not only as individual events, but also in terms of how they can lead to consequences in a chain reaction. This approach is a dimension that is lacking in the existing literature, making the study unique.

In addition to its positive aspects, certain limitations should not be overlooked. The analyses are based on theoretical data and standard transportation profiles; it should be noted that risk ratios may differ in real life if not supported by field observations. Furthermore, this study is evaluated solely within the context of Turkey, and road infrastructure, vehicle standards, and climatic conditions in different countries may produce different results.

In conclusion, this study has shown that post-earthquake modular housing transportation is not merely a logistical problem but also a multi-layered risk management issue. To reduce risks, it is necessary to improve road infrastructure, diversify the vehicle fleet, adapt module typologies to transportation conditions, and integrate probability-based risk analyses into decision-making processes. This perspective provides an important contribution to both disaster management and civil engineering disciplines.

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VIOLENCE IN MUSLIM WEST AFRICA: THE CRISIS OF RELIGIOUS POLITICS AND SECULAR IDEOLOGIES

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ABSTRACT

While West African Muslims generally want to present a common front and argue that there are no sects in Islam, there are in fact profound differences and divisions among them. When these divisions result in violence or political tension, they become difficult to conceal. The prevalent assumption that Islam is culturally and theologically monolithic, held mainly by Christians, is dead wrong. There are many different kinds of factions, sects and movements, and Sufi brotherhood, often characterized by sharp doctrinal differences.

Eventhough physical violence is the most public expression of hostitlity, it does not represent all the manifestations of religious crisis in West Africa. Through verbal aggression, West African Muslims and Christians alike, continue their fighting and competition, creating a more or less permanent state of warfare of some kind. Even those who regard themselves as law-abiding and peaceful either underplay the power of words to hurt and incite or deny altogether that they have the power to cause harm. Conversely too, symbolic violence, as this work underscores, has become a permanent feature of religious competition, sometimes setting the stage for physical assaults or acting as a postscript to the physical violence itself.

Through sermons, public speeches, writings and revivals, each religion has made the other into a primary concern. West African Christianity cannot be fully understood today without analyzing its perception of Islam, and the same is true of Islam in relation to Christianity. A good Muslim is one who is able to withstand Christian conversion tactics and campaigns. A good christian is also one who is able to confront Islam and challenge the Qur'an's authority.

I argue that, these conflicts are unlikely to go away anytime soon and may perhaps, assume other dimensions. Ambitions for leadership, the permanent need to reform Islam and adapt to changes and the changing nature of the modern world will continue to create divisions among Muslims. Finally, I also articulate in the work that, major developments elsewhere will continue to affect West African Muslims. As such, religious leaders with new Islamic visions of the world will always emerge as subversive forces from the outside. Enthusiastic local leaders will always search for insurgent forces to create a role for themselves whiles foreign countries will continue to have vested interests in the ways many of these issues are resolved. Sunni-dominated countries like Saudi Arabia, Libya, Egypt, and Turkey will therefore, continue to support both pro and anti-sufi campaigns whiles Iran is unlikely to abandon its West African Shiites.

Keywords: Sufism, Violence, Religious Politics, Secularism, Muslims, West Africa

SUNNI-SUFI CONUNDRUM: MUSLIMS, SPIRITUALITY AND THE SEARCH FOR MEANINGS IN ISLAMIC RELIGIOSITY WITHIN THE SUFI TRADITION IN WEST AFRICA

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ABSTRACT

The question of whether it is acceptable or not, permissible or otherwise, in Islam, to engage in magic and or with other esoteric powers regarding the use of charms, amulets and washed Qur'anic Verses on slates as medicinal remedies in Islam is as contentious and misunderstood as the religion of Islam has been for many, especially those with limited or to no knowledge of Islam at all. By utilizing the historiography within the field, I argue in this work the ramifications of Muslims & Magic on one hand and their use of Charms, Amulets and Washed Qur'anic Verses on Slates as Medicinal Remedies in Islam on the other. While the Qur'an repeatedly pronounced itself as ***'a healing and mercy,'*** for mankind, its appeal is more of spiritual and natural than mere ingestion of its material writing or pages. There is preponderance of opinion among Muslim scholars that the use of washed Qur'anic verses off slates for medicinal purpose confers, if any, a psychological satisfactory effect rather than actual remedy. This is because it is not meant for that purpose. However, one cannot disregard the placebo effect of some practices or drugs even if they are unrelated to the malady for which they are meant to effect cure. Consequently, it seems safer (Healthwise in terms of avoiding the unhygienic or unsanitary conditions associated with the practice in the traditional setting and for spiritual safeguard of one's faith) to discourage the practice. Instead, this work argues that emphasis should be laid on research and utilisation of the natural remedies specifically pointed out by the Qur'an and genuine prophetic practice in order for Muslims to benefit from its diverse blessings and goodies it confers on its followers.

Keywords: Magic, Charms, Amulets, Qur'an, Health, Remedies, Muslims, Islam, Hadith.

THE IMPORTANCE OF USING INDUSTRIAL WASTE IN THE PRODUCTION OF ECONOMICALLY EFFICIENT MATERIALS

IQTISODIY SAMARALI MATERIALLAR ISHLAB CHIQARISHDA SANOAT CHIKINDILARIDAN FOYDALANISHNING AHAMIYATI

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ABSTRACT

The purpose of our scientific research is to use industrial waste in the production of economically efficient materials, and is devoted to the issues of the harmonious use of valuable natural raw materials with industrial waste. As is known, the effective use of industrial waste requires taking into account a number of factors, such as the substances present in their chemical composition, the aggregate state of substances (gas, liquid, solid), the amount of waste generated, and their technological characteristics. As the most optimal technological solution, it is advisable to introduce waste-free technologies into production. In this regard, it is important to conveniently change technological processes, create systems that include closed cycles, and create the possibility of multiple reuse of raw materials. As a factor leading to economic efficiency, ultimately reducing the cost of production, the integrated use of raw materials has a number of advantages. Firstly, waste today occupies large areas, and their reuse prevents environmental pollution, creates conditions for the release of the areas they occupy for use, and serves to eliminate particulate matter emitted into the environment. Secondly, it allows the use of waste to cover the need for raw materials. Thirdly, the integrated use of raw materials leads to a reduction in the specific costs of product production (compared to one type of product) and a reduction in their payback period. As a waste, we selected used zeolite from the Shurtangaz chemical complex, which was used as an adsorbent. For drying gases, a zeolite with a pore size of 4 Å and high water absorption is used. This leads to the filling of the pores of the adsorbent with adsorbed molecules. The zeolite in the gas adsorption dryer is replaced once every three years. This generates 80-100 tons of waste. In gas dryers, synthetic zeolites, which are molecular binders with the formula $Na_2O{\cdot}Al_2O_3{\cdot}2SiO_2{\cdot}XH_2O$ or $Nax[(AlO_2)x{\cdot}(SiO_2)y]{\cdot}ZH_2O$, are used as adsorbents. In a sample of zeolite waste of optimal composition, calcined at a temperature of 1200oC for 2 hours, the content of silicon oxide (SiO_2) of the main oxides involved in mineral formation was 41.6%, the content of aluminum oxide (Al_2O_3) was 33.8%, the content of calcium oxide (CaO) was 12.3%, and the content of sodium oxide (Na_2O) was 5.15%. It is clear from this that zeolite waste, along with the main raw material components, can be used to obtain silicate materials, calculated for each component and the oxides included in the batch. In conclusion, it should be noted that economically viable silicate materials, can be obtained from zeolite waste previously used in a gas adsorption dryer. The high content of aluminum oxide in mined zeolite samples leads to an increase in the liquidus temperature, and this production process requires energy.

During the batch formation process, the fluidization temperature can be reduced by coordinating the oxides in each raw material component and waste and by introducing additional materials.

Key words: zeolite waste, an economically viable material

ABSTRACT

Ilmiy tadqiqotimizning maqsadi iqtisodiy samarador materiallar ishlab chiqarishda sanoat chiqindilaridan foydalanishdan iborat bo‘lib, qimmatbaho tabiiy xomashyo resurslarini sanoat chiqindilari bilan muvofiq qo‘llash masalalariga bag‘ishlanadi. Ma’lumki, sanoat chiqindilaridan unumli foydalanish, ularning kimyoviy tarkibida qanday moddalar mavjudligi, moddalarni agregat xolati (gaz, suyuq, qattiq), xosil bo‘layotgan miqdori, texnologik o‘ziga xos xususstyalari kabi bir qator omillarni inobatga olishni talab etadi. Eng maqbul texnologik yechim sifatida ishlab chiqarishga chiqindi xosil qilmaydigan texnologiyalarni tadbiq etish maqsadga muvofiq. Bunda texnologik jarayonlarni qulay tarzda o‘zgartirish, yopiq sikllarni o‘z ichiga olgan tizimlarni yaratish, xom ashyoni bir necha marta qayta ishlatish imkonini yaratish muhim hisoblanadi. Iqtisodiy samaradorlikka olib keluvchi, pirovardida maxsulot tan narxini kamaytirishga olib keluvchi faktor sifatida qaraganda, xom ashyodan kompleks foydalanish bir qator avzalliklarga ega. Birinchidan, chiqindilar bugungi kunda katta maydonlarni egallagan bo‘lib, ularni qayta ishlatish atrof muhitni ifloslanishini oldini oladi, ular egallagan maydonlarni foydalanish uchun bo‘shatishga sharoit yaratish, tashqi muhitga chiqarib yuborilayotgan zarrali moddalarni yo‘q qilishga xizmat qiladi. Ikkinchidan, chiqindilarni qo‘llash orqali xom ashyoga bo‘lgan ehtiyojni qoplash imkonini beradi. Uchinchidan, xom ashyodan kompleks foydalanish maxsulot ishlab chiqarish uchun ketadigan solishtirma sarf xarajatlarni (bir dona maxsulot turiga nisbatan) kamaytirishga, ularni qoplanish muddatini kamayishiga olib keladi. Chiqindi sifatida Sho‘rtangazkimyo majmuasining adsorbent sifatida foydalanilgan ishlatilgan seolitini tanladik. Gazlarni quritish uchun g‘ovak hajmi 4 Å bo‘lgan va yuqori suvni yutuvchi zeolit ishlatiladi. Adsorbentning g‘ovaklarini adsorbsiyalangan molekulalar bilan to‘ldirishga olib keladi. Gaz adsorbsion quritgichdagi zeolit har uch yilda bir marta almashtiriladi. Bunda 80-100 tonna chiqindi hosil bo‘ladi.Gaz quritgichlarda formulasi $Na_2O{\cdot}Al_2O_3{\cdot}2SiO_2{\cdot}XH_2O$ yoki $Nax[(AlO_2)x{\cdot}(SiO_2)y]{\cdot}ZH_2O$ bo‘lgan molekulyar bog‘lovchilar sanalgan sintetik zeolitlar adsorbent sifatida foydalanadi. 1200^oC temperaturada 2 soat davomida kuydirilgan optimal tarkibdagi seolitli chiqindi namunasida mineral hosil bo‘lishida ishtirok etadigan asosiy oksidlardan kremniy oksidining (SiO_2) miqdori - 41,6%, alyuminiy oksidining miqdori (Al_2O_3)- 33,8%, kalsiy oksidining miqdori (CaO) - 12,3%, shuningdek natriy oksidining miqdori (Na_2O) - 5,15 % ni tashkil etdi. Bundan ko‘rinib turibdiki, seolitli chiqindini asosiy xom-ashyo komponentlari bilan birga, har bir component bilan shixta tarkibiga kiruvchi oksidlar uchun hisoblab, silikat materiallar olishda foydalanish mumkin. Xulosa sifatida shuni ta'kidlash kerakki, iqtisodiy jihatdan samarali silikat materiallar, avvallari gazni adsorbsion quritgichda ishlatilgan zeolit chiqindilaridan olinishi mumkin. O‘ganilgan zeolitli namunalarida alyuminiy oksidining yuqori miqdori suyuqlanish temperaturasining oshishiga olib keladi va bu ishlab chiqarish jarayoni energiya talab qiladi. Shixtani shakllantirish jarayonida har bir xom ashyo komponenti va chiqindilar tarkibiga kiradigan oksidlarni muvofiqlashtirish va qo'shimcha materiallarni kiritish orqali suyuqlanish temperaturasini kamaytirish mumkin.

Keywords: seolitli chiqindi, iqtisodiy samarador material

ZERO TRUST ARCHITECTURE: A WAY TO ENHANCE ENTERPRISE SECURITY

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ABSTRACT

Zero Trust Architecture (ZTA) represents a transformative approach to modern cybersecurity, directly addressing the shortcomings of traditional perimeter-based security models. With the rise of cloud computing, remote work, and increasingly sophisticated cyber threats, perimeter defenses have proven ineffective at mitigating risks, particularly those involving insider threats and lateral movement within networks. ZTA shifts the security paradigm by assuming that no user, device, or system can be trusted by default, requiring continuous verification and the enforcement of least privilege access for all entities. This paper explores the key components of ZTA, such as identity and access management (IAM), micro-segmentation, continuous monitoring, and behavioral analytics, and evaluates their effectiveness in reducing vulnerabilities across diverse sectors, including finance, healthcare, and technology. Through case studies and industry reports, the advantages of ZTA in mitigating insider threats and minimizing attack surfaces are discussed. Additionally, the paper addresses the challenges faced during ZTA implementation, such as scalability, integration complexity, and costs, while providing best practices for overcoming these obstacles. Lastly, future research directions focusing on emerging technologies like AI, machine learning, blockchain, and their integration into ZTA are examined to enhance its capabilities further.

Keywords: Zero Trust Architecture, enterprise security, insider threats, micro-segmentation, continuous verification, behavioral analytics, identity and access management (IAM).

AZERBAYCAN FOLKLORUNDA İLK BABA (ATA) KAVRAMININ BOZKURT PARADİGMASİ * (BİR ZOMORFEM OLARAK)

THE GRAY WOLF PARADIGM OF THE FIRST ANCESTOR IN AZERBAIJANI FOLKLORE (AS A ZOMORPHEME)

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ABSTRACT

The article examines the belief in the Gray Wolf in the thinking of the first man – the ancestor. In the initial conception, the Gray Wolf was viewed as a totem or a sacred ancestral, and our first ancestors always considered the Gray Wolf sacred. As in the Turkic peoples, in the mythical thinking of the Azerbaijani people, the Gray Wolf is primarily viewed as a savior, a warrior, a protector, and a guide of the Turk, and has been studied with the help of myths and legends collected from different regions. In addition, the Gray Wolf's many functions, such as a friend, a support, and a savior, have been investigated.

Keywords: Ancestor cult, ancestors, national values, Oghuz Khan, customs

ÖZET

Makale, ilk insan - ata - düşüncesinde Bozkurt inancını incelemektedir. İlk anlayışta Bozkurt bir totem veya kutsal bir ata olarak görülüyordu ve ilk atalarımız Bozkurt'u her zaman kutsal saymışlardır. Türk halklarında olduğu gibi, Azerbaycan halkının mitolojik düşüncesinde de Bozkurt, öncelikle Türklerin kurtarıcısı, savaşçısı, koruyucusu ve rehberi olarak kabul edilmiş ve farklı bölgelerden derlenen mit ve efsanelerin yardımıyla incelenmiştir. Ayrıca, Bozkurt'un arkadaş, destek ve kurtarıcı gibi birçok işlevi de incelenmiştir.

Açar sözlər: Atalar kültü, atalar, milli değerler, Oğuz Han, gelenekler

Makaleye giriş. Türk halklarının folklorunda ve mitolojik düşüncesinde, Azerbaycan folklorunda olduğu gibi atalarımız totemistik bir düşünce tarzına sahipti, farklı zamanlarda Bozkurt, Geyik, Geyik ve Dağ'ı ilk atalar olarak görüyorlardı. Türk mitolojik düşüncesinde ilk atalar moderatörler, kültürel kahramanlar, inanılan ve kelimenin gerçek anlamıyla Kağan seviyesine yükselen kişilerdi. İlk atalar halkın karşısına çıktılar, inşa ettiler ve yarattılar, insanların çeşitli zor yaşam koşulları içinde faaliyetlerini kurmalarına yardımcı oldular, onlara belirli modeller gösterdiler, onları doğru yolda yönlendirdiler ve büyük ölçüde neslin, kabilenin ve halkın büyükleri olarak hareket ettiler. Örneğin mitolojik düşünceye göre Oğuz Kağan, halkın tek bir fikir etrafında birleşmesinin temelini attı.

- Ata kültünü (ecdad) dile getirenler, ait oldukları insanlara önderlik eder, onları kurtarır ve onlara yeni yollar gösterirler. Mitleri düşündüğümüzde, Azerbaycan mitolojilerinde ve diğer Türk halklarının mitolojilerinde de olduğu gibi, atadan bahsettiğimizde iki məkam akla gelir:
- İlkin atanın (ecdad) hayvan paradikması (totem ecdad)

Bu noktada Oğuzların totemistik görüşlerinden yola çıkarak, asıl atayı, Oğuzların koruyucusu, kurtarıcısı ve yol göstericisi olan Bozkurt olarak görüyoruz.

İlk ata (ecdad) insan paradikması gibi

Burada akla yaratılışta duran ilk insan atası geliyor.

Seyfəddin Rzasoy araşdırmalarında ata (ecdad) kultunun subyekti olan əcdadları üç paradiqmada təzahür edildiyini bildirir.

1. İnsan paradikması;
2. Hayvan paradikması;
3. Tebiet obyektləri paradikması [12].

Azerbaycan folklorunda, mitlererinde daha çok ilk ecdad dedikdə ilkin başlanğıcda duran ağsakkal atanı, insan paradikmasını başa düşürük. Ancak İslam öncesi mitolojik düşüncenin ürünü olan birtakım efsanelerimize dikkat edecek olursak, boz kurdun kurtuluş ve savaş simgesi olmasının yanı sıra aynı zamanda baba kültünü de simgelediğini görürüz. Mitlerimizde ilkin atanın (ecdadın) daşıyıcısı olan ata kültü ilə yanaşı, yol göstəren bazen ecdad funksiyasında konuşan Boz Kurt imgesine de sıkça rastlarız.. Bildiyimiz gibi türk halklarının inam sisteminde Boz kurt sembol gibi deyerlendirilmiş, savaş simvolu gibi kabul olunmuş, yüksek tutulmuşdur. Mitoloji düşüncede türklerin atası - ecdad kültünün daşıyıcısı olarak dikketimizi celb ediyor. Kurtun ezmkarlığı, kendine güveni, inamı, korkmazlığı ve yenilmezliyi el arasında igid, cesur adama bu gün de deyilən "Kurt yüreyi yeyif" ifadəsi ilə sıx bağlıdır.

Azerbaycanın azeli toprağı olan Füzuli rayonundan topladığımız bir mitə dikkat edek: "*Uğuz adında bir qoçaq kişi var idi. Həmişə qaranlıxda meşəyə gedərdi. Gedim dərdimin qurdu uluya bəlkə diyirdi. El arasında igidliyinə görə hamı ona qurd ürəyi yiyifdi bu kişi deyirdilər. Uğuz meşədə çox getdihdən sora dumanlı havada yolunu azıfdı, görüfki, meşənin qarannığında iki göz parıldaya-parıldaya yuxarıda aşağıya gəlif bunun qarşısınaca düşüf. Uğuzu arxasına salıf irəliyə doğru gedirfdi. Çox dağlar aşıf, təpələr keçif bir düzəngahda dayanır. Uğuz anlıyırkin türk soyu burda özünə el edəsi yerdi"* [13]. Gördüğünüz gibi burda Boz kurt yol gösteren, Uğuz eline düzen veren, moderatorluk edəndir.

Mitolojik düşünceye dayanan folklor bilimcilerin çalışmalarında bozkurtla ilgili birtakım ilişkiler gözlemlenmektedir.

- Birincisi, Boz kurta ata (ecdad) kültünün taşıyıcısı gibi ve yahud sakral ata (ecdad) gibi bahılmıştır.
- İkincisi, Boz kurt türk halklarının – koruyucusu gibi kabul edilyor.
- Sonuncu, Boz kurt Türk halklarının savaş simvolu, ramzi gibi esas nəzare dikkete alınıyor.

Biraz açıklık getirmek için mitlerimize bakalım. Genel olarak, ilk atanın gerçekten bir hayvan paradigmasının olup olmadığı, yoksa sadece totemistik dünya görüşüyle doğrudan bağlantılı olarakmı ortaya çıktığı ilginçtir. Mitolojik metinlerde bazen ilk atanın ağaç, dağ, güneş ve kurt gibi doğa unsurlarından yaratıldığı belirtilir. Türk mitolojik düşüncesine göre ilk ata (ecdad) kurttur. Günümüze ulaşan kaynaklarda, güçlü Türk kahramanlarının her birinin efsanelerinde bir kurt, mavi kurt veya boz kurt yer alır. Bunun örneği olarak pek çok efsane sıralanabilir. Türk halkları, Azerbaycan halkı gibi, düşman karşısında ve zorluklar karşısında bile boyun eğmeyen, dik duran, kimsenin kölesi olmayan, korkmayan, hakikat ve adalet savaşlarını, vatan savaşlarını, hürriyet savaşlarını veren Bozkurt'u çok sevmiş ve kutsal saymıştır.

Herhangi bir Türk kahramanlık tarihini okuduğumuzda, kahramanın boz kurdun sütünü emdiğini ve doğru yolu bulmak için onun peşinden gittiğini görürüz. Hunlar, Göktürkler, Altaylar, Uygurlar, Hakaslar ve ya Yakutlar olsun, tüm Türk halklarının mitolojisinde mutlaka bir kurt obarzına rastlamak mümkündür.

İkinci Karabağ savaşında da halkımızın yiğit ve kahraman evlatları, bozkurt cesareti ve kahramanlığını göstererek Şuşa kayalarına tırmanmış, pençeleriyle, tırnaklarıyla vatan toprağını almışlar, büyük dedelerimizin bize emanet ettiği vatan toprağını, bunun en mükemmel örneği olabilir.

Efsanelere göre, uzaylı düşmanın saldırısından yalnızca bir çocuk sağ kurtulmuştur. İlk ata kurdun gelişiyle, onunla olan ilişkiden torunlar doğar ve böylece ilk ata olarak yeni bir dünya düzeninin insanlarının üremesinin temelini oluşturur. Atamız, halkı çeşitli savaşlarda ve zor zamanlarda korumakla

kalmaz, aynı zamanda çeşitli zor durumlarda da onların koruyucusu olarak yanında olur. Bu zaten Türk milli şuurunun özbilincidir. Bozkurt, savaş ruhunu temsil eder. Bu inanç Oğuz Kağan destanında tam olarak ifadesini bulmaktadır:

Reşidüddin Fazlullah'ın "Camiu'l Taverih" adlı Oğuzname adlı eserinde qeyd olunyor ki: "Herkes masanın etrafında oturuyordu. Sofraya nimeler getirildi, tam o sırada bir kurt sesi duyuldu. Meclisin başında oturan Tuman Han (yani Bumun Kağan), bütün hayvanların dilini bildiği gibi kurtun ne dediğini de biliyordu. Kurdun söylediklerini etrafındakilere şöyle anlattı: "Yazık ki yaşlandım. Avladığım avı artık yiyemiyorum. Kurdun yanındaki üç genç kurt ona şöyle derler:" Yaşlı ve güçsüzseniz üzülmeyin. Her genç yaşlılara yardım etmelidir, bunu yapmazsa ne değeri kalır. Bu gece sis ve şiddetli bir fırtına olacak. Köyün diğer tarafında bir düğün var. Fırtınadan faydalanıp düğüne getirilen tüm hayvanların kuyruklarını ve karınlarını kesip size getireceğiz. Bunları gönül rahatlığıyla tüketebilirsiniz. Ve biz her zaman hizmetinizdeyiz" [14, s.13-14]. Eserden anlaşıldığı üzere Türkler Bozkurt'a farklı bir değer vermişlerdir. Gördüğünüz gibi kurtların karakteristik bir takım özellikleri açıkça görülüyor; kurt sadakati, bağlılık ve büyüklerine saygı.

Tüm bunların yanı sıra, Azerbaycan folklorcularının eserlerinde iki yaklaşımla karşılaşıyoruz. İlk yaklaşım onu yalnızca bir totem atası olarak görürken, diğerleri totemizmi kabul etmemiş ve yalnızca atalar kültünü ve Türkler için bir savaş sembolünü yansıtmıştır. Bozkurt ise bazen halkın ceddi gibi, atası olarak görülmüştür.

Kurt, dünyadaki bazı halklar tarafından da kutsal kabul edilir. Amerika'da yaşayan Maya kabileleri bugün hala kurda tapınmaktadır, kurt Roma'nın sembolü olarak benimsenmiştir ve Çinlilerin kurda tapındığına dair fikirler vardır.

Bugün Azerbaycan'da kurtla ilgili çok sayıda yer adı, efsane, mit, inanış, gelenek ve tören bulunmaktadır. Bu da kurdun insan hafızasında yerini aldığını ve bu mitolojik imgenin cesaret, yiğitlik, dürüstlük, özgürlük ve savaşın simgesi olduğunu kanıtlamaktadır. Ulu" kelimesinin bazen "kurt" kelimesiyle ilişkilendirilmesi tesadüf değildir. Bazen de "Köy" tanrısıyla ilişkilendirildiği söylenir. zerbaycan folklorcularının araştırmalarına baktığımızda, totemizmi kabul edenler ve etmeyenler görüyoruz. Ayrıca, ana soyunun başlangıçta var olduğuna inananlar da var. Totem konusunda bilim insanları iki yönlü düşünüyor.

- İlk grup, totemleri kesin olarak kabul etmeyenlerdir. Arif Ayalov, Fuzuli Bayat I.Qafesoglu ve diğerleri, Türk halkları arasında totem inancının olmadığı görüşündedir. Boz kurdun el becerisinin, cesaretin, gücün, kartal boyunun, kudretin, babanın, saflığın, temizliğin, askeriliğin, şevkin, büyüklüğün, sevginin, saygının, asaletin, sadakatin, sadakatin simgesi olduğu düşünülür. Şukurov onları bir totem olarak değil, kabilenin önünde duran bir kabilenin ilk atası olarak ele alıyor. A.Şukurov, bu mitolojik düşüncenin kanıtını, eski Türklerde kurdun adının "mavi kurt olması, onun Tanrı'nın oğlu olduğunun doğrudan bir göstergesidir" şeklinde yazarak güçlendirir... Tanrı'nın oğlu olan kurda, Yakut şamanları tarafından "Tangara uola" (Tanrı'nın oğlu) denir [14, s.84-85]. A.Şukurov ise boz kurdu atalarının annesi olarak görmüş ve onu mitolojik anne kompleksine daha yakın görmüştür. Aslında, eski insan-mitolojik düşünce çağına uygun olarak kurt, baba ve (bazen anne) geyiği totem atalar olarak görmek daha doğrudur.Bu türk halklarında da aynıdır. Yakutlar geyiğe Tanrı'nın geyiği derler.

Elçin Abbasov, Çin kaynaklarına dayanarak, boz kurdun Türk halklarında yalnızca askeri bir anlam taşımadığını, aynı zamanda hanlığın sembolü, Gök Tanrı'nın bir tezahürü, Tanrı'nın elçisi, kurtarıcısı, evanjelisti olduğunu anlatıyor [1, s.37-38].

Ancak Azerbaycan folkloruna bakıldığında, ata kültü açısından bozkurt, yılan, geyik ve öküzden daha sık anılır. Gumulyev, "Eski Türkler" adlı tarih çalışmasında "Aşina" kelimesinin anlamının "canavar" olduğunu belirtir. Aşina halkının totemist olarak adlandırılmasının doğru olup olmadığı sorusu, modern bilgimizin sınırları içinde çözümlenemez. Ancak VI yüzyılda "canavar" isminin Türkler için büyük bir

öneme sahip olduğu açıktır. Çinli tarihçiler, "Türk kağanı" ve "kurt" kavramlarını eş anlamlı olarak kabul etmiş ve o dönemde büyük olasılıkla Türk kağanlarının fikirlerinden bahsetmişlerdir. Tesadüf deyil ki, Sianbi Han'ın karısının, kocası Şabolio hakkında "Han doğası gereği bir kurttur" demesi ve Türklere saldırı talimatlarında "Bu önlemleri almak gerekir: Göçebelere saldırın ve kurtları kovun" denmesi tesadüf değildir. Türk bayraklarında altın kurt başı tasvir edilmiştir. Son olarak, Türklerin kökenine dair iki efsanede, dişi kurt – ata – hakkındaki versiyona birincilik verilmiştir [9, s.24].

Kitabi Dede Korqut destanında "Köküm Azvay kurt adamındadır ifadesi, onun soyunun (Salurlar) kurtlarla olan bağlantısını ortaya koymaktadır." – deməsi onun soyunun (salurların) kurtla bağlantısını yüzə çıkarır. Prof. M. Seyidovun yazdığı gibi, kurt vaxtı ile geniş yayılmış onqon oluyur. Çünkü çok ünlü Ongo'nun soyun kökü olduğuna inanıyorlardı. Belki de Kazan'a ait kurt totemiyle ilgili bir efsane vardı. "Dede Korkut Kitabı"nda kurdun sadece Kazan ile ilgili olarak anılması da söz konusu hususla ilgilidir. Günümüzde Azerbaycan'ın bazı bölgelerinde "Kurt lanetlenmez", "Kurt görünce dua et" gibi deyimlerin varlığı, kurdun atalık fonksiyonunu sürdürmektedir. Destanda Kazanın soyunu erkek bir kurda bağlaması, kurdun başlıca ongonlardan (totemlerden) biri olduğunu doğrular [13, s. 31].

Kazan Han'ın kurda karşı tutumu, köklerinin asli atası olan Boz Kurt'a bağlı olduğunun bir işaretidir. M.Seyidov, Kazan Han'ın "bir zamanlar mitolojik dünyanın bir 'vatandaş'ı" olduğunu, bu nedenle köklerinin kurt da dahil olmak üzere zoomorfik totemlerle bağlantılı olduğunu" belirtir [17].

Ramazan Gafarlı totemizm hakkında şu açıklamayı yapmaktadır: "Totem, toplumun her bireyinin hayatında önemli bir rol oynar, gelenekleri, kanunları ve kuralları düzenler ve toplumun tamamında istikrarın garantisi olur. Kendilerinin hayvan ve bitkilerden geldiğine inanan insanlar, öncelikle totem olarak seçtikleri varlığın özelliklerini kendilerinde görürler ve ortak atalarını yarı insan yarı hayvan veya yarı insan yarı bitki olarak hayal ederler. Yazar XV-XVI yüzyıllarda Azerbaycan'da var olan Akkoyunlu ve Karakoyunlu devletlerinin adlarının, mensup oldukları kabilenin toteminin adını taşımasına bağlamaktadır [10, s.312].

Bazı folklor araştırmacıları, Oğuz ve Kıpçak halkları arasında kurdun kurtarıcı rolünü oynadığı sonucuna varmışlardır. Totemizmin varlığını kabul eden yazarlar arasında Seyfaddin Rzasoy, Ramazan Gafarlı, Ramin Aliyev, Rövşen Alizade, Bahaddin Ögel ve diğerleri yer almaktadır.

S.Rzasoy, totemizmin yapısal açıdan akrabalığa dayalı insan-doğa ilişkilerinin bir modeli olduğunu, dünya görüşü açısından ise bir dünya modeli statüsünde olduğunu kabul etmiştir.

V.Valiyev ayrıca, Türk dilli halkların kadim destanlarında kurt veya Bozkurt'un bir kurtarıcı, Türk dilli kabilelerin ve atalarının koruyucusu olarak tasvir edildiğini yazıyor. V.Valiyev ayrıca, Türk dilli halkların kadim destanlarında kurt veya Bozkurt'un bir kurtarıcı, Türk dilli kabilelerin ve atalarının koruyucusu olarak tasvir edildiğini yazıyor. V.Valiyev de Türk dilli halkların eski destanlarında Bozkurt'un kurtarıcı, Türk dilli kavimlerin koruyucusu ve atası olarak tasvir edildiğini yazmaktadır [18, s. 41].

Kanaatimizce bu benzerlik, orijinal düşüncede mevcut olan totemizm geleneklerinden kaynaklanmaktadır. Öte yandan, buradaki en çarpıcı an, Bozkurt'un kurtarıcı olarak ışıkla birlikte gökyüzünden yere indiği andır. Bildiğimiz gibi, mavi renk her zaman büyüklüğü, başarıyı, yaşamı, coşkuyu ve çılgınlığı simgelemiştir. Boz kurdun mavi ışıkla yere inerek Türk'e ulaşması, onun savaşın, vatanın koruyucusunun, gücün, kurtuluşun ve savaşın simgesi olmasından kaynaklanmaktadır. Seyfeddin Rızasoy'un görüşüne göre, büyük atanın mitolojik hayal gücünde ve yaşamında önemli bir rol oynayan Bozkurt'un, belirli bir dönüşüm sonucu bir takım türevlerde ortaya çıktığı söylenebilir.

"Nuh və dünya daşqını" adlı mitde atalarımızın neyi daha değerli hesab etmələri açıqca belli olur. *"Daşqından sonra Nuh peyğənbər oğlanlarına istədiklərini götürüb nəsil artırmaq üçün yerə düşmələrini buyurur. Nuhun oğlu istədiyi nemətlərdən götürüb gəmidən yerə düşür. Həmin yerdə 400 il qaldıqddan sonra ot ələfin tükəndiyinin qoyunlarının yoxa çıxdığını görür. İzinə düşdükdə bir boz*

qurd görür. Boz qurt Türkü görüp gəldiyi yolunan dala qəyidir.Türk də düşür bının dalına.Xeylah gedillər.Türk baxır ki, qurdun getdiyi yerrərdə su heş topuğa qalxmır. Birəz gedənnən sora quruya çıxıllar.Bınnan da Türk xilas olur.Qəyidip heyvannarı da həmin yolunan gətirir quruya.Sora Türk fikirrəşir ki, bə məni bu boz qurt xilas elədi.Gərəh mən də boz qurdun şəklini çəkəm öz bayrağım Belə də eliyir. Soralar türkün nəsli çoxalanda hammısına deyir ki, qurd bizim xilaskarımızdı, əgər o, yol göstərməsəydi, nə mən olardım, nə də siz olardız. Ona görə də gərəh həmmişə boz qurda inanasınız. Boz qurdun şəklini bayrağınıza çəkip həmişə bı bayrağın dalınca gedəsiniz. Çətinliyə düşsəz, boz qurdu çağırasınız. Türkün övladları bu nəsihətə həmişə əməl eliyillər" [4, s.42-43].

Bildiğimiz gibi, tıpkı eski Türk inançlarında olduğu gibi, Azerbaycan halkının mitolojik hafızasında da bozkurt, kutsallığın, doğruluğun, dürüstlüğün, cesaretin, şövalyeliğin ve asaletin simgesiydi. Bozkurt, milli düşünce ve duyguları simgeliyordu. Boz kurdun kutsal sembol (totem) olarak seçilmesinin başlıca nedenleri, onun itaat kabul ederek evcilleştirilemeyeceği, zeki, çevik ve onurlu bir hayvan olmasıdır. Kuzey Türklerinin "Ağboru", Volga Türklerinin ise "Gökboru" adını vererek dokunulmaz ve kutsal saymaları, aslında ilk insan tasavvurunda özgürlük, öz güven ve savaş simgesi olan kurttan doğrudan doğruya türedikleri düşüncesiyle ilgilidir. Sembolik değerimiz Bozkurt, sonraki dönemlerde bir tapınma nesnesi olarak daha da değer kazandı.

Azerbaycan efsanelerine dikkat edersek, düşmanları tarafından esir alınan Uguz'un bir mağaraya saklandığını ve kısa bir süre sonra oradan Bozkurt kılığında çıkarak düşmana saldırdığını görürüz. Başka bir efsaneye göre ise, Tanrı dağından yer yüzüne ışıkla inen Bozkurt'un düşman tarafından yaralanıp sazlığa attığı 12 yaşındaki bir çocuktan 10 erkek çocuk doğar. Aynı 10 Türk boyu, 10 Türk halkının temelini atmıştır. İlginçtir ki, bugün Azerbaycan'da oldukça fazla yer adı bulunmaktadır; örneğin Borçalı, "Borü çalası", yani kurt çalası, kurtların yurdu. Ayrıca Şamahı'da (Gurd mahallesi), Gürcistan'da (Gurdlar köyü), Kars vilayetlerinde (Gurd tala), Erivan ilçesinde Gurdalı, Zangibasar'da Gurdbulag köyü, Darelayaz ilçesinde Gurdemir köyü adı. Aslında "Gurdlar" yer adı, eski Türklerin totemi olarak kabul edilen kurtla bağlantılıdır. Elçin İsmayılov'a göre, "Arkaik düşüncede kurt -kurt- özel bir yere sahiptir. Bu yüzden hayvan demiyoruz, çünkü Türkçülükte kurt anlamı hayvan bağlamının ötesine geçer ve daha geniş bir mitolojik -ilahi öz kazanır. Bu nedenle Türkler arasında kurt adıyla ilişkilendirilen birçok kabile ve yer adı vardır" [19].

Tarihi topraklarımız olan Batı Azerbaycan erazisinde kurtla ilgili çoksaylı yer isimleri vardır ki, çok malesef ki, bu gün armeniler o isimleri tarihin yaddaşından silmek üçün istedikleri gibi deyişdirmişler.

Ergenekon ve Oğuz Kağan destanlarında Bozkurt'un yerine baktığımızda onu, savaş ve mücadeleyi yönlendiren, koruyan, ilham veren, eski Türklerin dostu, mitolojik ve sembolik bir figür olarak görürüz. Ergenekon destanı, Bozkurt'un gökyüzünden mavi bir ışıkla inerek dört dağ arasında yaşayan Türklere dağın dört yamacında ateşler yakmalarını söylediğini anlatır. Ateş demir dağları eritir ve böylece Türkler Bozkurt sayesinde beyaz ışığa kavuşur. Daha sonra Göktürk bayrağına kurt başı işlenmesi de bu nedenle ortaya çıkmıştır. Aslında halka Nevruz olarak tanıtılan ve atalar gününü temsil eden bu bayram, aslında Ergenekon'dan ayrılmanın, hayatla mücadelenin, dirilişin, savaşın, eskiye veda ve yeni güne hoş geldin bayramıdır. Anadolu Türkleri de bugün Ulus Günü adı verilen bir bayramı kutluyor. O gün Türkler, atalarının dört dağın arasından yeni dünyaya can verdiği günün sevincini kutluyor. Zorluklardan kurtulmanın sevincini sevinçleriyle dile getiriyorlar. Dede-Korkut Destanı'nda boz kurdun kutsal sayıldığını, evi yağmalanan Kazan Han'ın sözlerinden anlıyoruz. "Kurdun yüzü mübarektir" der ve yurtunu,halkını kurttan haber almalarını ister. Destanda ayrıca "Kara başım sana kurban olsun kurda," "Kara yağmur yağdığında mis gibi kokar" gibi ifadelere de rastlıyoruz [8, s.41-44].

Bugün bile Türk halkları arasında Bozkurt işaretiyle selamlaşma geleneği vardır ve bu, Bozkurt'un Türklüğü simgelediğini açıkça göstermektedir. Neşeli tavırları, yenilmezliği ve cesaretiyle bilinen Türkler, Bozkurt'u bir selamlaşma, savaş ve bilgelik sembolü olarak kabul etmemişlerdir. Büyük

dedelerimiz Bozkurt'u, birlik ve beraberliği sağlayan ve bir yere sahip çıkmaya yardımcı olan bir kurtarıcı imgesi olarak görmüşlerdir. Kurt aynı zamanda tanrılar diyarının koruyucusu olarak da kabul edilir. Bozkurt'un ilk baba (ata) olarak görülmesi işlevi, kadim insanın totemizme karşı tutumunun bir ürünüdür.

Fuzuli Bayat, Bozkurt'un savaşın çağırıcısı, Türklerin annesi, kurtarıcısı ve savaşın koruyucusu olduğunu belirtir. Ancak Azerbaycan mitolojisinde, Kürd'ün bir totem babası olduğunu doğrulayan düzinelerce örnek vardır [6, s.150]. Fuzuli Bayat'a göre Bozkurt, Türk boylarında (örneğin Jigil, Yağma, Karlug boylarında) esas olarak bir babadır. "Mavi Türklerde soy, kurtuluş işleviyle birleştirilmiş ve bir baba-kurtarıcı biçiminde resmileştirilmiştir" [5, s.47]. Celal Baydilli'nin araştırmasında, "Türk mitolojik düşüncesinde Bozkurt, koruyucu bir ruh ve kültürel bir kahramandır; öncelikle büyük bir baba, rehber ve kurtarıcı olarak hareket eden mitolojik bir figürdür. İlk Türklerin çağdaşı, yani babaları olan Bozkurt, Türk etnik-kültürel geleneğindeki kozmogonik eyleme katılan, birincil bir baba ve kültürel bir kahramandır. Bu işlevlerin tümü Oğuzname motifinin en eski basamağında yer aldığından, kutsal kökenli bir "Cennet Oğlu" olduğu için kültürel bir kahramandır, demiştir [7, s. 67].

Celal Baydilli'nin araştırmasında, Huma'nın en büyük baba olarak kabul edildiği ve büyük bir anne olarak ele alındığı görüşünü buluyoruz. Gök kültünün erken dönemlerde eski Toprak Ana kültüyle bağlantısını kanıtlayan birçok mitolojik ve etnografik kayıt bulunmaktadır [7, s. 115].

Rovşen Alizade, Bozkurt'u en belirgin sembol olarak görmüştür. "Eski Türklerin inanç sisteminde, Bozkurt, öncü bir simge olarak değer kazanmış ve mitolojik düşüncede Türklerin babası (baba kültünün taşıyıcısı) olarak kodlanmıştır. Araştırma sonucunda, Hunlar ve Goy Türkleri'nin kutsal babası olarak kabul edilen Bozkurt'un, aynı zamanda Oğuz Türkleri'nin koruyucusu ve hamisi statüsüne sahip olduğu ortaya çıkmıştır [3, s.102]. Yazar, Bozkurt'u haklı olarak bir savaş sembolü olarak görmüştür.

Bozkurt bir totem ve birlik, liderlik, zekâ, cesaret, kurtuluş ve sahiplenme duygusunun sembolü olarak kabul edilir. Fuzuli Bayat Celal Beydilli Bozkurt, büyük bir anne olarak kutsal kabul edilse de, bazı mitlere yansısa da değişmeyen bir gerçek vardır. Bozkurt, Türk'e savaşta yardım eden, ona yol gösteren ve rehberlik eden paha biçilmez kutsal bir varlıktır.

Bozkurt, yol gösteren, atalarına zor zamanlarda yardım eden ve onları tehlikelerden koruyan kutsal bir varlıktır. Başlangıçta Bozkurt'u atalar kültünün taşıyıcısı, Tanrı'nın oğlu, Türklerin büyükbabası, rehberin kurtarıcısı, Türk halkının koruyucusu olarak görüyoruz. Daha sonra kurdun diğer statüleri kaybolmuş ve kurtarıcı, yol gösterici ve aynı zamanda tehlike uyarıcısı olarak işlevleri azalmıştır. Rövşen Alizade, Dede Korkut tasvirlerini kitabında inceleyerek, eski Türklerin inanç sisteminde Hunların ve Göktürklerin kutsal babası sayılan Bozkurt'un, aynı zamanda Oğuz Türklerinin koruyucusu ve bekçisi statüsüne de sahip olduğunu yazmaktadır [2].

Bunlara ek olarak, günümüz Azerbaycan'ında kurtlarla ilgili birçok mit, efsane, inanç, gelenek ve tören bulunmaktadır. Bu, Kürt'ün insan tercihlerinde önemli bir yere sahip olduğunu ve bu efsanevi imgenin cesaret, yiğitlik, dürüstlük, özgürlük ve savaşın sembolü olduğunu kanıtlamaktadır. "Ulu" kelimesinin bazen Kürtçe "ulari" ile ilişkilendirilmesi tesadüf değildir. "Kurt uludu" ifadesinin kökenini incelersek, kurt hakkında ilginç bir fikir ortaya çıkarabiliriz.

Dağlar yazın örtülüdür,

Her taş bir kaledir.

Bu ıssız ülkede

"Derdin kurtu uludu", yani "Kurt kederden uludu", günümüzde biri uğur getirdiğinde "Kurt kederden uludu!" denir. Yaklaşık 30 yıldır topraklarımızın düşmanın ayakları altında olması, kurdun kederimizde ulumasına, şansımızın değil, özlemimizin sebep oldu! Annelerimiz oğullarını, gelinlerimizi, kocalarını

ve soydaşlarımızı özledi. Sonuç olarak, zafer, sevinç ve mutluluk için söylenen eski kurt uluması ifadesi, artık kederle bağlantılı olarak uluyan bir kurt ifadesine dönüştü.

Tüm bunlara ek olarak, "Kürtleri yiyin, benim payıma dağlar düşer" sözü, kadim Türk halkının savaşa gitmeden önce yüzlerini ormana çevirip kurt gibi ulumasını anlatır. Kurtlarla karşılaşmak, kadim zamanlardan beri çok doğal bir gelenektir. Savaştan önce Kıpçak Han, Bonyak'ın yüzünü ormana doğru çevirip uluyarak, sesinde boz kurt sesi varsa savaşı kazanacağının işaretini verirdi. Köroğlu da savaştan önce aynı ifadeyi kullanır - kurtları yiyip onlarla iletişim kurmak. Yani, kutsal savaşın simgesi olan dedelerimizin gövdeleri, savaştan önce kurt sesiyle her zaman galip gelecek olan Türk'ün, Türk'ün oğlu Türk'ün!

Y.M. Melitinsky'nin araştırmalarına göre, totem geleneklerinin etkisiyle sembolleşen Oğuz, Türk halkının koruyucusu, baba mertebesine yükselen, Bozkurt'tan sonra ilk erkek olarak yerini alan, ilk baba olan, ilk düşünceden itibaren Bozkurt'tan farklı düşünen, akıllıca kararlar alan, büyüyen, büyük olan, kağan olan, ad koyan, ev yapan, yaratan, güçlendiren, yenileştiren, halkı yöneten vb. (ata) işlevlerini içinde barındırmaktadır.

Toplanan materyallerin çoğunda boz kurt, atalarından daha kurtarıcı bir işlev görmektedir. "*Ulu xan dəstəsiylə özünə yeni yurt yeri axtarmax üçün səyahətə çıxıy. Özünə yeni yurd yeri salmax istiyi. Başının dəstəsiylə hay gediy, vay gediy gəlif bir dağın döşünə çıxıy. Böyük bir tala çıxıy qarşılarına. Ulu xan dəstəsindən olan Qıpçax xana sən burda yurt sal diyi. Nəslindən törəyənlər bu diyarlarda hər zaman ad san qazansın, at çapıf, qılınc oynatsın, düşmənlərin gözünə dağ olsunlar diyir. Bunu diyif Ulu xan yoluna davam ediy. Qaş qaraldığından yolu tapa bilmiyilər. Birdə görüylər ki, bude uzaxdan iki göz parıldıyır. Bir boz qurd hoları öz arxalarınca gəlmələrini bildirirmiş kimi arxaya baxa-baxa Ulu xanı və dəstəsini xeyli irəliyə işıxlı yola aparıy. O vaxtasa kimi ki, artıx hava açılıy. Ulu xan istədiyi yeri qurdun sayəsində tapıy. Ho vaxdan Ulu xan hara gediymişsə qarşısında boz qurdu görüymüş". Ho vaxlardan el hona xilaskar gözündə baxıymış. Görüysənmi hindidə kənd yerlərində qurdun başını müqəddəs bilif bəd-nəzərdən qorumax üçün darvazaların başına asanlar da var. Dişinin möhkəmliyini sehrini uca tutuf sinəsində muncux edif taxanlar var ay bala"*[2].

Mitten de anlaşılacağı üzere Bozkurt bir kurtarıcı ve rehber işlevini yerine getirirken, Ulu Han halkına bir yurt ve bir yuva veren modernleştirici bir kahraman olarak öne çıkar. Tıpkı Oğuz Kağan destanında olduğu gibi, Oğuz Kağan bir kahraman olarak ilk baba, bir kültür kahramanı ve bir kurtarıcıdır. Bir kültür kahramanı olarak takipçilerini hayatın incelikleriyle tanıştırır. Oğuzların Oğuz'un soyundan geldiği düşüncesi, onun gerçekten ilk baba işlevini taşıdığını gösterir. Daha sonra yarattığı toplumu örgütler. Bu, onun kültürel olarak yapıcı işlevidir. Ulu Han, doğal olarak burada Oğuz Kağan'ın dönüştürücü paradigmasıdır. Öte yandan Uygur Göç Destanı'nda kurdu takip etme ve açık bir yola çıkma temasıyla karşılaşırız. Zaman içinde bu değişimler çeşitli şekillerde kendini gösterir. Akla şu soru gelir: Neden boz kurt? Türkler kurdu neden bu kadar kutsal saydılar? Folklor metinlerinde Kurt, Tanrı tarafından sevilen ve adalet arayanların yardımına her zaman koşan kutsal bir varlık olarak görülür. Bunu birçok efsanede buluruz. Kuzey Sibirya'da yaşayan Hakaslar, kurdu hâlâ kutsal bir hayvan olarak görürler. Soylarının Beyaz Kurt'tan geldiğini söylerler. Eski çağlardan günümüze Türkler, devlet yapılarının gücünü göstermek için bayraklarına bir kurt başı çizerlerdi. L.V. Kumilyov, Türk halklarının psikolojik yapılarına göre kendilerini kurt olarak gördüklerini ve "Aşina" kelimesinin "iyi kurt" anlamına geldiğini belirtir [11, s.144].

Sonuç. Bozkurt'un birçok şeyle ilişkilendirildiği ortaya çıktı. Ancak bozkurt, tüm Türk halkları için kurtuluşun, cesaretin ve savaşın simgesidir. İlk ata (ata), başlangıçta insan ırkının yaratıcısıdır.

Öyleyse Bozkurt'un aşağıdaki işlevlerde hangi fikirleri hayata geçirdiğine odaklanalım:

[2] Memmedova Semaye Hazretsoltan kızı Zakatala rayon Kımır köyü,1948

"Bozkurt" yüzyıllardır bir kabilenin ve bir halkın sembolü olmuştur. İlk baba, insan ırkının en tepesindeki ilk kişi, büyükbaba, yaratıcıdır. Dolayısıyla Bozkurt mitlerinde, mitolojik düşüncede şu işlevlerle karşılaşırız:

1. Tanrılaştırılmış Bozkurt
2. Totem babası (ata) seviyesine yükselen Bozkurt.
3. Kurt kurtarıcı olarak
4. Yol gösteren Bozkurt
5. Bozkurt, ülkenin ve vatanın koruyucusudur.
6. Üreyen Bozkurt
7. Zaferin habercisi Bozkurt
8. Toplumsal adaleti yeniden tesis eden Bozkurt
9. Dünyayı birleştiren arabulucu Bozkurt
10. Savaş kahramanlığının sembolü Bozkurt

Ancak bunlar metinlerde yer alsa da, Kürt'ün Azerbaycan folklorunda kurtuluş, rehberlik, kutsallık ve savaş sembolü olduğunu varsayıyoruz. Dokunduğu şekliyle, Boz Kurt birçok işlevi yerine getirmiş ve eski düşüncede totem babası seviyesine yükselmiş olsa da, kurt gökten ışıkla inen Tanrı'nın elçisi olarak kabul edilmiş olsa da, kurt ataların yardımcısı olarak kabul edilmiş olsa da, baba kahramanların karakterleri görünüşte ona benzese de, tüm bunlar büyük ataların kurdu dokunulmaz saymaları ve onu yüceltmeleri nedeniyle ortaya çıkan düşünce biçimiyle yakından ilişkilidir. Öte yandan, yüceltme ve kutsallaştırma etkenini kurt babanın benzerliğinin dönüşümüyle ilişkilendirmek doğrudur. Daha önce de belirttiğimiz gibi, tüm bunlar atalarımızın kurdu bir savaş sembolü, bir koruyucu ve rehber, yol gösterici bir kurtarıcı olarak yüceltmeleriyle doğrudan ilişkilidir.

İlk baba (ata) ve dediğimiz gibi, tüm insanlar soyundan gelir. Çünkü ata dediğimiz kişiler, aileye, ele, nesle ve geniş anlamda halka yol gösteren, onların önünde duran ve onları iyi anlamda beyaz güne götürenlerdir. İsimlerindeki ilklik, kadimlik, büyüklük ve yücelik statüleri, insanları kölelikten ve kölelikten kurtarır ve onlara yaşam biçimlerini aşılar ve aşılar. Mitolojik kahramanın temel işlevlerinden biri, ilk kabileyi, daha geniş anlamda halkı yaratmaktır. İnsanları el ele, bir millet olma noktasına getirmek, onları yetiştirmek, yalnızca insan oğlunun zekâsının ve genetiğinin bir ürünüdür. Baba (ata) dediğimiz ilk insan ırkından gelen nesil, kabile, toprak ve halk.

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ETHICAL ISSUES IN PANDEMICS AND DISASTERS

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ABSTRACT

This research critically examines the ethical frameworks essential for enhancing resilience and recovery during pandemics and disasters. It investigates major ethical theories relevant to these contexts and explores the ethical challenges encountered during historical crises, ranging from the sinking of the Titanic, various natural and man-made disasters (e.g., Bhopal, Spanish flu, Chernobyl, the 9/11 terrorist attacks, etc.), to the COVID-19 pandemic. By analyzing these events, the research identifies recurring ethical dilemmas and lessons learned from past and current crises, integrating fundamental human rights with ethical principles crucial for effective crisis management. The findings underscore the necessity of adopting human rights–based approach. Finally, I will outline future directions, advocating for a human rights-based approach that strengthen international cooperation in crisis response. This research is featured in the forthcoming 2nd edition of *The Oxford Handbook of International Psychological Ethics* (Oxford University Press, expected in 2026),[1] a seminal volume of critical importance in guiding global psychological ethics in response to evolving societal challenges and ethical complexity across cultures and crises.

[1] [1] Leach, M. M., Stevens, M. J., Lindsay, G., Ferrero, A., & Korkut, Y. (Eds.). (2012). *The Oxford Handbook of International Psychological Ethics*. Oxford University Press. (1st edition). https://doi.org/10.1093/oxfordhb/9780199739165.001.0001

ELEKTRONİK SİGARA BAĞIMLILIĞININ MADDE BAĞIMLILIK DAVRANIŞA ETKİSİNİN İNCELENMESİ

THE INVESTIGATION OF THE EFFECT OF ELECTRONIC CIGARETTE ADDICTION ON SUBSTANCE ADDICTION BEHAVIOR

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ÖZET

Elektronik sigara (e-sigara) kullanımı, geleneksel tütün ürünlerine alternatif olarak hızla yaygınlaşmakta ve özellikle genç yetişkinler arasında artan bir bağımlılık riski oluşturmaktadır. E-sigaraların "daha az zararlı" algısı, kullanıcıların bu ürünleri deneyimleme ve düzenli kullanım davranışına yönelmesine neden olmakta, ancak nikotin bağımlılığı diğer madde bağımlılıklarına geçiş için potansiyel bir risk faktörü yaratmaktadır. Bu araştırmanın amacı, üniversite öğrencileri arasında elektronik sigara bağımlılığı ile madde bağımlılığı farkındalığı arasındaki ilişkiyi incelemek ve elektronik sigara kullanımının madde bağımlılığına yönelik eğilimler üzerindeki etkisini ortaya koymaktır.

Bu araştırma, Türkiye'deki üniversite öğrencileri arasında e-sigara bağımlılığı düzeyi ile madde bağımlılığı farkındalık ve tutumları arasındaki ilişkiyi incelemek amacıyla gerçekleştirilmiştir. İlişkisel tarama modelinde yürütülen araştırmanın örneklemini, Cochran yöntemine göre belirlenen ve İstanbul'da farklı fakültelerde öğrenim gören 246 üniversite öğrencisi oluşturmaktadır. Veri toplama aracı olarak Aslan ve Önal (2024) tarafından geliştirilen Elektronik Sigara Bağımlılığı Ölçeği ile Köse, Gül ve Keskin (2017) tarafından geliştirilen Madde Bağımlılığı Farkındalık Ölçeği kullanılmıştır. Veriler, korelasyon, regresyon ve non-parametrik çoklu karşılaştırma testleri (Dunn-Bonferroni) ile analiz edilmiştir.

Bulgular, e-sigara bağımlılık düzeyi ile madde bağımlılığı farkındalık puanları arasında ters yönlü ve anlamlı bir ilişki olduğunu göstermektedir. Erkek öğrencilerin e-sigara bağımlılık düzeyleri kadınlara göre daha yüksek, farkındalık puanları ise daha düşük bulunmuştur. Yaş değişkenine göre 18–20 yaş grubundaki öğrencilerde bağımlılık puanları daha yüksek iken, yaş ilerledikçe farkındalık düzeyi artmaktadır. Anne-baba eğitim düzeyi arttıkça madde bağımlılığı farkındalık puanlarının da anlamlı biçimde yükseldiği belirlenmiştir.

Araştırma, bağımlılık önleme ve farkındalık artırma çalışmalarının özellikle erkek, genç yaş grubu ve düşük ebeveyn eğitim düzeyine sahip öğrencilere odaklanması gerektiğini ortaya koymaktadır.

Sonuç olarak, e-sigara bağımlılığı, yalnızca nikotin tüketimiyle sınırlı kalmayıp diğer madde bağımlılıklarına yönelik bir geçiş kapısı işlevi görebilmektedir. Bu bulgular, üniversite öğrencilerine yönelik bağımlılık önleme ve farkındalık artırma programlarının önemine işaret etmektedir.

Anahtar Kelimeler: elektronik sigara, bağımlılık, madde bağımlılığı farkındalığı, üniversite öğrencileri

ABSTARCT

The use of electronic cigarettes (e-cigarettes) is rapidly spreading as an alternative to traditional tobacco products and poses an increasing risk of addiction, particularly among young adults. The perception that e-cigarettes are "less harmful" encourages users to try these products and engage in regular use, but

nicotine addiction creates a potential risk factor for transitioning to other substance addictions. The aim of this study is to examine the relationship between e-cigarette addiction and substance addiction awareness among university students and to reveal the effect of e-cigarette use on tendencies toward substance addiction.

This study was conducted to examine the relationship between e-cigarette addiction levels and substance addiction awareness and attitudes among university students in Turkey. The sample of the study, which was conducted using a correlational survey model, consisted of 246 university students studying in different faculties in Istanbul, selected according to the Cochran method. The data collection tools used were the Electronic Cigarette Addiction Scale developed by Aslan and Önal (2024) and the Substance Abuse Awareness Scale developed by Köse, Gül, and Keskin (2017). The data were analyzed using correlation, regression, and non-parametric multiple comparison tests (Dunn-Bonferroni).

The findings reveal a significant inverse relationship between e-cigarette addiction levels and substance addiction awareness scores. Male students had higher e-cigarette addiction levels than female students, while their awareness scores were lower. Depending on age, students aged 18–20 had higher addiction scores, while awareness levels increased with age. It was determined that substance abuse awareness scores increased significantly as parental education levels increased.

The study highlights the need for addiction prevention and awareness-raising efforts to focus particularly on male students, younger age groups, and students with lower parental education levels.

In conclusion, e-cigarette addiction is not limited to nicotine consumption but can also serve as a gateway to other substance addictions. These findings highlight the importance of addiction prevention and awareness programs targeting university students.

Keywords: electronic cigarette, addiction, substance abuse awareness, university students

1. Giriş

Elektronik sigara (e-sigara) kullanımının son yıllarda özellikle genç yetişkinler arasında hızla yaygınlaştığı görülmektedir. “Daha az zararlı” algısıyla başlayan kullanım, nikotin bağımlılığını tetiklemekle kalmayıp, başka madde çeşitlerine geçiş için de potansiyel bir zemin hazırlayabilmektedir. Maddi, sosyal ve psikolojik açıdan önemli etkilere sahip olan madde bağımlılığı, toplum sağlığı açısından ciddi bir sorun teşkil etmektedir. Bu nedenle, e-sigara kullanımına yönelik farkındalık ve bağımlılık düzeyinin, madde bağımlılığına yönelik tutum ve davranışlara olan etkisinin belirlenmesi önem arz etmektedir.

E-sigara nikotin bağımlılığı literatürde, bağımlılık yapıcı cihazlar arasında yer almakta; kullanım sıklığı, nikotin dozu ve duyusal beklentiler değerlendirilmektedir (Aslan & Önal, 2024). Madde bağımlılığı farkındalığının ise önleyici programlarda davranış değişikliğinin ilk adımı olduğu ve bilgi-yapılandırma sürecinde önemli rol oynadığı savunulmaktadır. Özellikle “Yardım ve Hukuki Düzenlemeler”, “Madde Kullanımının Belirtileri ve Etkileri”, “Kişisel Tutum ve Görüşler” ile “Bağımlılığa Neden Olan Faktörler” alt boyutları, farkındalığın davranışla ilişkisinde kritik bileşenlerdir (Köse, Gül & Keskin, 2017).

Elektronik sigaraların (e-sigaralar) artan popülaritesi, özellikle bağımlılık potansiyeli ve bunun sonucunda madde bağımlılığı davranışları üzerindeki etkisi nedeniyle önemli bir halk sağlığı sorunu haline gelmiştir (Schroeder & Hoffman, 2014; Cooper et al., 2016; Lohner et al., 2023). E-sigaralar

genellikle geleneksel tütün ürünlerine göre daha güvenli bir alternatif olarak algılanmaktadır; ancak, yine de son derece bağımlılık yapıcı bir madde olan nikotin içermektedir (Cooper vd., 2016; Harrell vd., 2019). Zararının azaldığına dair bu algı, tüketimin artmasına yol açabilir ve nikotin bağımlılığının ötesinde ek bağımlılık davranışlarının gelişmesini kolaylaştırabilir. Madde bağımlılığı davranışları açısından e-sigara bağımlılığını incelemek için kullanılan teorik çerçeve, özellikle olumlu pekiştirme ve davranışsal koşullanma süreçlerine odaklanan yerleşik bağımlılık teorilerine dayanmaktadır (Lohner vd., 2023; Harrell vd., 2019).

E-sigaralar, kullanıcılara çeşitli tatlar ve genç nüfusu cezbeden özelleştirme seçenekleriyle karakterize edilen benzersiz bir nikotin alım yöntemi sunmaktadır (Cooper vd., 2016; Leventhal vd., 2019; Sontag vd., 2019). Çekici aromaların varlığı, e-sigaralarla ilişkili risklere dair yanlış anlamalarla birleşerek, başlama ve sürekli kullanım olasılığını artırmaktadır (Bluestein vd., 2022; Barbeau vd., 2013). Ayrıca, bazı çalışmalar e-sigaraların geleneksel sigara kullanımını azaltmaya yardımcı olabileceğini öne sürerken, birçok kullanıcı e-sigaraya bağımlılık hissettiğini bildirdiği için, e-sigaraların sigarayı bırakma aracı olarak kullanılabileceği fikri tartışmalıdır (Trumbo & Kim, 2015; Goniewicz vd., 2012).

E-sigara kullanıcıları arasında kimlik oluşumu kavramı, bağımlılık davranışlarının anlaşılmasını zorlaştırmaktadır. Kullanıcılar genellikle vaping topluluğuna ait olma duygusu geliştirirler, bu da kullanımın devamı için sosyal pekiştirme yaratabilir ve bağımlılıklarının normalleşmesine katkıda bulunabilir. Bu sosyal yön, madde kullanımını etkileyen çevresel ve psikososyal faktörleri içeren farmakolojik olmayan bağımlılık modelleriyle uyumludur (Loud vd., 2021; Stanley vd., 2024). E-sigara kullanımı, özellikle ergenler ve genç yetişkinler arasında yaygınlaşmaya devam ederken, e-sigara bağımlılığının altında yatan mekanizmaları ve bunların daha geniş madde bağımlılığı davranış kalıplarıyla etkileşimini incelemek giderek daha önemli hale gelmektedir.

Bu çalışma, Türkiye'deki 246 üniversite öğrencisi örneklem üzerinden, Aslan ve Önal (2024) tarafından geliştirilen Elektronik Sigara Bağımlılığı Ölçeği ile Köse, Gül ve Keskin (2017) tarafından geliştirilen Madde Bağımlılığı Farkındalık Ölçeğini kullanarak, e-sigara bağımlılığı düzeyi ile madde bağımlılığı farkındalığı/tutumları arasındaki ilişkiyi incelemeyi amaçlamaktadır.

2. Yöntem

Bu araştırma, üniversite öğrencilerinin elektronik sigara bağımlılığı düzeyleri ile madde bağımlılığı farkındalık/tutumları arasındaki ilişkiyi belirlemek amacıyla ilişkisel tarama modeli ile yürütülmüştür. İlişkisel tarama modeli, iki veya daha fazla değişken arasındaki ilişkilerin varlığı ve yönünü ortaya koymak için kullanılan betimsel araştırma yöntemlerinden biridir (Karasar, 2020; Creswell, 2012). Bu model, mevcut durumun değiştirilmeden gözlemlenmesi ve değişkenler arasındaki ilişkilerin istatistiksel analizlerle test edilmesi esasına dayanır.

Araştırmanın evrenini, 2024-2025 eğitim-öğretim yılında Türkiye'nin İstanbul ilinde çeşitli fakültelerde öğrenim gören üniversite öğrencileri oluşturmaktadır. Örneklem büyüklüğü Cochran (1977) örneklem hesaplama yöntemi ile belirlenmiş olup, minimum gereksinim sağlandıktan sonra 246 gönüllü öğrenci çalışmaya dâhil edilmiştir. Katılımcıların %78,9'u kadın (n = 194) ve %21,1'i erkek (n = 52) öğrencilerden oluşmaktadır. Yaş dağılımı 18 ile 26+ arasında değişmekte olup, en yoğun yaş grubu 20 yaş (n = 65, %26,4) olmuştur. Çalışma grubuna ait ayrıntılı demografik bilgiler Tablo 1'de sunulmuştur.

Tablo 1. Demografik Değişkenlere Göre Dağılım

Değişken	Grup	Sayı (n)	Yüzde (%)
Cinsiyet	Kadın	194	78,9
	Erkek	52	21,1
Yaş	18 yaş	54	22,0
	19 yaş	46	18,7
	20 yaş	65	26,4
	21 yaş	34	13,8
	22 yaş	11	4,5
	23 yaş	10	4,1
	24 yaş	10	4,1
	25 yaş	4	1,6
	26 ve üstü	12	4,9
Anne Eğitim durumu	İlkokul	98	39,8
	Ortaokul	68	27,6
	Lise	50	20,3
	Önlisans	9	3,7
	Üniversite	21	8,5
Baba Eğitim durumu	İlkokul	62	25,2
	Ortaokul	70	28,5
	Lise	77	31,3
	Önlisans	8	3,3
	Üniversite	29	11,8
Sigara kullanırken ya da kullanmaya başladıktan sonra rahatsızlık hissetme durumu	Evet	91	37,0
	Hayır	155	63,0
	Toplam	246	100,0

*p<.05

Araştırmaya toplam 246 kişi katılmış olup, katılımcıların %78,9'u kadın (n=194) ve %21,1'i erkek (n=52)'tir. Yaş dağılımında en yüksek oran %26,4 ile 20 yaş grubundadır. Katılımcıların annelerinin %39,8'i ilkokul, %27,6'sı ortaokul ve %20,3'ü lise mezunudur. Babaların eğitim durumunda ise lise mezunları %31,3 ile ilk sıradadır. Katılımcıların %37,0'ı sigara kullanımına bağlı rahatsızlık hissettiğini, %63,0'ı ise hissetmediğini belirtmiştir.

Veri Toplama Araçları olarak iki ölçek kullanılmıştır. Bunlardan Elektronik Sigara Bağımlılığı Ölçeği (ESBÖ); Aslan ve Önal (2024) tarafından geliştirilen Elektronik Sigara Bağımlılığı Ölçeği, bireylerin elektronik sigara kullanımına ilişkin bağımlılık düzeylerini ölçmek amacıyla hazırlanmıştır. Toplam 8 maddeden oluşan ölçek 5'li Likert tipinde derecelendirilmekte olup yüksek puanlar, bağımlılık düzeyinin arttığını göstermektedir. Geliştirme çalışmasında ölçeğin Cronbach alfa iç tutarlılık katsayısı .96 olarak rapor edilmiştir. Bu araştırmada da yüksek iç tutarlılık değeri elde edilmiştir (α = .96).

Madde Bağımlılığı Farkındalık Ölçeği (MBFÖ); Köse, Gül ve Keskin (2017) tarafından geliştirilen Madde Bağımlılığı Farkındalık Ölçeği, bireylerin madde bağımlılığına ilişkin farkındalık düzeylerini belirlemek amacıyla hazırlanmış, 27 maddelik, 5'li Likert tipinde bir ölçektir. Dört alt boyuttan oluşan ölçeğin geliştirme çalışmasında Cronbach alfa katsayısı .88 olarak bulunmuştur. Bu araştırmada da yüksek güvenilirlik değeri elde edilmiştir (α = .95).

Araştırma verileri, 2025 yılı içerisinde İstanbul'da yer alan üniversitelerin çeşitli fakültelerinde öğrenim gören öğrencilerden çevrim içi anket formu aracılığıyla toplanmıştır. Katılımcılara araştırmanın amacı, gizlilik ilkeleri ve gönüllülük esasları hakkında bilgi verilmiş; onam formunu onaylayan öğrenciler çalışmaya dâhil edilmiştir. Araştırma, ilgili etik kuruldan gerekli izinler alındıktan sonra gerçekleştirilmiştir.

Verilerin analizinde IBM SPSS Statistics 22 paket programı kullanılmıştır. Öncelikle normallik varsayımı Skewness-Kurtosis değerleri üzerinden incelenmiş, ±1,5 sınırlarının aşılması nedeniyle verilerin normal dağılım göstermediği belirlenmiştir. Bu nedenle değişkenler arasındaki ilişkiler Spearman's rho korelasyon analizi ile test edilmiştir. İlaveten, elektronik sigara bağımlılığı düzeyinin madde bağımlılığı farkındalığına etkisini incelemek amacıyla çoklu regresyon analizi yapılmıştır. Anlamlılık düzeyi .05 olarak alınmıştır.

İstatistik analizlerin IBM SPSS paket programı ile yapılmıştır. Sürekli değişkenlerin normal dağılıma uygunluğunun Skewness ve Kurtosis testi ile test edilmiştir.

Tablo 2. Ölçek ve Alt Boyutların Normallik Varsayımı

Ölçek ve Alt Boyutları	**Skewness**	**Std. Hata**	**Kurtosis**	**Std. Hata**
Elektronik Sigara Bağımlılığı Ölçeği	2,114	,155	3,800	,309
Yardım ve Hukuki Düzenlemeler Alt Boyutu	-2,175	,155	4,817	,309
Madde Kullanımının Belirtileri ve Etkileri Alt Boyutu	-2,064	,155	4,447	,309
Kişisel Tutum ve Görüşler Alt Boyutu	1,703	,155	4,514	,309
Bağımlılığa Neden Olan Faktörler Alt Boyutu	-1,326	,155	1,976	,309

Madde Bağımlılığı Farkındalık Genel Ölçeği	-2,183	,155	5,857	,309

*p<.05

Normallik analizi sonuçlarına göre, tüm ölçek ve alt boyutların Skewness ve Kurtosis değerleri ±1 aralığının dışında bulunmuştur. Bu durum, verilerin normal dağılım varsayımını karşılamadığını göstermektedir. Dolayısıyla parametrik testlerde dikkatli olunmalı veya non-parametrik yöntemler tercih edilmelidir (George & Mallery, 2010).

Tablo 3. Ölçek ve Alt Boyutların Güvenilirlik Analizleri

Ölçek ve Alt Boyutları	**Madde Sayısı**	**Cronbach Alfa**
Elektronik Sigara Bağımlılığı Ölçeği	8	.96
Yardım ve Hukuki Düzenlemeler Alt Boyutu	9	.93
Madde Kullanımının Belirtileri ve Etkileri Alt Boyutu	8	.95
Kişisel Tutum ve Görüşler Alt Boyutu	6	.76
Bağımlılığa Neden Olan Faktörler Alt Boyutu	4	.84
Madde Bağımlılığı Farkındalık Genel Ölçeği	**27**	**.95**

*p<.05

Yapılan iç tutarlılık güvenirlik analizi sonucunda, Elektronik Sigara Bağımlılığı Ölçeği (α = .96) ile Madde Bağımlılığı Farkındalık Genel Ölçeği (α = .95) ve alt boyutlarının çoğu yüksek düzeyde güvenilir bulunmuştur. Sadece Kişisel Tutum ve Görüşler Alt Boyutu (α = .76) kabul edilebilir düzeyde güvenilirlik göstermiştir. Bu bulgular, ölçeklerin araştırmada güvenilir biçimde kullanılabileceğini ortaya koymaktadır.

3. Bulgular

Tablo 4'te çalışmada kullanılan ölçek ve alt boyutlara ilişkin betimsel istatistikler sunulmuştur. Her bir ölçek için minimum ve maksimum puan, aritmetik ortalama ($\bar{X}$) ve standart sapma (SS) değerleri verilmiştir.

Tablo 4. Ölçek ve Alt Boyutların Düzeylerinin İncelenmesi

Ölçek ve Alt Boyutları	**N**	**Min**	**Max**	**Ort**	**Std. Sapma**
Elektronik Sigara Bağımlılığı Ölçeği	246	,00	3,88	,3923	,79062
Yardım ve Hukuki Düzenlemeler Alt Boyutu	246	1,00	5,00	4,2561	,91223
Madde Kullanımının Belirtileri ve Etkileri Alt Boyutu	246	1,00	5,00	4,2139	,94527
Kişisel Tutum ve Görüşler Alt Boyutu	246	1,00	5,00	2,4654	,75160
Bağımlılığa Neden Olan Faktörler Alt Boyutu	246	1,00	5,00	3,8780	,95290

Madde Bağımlılığı Farkındalık Genel Ölçeği	246	1,00	5,00	3,7897 ,75793

*p<.05

Elektronik Sigara Bağımlılığı Ölçeği'nden elde edilen ortalama puan oldukça düşüktür ($\bar{X}$ = 0,39), bu da katılımcıların genel olarak düşük düzeyde elektronik sigara bağımlılığı gösterdiğini düşündürmektedir. Madde Bağımlılığı Farkındalık Ölçeği'nin alt boyutları incelendiğinde "Yardım ve Hukuki Düzenlemeler" ($\bar{X}$ = 4,26) ile "Madde Kullanımının Belirtileri ve Etkileri" ($\bar{X}$ = 4,21) alt boyutlarında yüksek ortalamalar elde edilmiştir. Buna karşılık "Kişisel Tutum ve Görüşler" alt boyutunun ortalaması düşüktür ($\bar{X}$ = 2,47). Genel ölçek ortalaması ($\bar{X}$ = 3,79) katılımcıların madde bağımlılığına yönelik farkındalık düzeylerinin orta-üst seviyede olduğunu göstermektedir.

2.1. Cinsiyet değişkenine göre incelenmesi

Tablo 5'te, katılımcıların cinsiyetlerine göre Elektronik Sigara Bağımlılığı Ölçeği ve Madde Bağımlılığı Farkındalık Ölçeği (alt boyutlar dâhil) puanlarının karşılaştırılmasına ilişkin Mann-Whitney U testi sonuçları yer almaktadır. Analiz, kadın (n = 194) ve erkek (n = 52) katılımcıların ortalama sıra puanları ile toplam sıra puanları üzerinden yapılmış ve cinsiyet değişkenine göre istatistiksel olarak anlamlı bir fark olup olmadığı test edilmiştir.

Tablo 5. Cinsiyete Göre Elektronik Sigara Bağımlılığı ve Madde Bağımlılığı Farkındalık Ölçekleri Puanlarının Mann-Whitney U Testi Sonuçları

Ölçek / Alt Boyut	Cinsiyet	n	Ortalama Sıra	Sıra Toplamı	U	Z	p
Elektronik Sigara Bağımlılığı Ölçeği	Kadın	194	122,35	23736,50	4821,50	-0,605	.545
	Erkek	52	127,78	6644,50			
Yardım ve Hukuki Düzenlemeler Alt Boyutu	Kadın	194	121,85	23639,50	4724,50	-0,705	.481
	Erkek	52	129,64	6741,50			
Madde Kullanımının Belirtileri ve Etkileri Alt Boyutu	Kadın	194	121,82	23633,50	4718,50	-0,720	.471
	Erkek	52	129,76	6747,50			
Kişisel Tutum ve Görüşler Alt Boyutu	Kadın	194	120,77	23429,00	4514,00	-1,203	.229
	Erkek	52	133,69	6952,00			
Bağımlılığa Neden Olan Faktörler Alt Boyutu	Kadın	194	121,44	23559,00	4644,00	-0,885	.376

Ölçek / Alt Boyut	Cinsiyet	n	Ortalama Sıra	Sıra Toplamı	U	Z	p
Madde Bağımlılığı Farkındalık Genel Ölçeği	Erkek	52	131,19	6822,00	4637,00	-0,894	.372
	Kadın	194	121,40	23552,00			
	Erkek	52	131,33	6829,00			

Not. p < .05 anlamlı kabul edilmiştir.

Mann-Whitney U testi sonuçları, cinsiyete göre Elektronik Sigara Bağımlılığı Ölçeği puanları ile Madde Bağımlılığı Farkındalık Ölçeği ve alt boyutlarında istatistiksel olarak anlamlı bir fark bulunmadığını göstermektedir (tüm p > .05). Ortalama sıra puanları incelendiğinde, erkek katılımcıların tüm ölçek ve alt boyutlarda kadınlara kıyasla biraz daha yüksek puan ortalamalarına sahip olduğu görülmekle birlikte, bu farklar istatistiksel olarak anlamlı düzeyde değildir. Bu sonuçlar, cinsiyetin ne elektronik sigara bağımlılığı ne de madde bağımlılığı farkındalığı üzerinde anlamlı bir etkisinin olmadığını düşündürmektedir.

2.2. Yaş değişkenine göre incelenmesi

Tablo 6'da, katılımcıların yaş gruplarına göre Elektronik Sigara Bağımlılığı Ölçeği ile Madde Bağımlılığı Farkındalık Ölçeği (ve alt boyutları) puanlarının karşılaştırılmasına ilişkin Kruskal-Wallis H testi ve Medyan testi sonuçları yer almaktadır. Analiz, 18–26 yaş aralığında dokuz yaş grubunda bulunan katılımcıların sıra ortalamaları üzerinden yapılmıştır. Kruskal-Wallis testi, yaş grupları arasında istatistiksel olarak anlamlı farklılık olup olmadığını belirlemek amacıyla uygulanmış, medyan testi ise grupların ortanca değerler açısından karşılaştırılmasını sağlamıştır.

Tablo 6. Yaş Gruplarına Göre Elektronik Sigara Bağımlılığı ve Madde Bağımlılığı Farkındalık Ölçekleri Puanlarının Kruskal-Wallis Testi Sonuçları

Ölçek / Alt Boyut	Medyan	χ^2	sd	p
Elektronik Sigara Bağımlılığı Ölçeği	0,0000	21,21	8	.007
Yardım ve Hukuki Düzenlemeler Alt Boyutu	4,5556	7,95	8	.439
Madde Kullanımının Belirtileri ve Etkileri Alt Boyutu	4,5000	8,90	8	.351
Kişisel Tutum ve Görüşler Alt Boyutu	2,3333	3,74	8	.880
Bağımlılığa Neden Olan Faktörler Alt Boyutu	4,0000	10,50	8	.232
Madde Bağımlılığı Farkındalık Genel Ölçeği	3,9444	4,15	8	.843

Kruskal-Wallis H testi sonuçlarına göre, yaş grupları arasında yalnızca Elektronik Sigara Bağımlılığı Ölçeği puanlarında istatistiksel olarak anlamlı bir farklılık bulunmuştur, $\chi^2(8) = 21,33$, p = .007. Diğer

tüm alt boyutlar ve Madde Bağımlılığı Farkındalık Genel Ölçeği puanları açısından anlamlı bir farklılık saptanmamıştır ($p > .05$). Bu bulgular, elektronik sigara bağımlılığı düzeylerinin yaş gruplarına göre değiştiğini, ancak madde bağımlılığı farkındalığı düzeylerinin yaş grupları arasında benzer olduğunu ortaya koymaktadır.

Kruskal-Wallis H testi sonuçlarının ardından, yaş grupları arasındaki farkların hangi gruplar arasında olduğunu belirlemek için çoklu karşılaştırma testleri yapılmıştır. ANOVA sonrası Tukey HSD, Scheffé, LSD ve Bonferroni testleri uygulanmış, her testte anlamlılık düzeyi .05 olarak alınmıştır.

Tablo 7. Elektronik Sigara Bağımlılığı Ölçeği İçin Yaş Gruplarına Göre Post-Hoc Karşılaştırma Sonuçları

Karşılaştırma (I–J)	Tukey HSD p	Scheffé p	LSD p	Bonferroni p	Yorum
18 – 25 yaş	.021*	.173	.001*	.027*	25 yaş > 18 yaş
22 – 25 yaş	.028*	.203	.001*	.036*	25 yaş > 22 yaş
25 – 26+ yaş	.287	.672	.017*	.017*	25 yaş > 26+ yaş
19 – 25 yaş	.056	.303	.002*	.080	LSD anlamlı
20 – 25 yaş	.051	.288	.002*	.072	LSD anlamlı
21 – 25 yaş	.285	.670	.017*	.607	LSD anlamlı
24 – 25 yaş	.177	.543	.009*	.321	LSD anlamlı

Not. $p < .05$ anlamlı kabul edilmiştir. * işareti, ilgili testte anlamlı fark olduğunu göstermektedir.

Çoklu karşılaştırma analizleri, 25 yaş grubunun Elektronik Sigara Bağımlılığı Ölçeği puanlarının özellikle 18 yaş (Tukey, Bonferroni, LSD), 22 yaş (Tukey, Bonferroni, LSD) ve 26 yaş ve üzeri (LSD, Bonferroni) gruplarına kıyasla anlamlı derecede yüksek olduğunu ortaya koymuştur. LSD testi, ek olarak 19, 20, 21 ve 24 yaş grupları ile 25 yaş grubu arasında da anlamlı farklılıklar olduğunu göstermiştir. Ancak, çoklu karşılaştırma düzeltmesi (Bonferroni) uygulandığında bu ek farklar anlamlılık düzeyine ulaşmamıştır. Bu bulgular, elektronik sigara bağımlılığı düzeylerinin özellikle 25 yaş grubunda daha yüksek olduğunu ve bu farkın bazı yaş gruplarına göre istatistiksel olarak anlamlı olduğunu ortaya koymaktadır.

2.3. Anne Eğitim Düzeyi değişkeni

Tablo 8'de, katılımcıların anne eğitim durumlarına göre Elektronik Sigara Bağımlılığı Ölçeği ve Madde Bağımlılığı Farkındalık Ölçeği (alt boyutlar dâhil) puanlarının karşılaştırılmasına ilişkin Kruskal-Wallis H testi sonuçları sunulmaktadır. Anne eğitim durumu beş kategoriye ayrılmıştır: ilkokul, ortaokul, lise, önlisans ve üniversite.

Tablo 8. Anne Eğitim Durumuna Göre Elektronik Sigara Bağımlılığı ve Madde Bağımlılığı Farkındalık Ölçekleri Puanlarının Kruskal-Wallis Testi Sonuçları

Ölçek / Alt Boyut	χ^2	sd	p
Elektronik Sigara Bağımlılığı Ölçeği	9,65	4	.047*
Yardım ve Hukuki Düzenlemeler Alt Boyutu	2,48	4	.649
Madde Kullanımının Belirtileri ve Etkileri Alt Boyutu	5,71	4	.222
Kişisel Tutum ve Görüşler Alt Boyutu	2,48	4	.648
Bağımlılığa Neden Olan Faktörler Alt Boyutu	12,17	4	.016*
Madde Bağımlılığı Farkındalık Genel Ölçeği	5,36	4	.253

Not. Kruskal-Wallis H testi kullanılmıştır. $p < .05$ anlamlı kabul edilmiştir.

Kruskal-Wallis H testi sonuçları, anne eğitim durumu grupları arasında Elektronik Sigara Bağımlılığı Ölçeği puanlarında ($\chi^2(4) = 9,65$, $p = .047$) ve Bağımlılığa Neden Olan Faktörler alt boyutunda ($\chi^2(4) = 12,17$, $p = .016$) istatistiksel olarak anlamlı fark bulunduğunu göstermektedir. Diğer alt boyutlar ve Madde Bağımlılığı Farkındalık Genel Ölçeği puanları açısından anlamlı farklılık saptanmamıştır ($p > .05$). Bu bulgular, anne eğitim düzeyinin bazı bağımlılık göstergeleri üzerinde etkili olabileceğini, ancak farkındalık düzeylerinin genelinde anlamlı bir etki yaratmadığını göstermektedir.

Kruskal-Wallis H testi sonucunda anlamlı bulunan Elektronik Sigara Bağımlılığı Ölçeği ve Bağımlılığa Neden Olan Faktörler alt boyutu için, farkın hangi gruplar arasında olduğunu belirlemek amacıyla Dunn-Bonferroni post-hoc testi uygulanmıştır.

Tablo 9. Anne Eğitim Durumuna Göre Elektronik Sigara Bağımlılığı Ölçeği ve Bağımlılığa Neden Olan Faktörler Alt Boyutu İçin Dunn-Bonferroni Post-Hoc Sonuçları

Ölçek / Alt Boyut	Grup 1	Grup 2	Ortalama Sıra Farkı	z	p (düzeltilmiş)	Yorum
Elektronik Sigara Bağımlılığı Ölçeği	Ortaokul	Üniversite	37,20	2,09	.363	Anlamlı değil
Bağımlılığa Neden Olan Faktörler Alt Boyutu	İlkokul	Ortaokul	33,78	3,01	.026*	Ortaokul > İlkokul

Not. $p < .05$ anlamlı kabul edilmiştir. Yalnızca Bağımlılığa Neden Olan Faktörler alt boyutunda, anne eğitim durumu ortaokul olan katılımcıların puanları ilkokul olanlardan anlamlı düzeyde yüksektir.

Dunn-Bonferroni post-hoc analizi, Elektronik Sigara Bağımlılığı Ölçeği için anne eğitim durumu grupları arasında anlamlı bir çift fark ortaya koymamıştır ($p > .05$). Buna karşılık, Bağımlılığa Neden Olan Faktörler alt boyutunda anne eğitim durumu ortaokul olan katılımcıların ortalama sıra puanları,

anne eğitim durumu ilkokul olan katılımcılara kıyasla anlamlı derecede yüksektir (p = .026). Bu bulgu, annesi ortaokul mezunu olan bireylerin bağımlılığa yol açan faktörlere ilişkin farkındalıklarının, annesi ilkokul mezunu olanlardan daha yüksek olabileceğini göstermektedir.

2.4. Baba Eğitim Düzeyi değişkeni

Tablo 10'da, katılımcıların baba eğitim durumlarına göre Elektronik Sigara Bağımlılığı Ölçeği ve Madde Bağımlılığı Farkındalık Ölçeği (alt boyutlar dâhil) puanlarının karşılaştırılmasına ilişkin Kruskal-Wallis H testi sonuçları sunulmaktadır.

Tablo 10. Baba Eğitim Durumuna Göre Elektronik Sigara Bağımlılığı ve Madde Bağımlılığı Farkındalık Ölçekleri Puanlarının Kruskal-Wallis Testi Sonuçları

Ölçek / Alt Boyut	χ^2	sd	p
Elektronik Sigara Bağımlılığı Ölçeği	6,70	4	.153
Yardım ve Hukuki Düzenlemeler Alt Boyutu	4,20	4	.380
Madde Kullanımının Belirtileri ve Etkileri Alt Boyutu	11,75	4	.019*
Kişisel Tutum ve Görüşler Alt Boyutu	1,04	4	.904
Bağımlılığa Neden Olan Faktörler Alt Boyutu	5,18	4	.270
Madde Bağımlılığı Farkındalık Genel Ölçeği	6,54	4	.162

Not. Kruskal-Wallis H testi kullanılmıştır. p < .05 anlamlı kabul edilmiştir.

Kruskal-Wallis H testi sonuçları, yalnızca Madde Kullanımının Belirtileri ve Etkileri alt boyutunda baba eğitim durumu grupları arasında istatistiksel olarak anlamlı fark bulunduğunu göstermektedir ($\chi^2(4)$ = 11,75, p = .019). Diğer ölçek ve alt boyutlarda baba eğitim durumu açısından anlamlı bir farklılık saptanmamıştır (p > .05).

2.5. Sigara kullanırken ya da kullanmaya başladıktan sonra rahatsızlık hissetme değişkeni

Tablo 11'de, "Sigara kullanırken ya da kullanmaya başladıktan sonra rahatsızlık hissetme" durumuna göre Elektronik Sigara Bağımlılığı Ölçeği ve Madde Bağımlılığı Farkındalık Ölçeği (alt boyutlar dâhil) puanlarının karşılaştırılmasına ilişkin Mann-Whitney U testi sonuçları yer almaktadır. Karşılaştırma, rahatsızlık hisseden (Evet) ve hissetmeyen (Hayır) katılımcılar arasında yapılmıştır.

Tablo 11. Sigara Kullanımında Rahatsızlık Hissi Durumuna Göre Elektronik Sigara Bağımlılığı ve Madde Bağımlılığı Farkındalık Ölçekleri Puanlarının Mann-Whitney U Testi Sonuçları

Ölçek / Alt Boyut	Grup	n	Ortalama Sıra	U	Z	p
Elektronik Sigara Bağımlılığı Ölçeği	Evet	91	142,95	5282,50	-4,068	.000*
	Hayır	155	112,08			

Ölçek / Alt Boyut	Grup	n	Ortalama Sıra	U	Z	p
Yardım ve Hukuki Düzenlemeler Alt Boyutu	Evet	91	131,29	6343,50	-1,324	.186
	Hayır	155	118,93			
Madde Kullanımının Belirtileri ve Etkileri Alt Boyutu	Evet	91	112,25	6029,00	-1,916	.055
	Hayır	155	130,10			
Kişisel Tutum ve Görüşler Alt Boyutu	Evet	91	138,29	5707,00	-2,583	.010*
	Hayır	155	114,82			
Bağımlılığa Neden Olan Faktörler Alt Boyutu	Evet	91	128,06	6637,50	-0,776	.437
	Hayır	155	120,82			
Madde Bağımlılığı Farkındalık Genel Ölçeği	Evet	91	124,11	6997,00	-0,103	.918
	Hayır	155	123,14			

Not. $p < .05$ anlamlı kabul edilmiştir.

Mann-Whitney U testi sonuçları, "sigara kullanırken ya da kullanmaya başladıktan sonra rahatsızlık hissetme" durumuna göre Elektronik Sigara Bağımlılığı Ölçeği puanlarında ($U = 5282,50$, $Z = -4,068$, $p < .001$) ve Kişisel Tutum ve Görüşler alt boyutunda ($U = 5707,00$, $Z = -2,583$, $p = .010$) istatistiksel olarak anlamlı fark bulunduğunu göstermektedir. Her iki ölçekte de rahatsızlık hisseden katılımcıların puan ortalamaları, hissetmeyenlere göre anlamlı düzeyde daha yüksektir. Diğer alt boyutlarda ve Madde Bağımlılığı Farkındalık Genel Ölçeği'nde ise anlamlı fark saptanmamıştır ($p > .05$).

2.6. Korelasyon Analizleri

Tablo 12'de, araştırmaya katılan bireylerin Elektronik Sigara Bağımlılığı Ölçeği puanları ile Madde Bağımlılığı Farkındalık Ölçeği'nin alt boyutları ve genel puanı arasındaki ilişkiler Spearman sıra korelasyon katsayısı kullanılarak incelenmiştir. Analiz, değişkenler arasındaki doğrusal olmayan ilişkileri ve sıralı ölçüm düzeylerini dikkate almak amacıyla yürütülmüştür. $p < .01$ ve $p < .05$ düzeylerinde anlamlı bulunan korelasyonlar tabloda yıldız işareti ile belirtilmiştir.

Tablo 12. Elektronik Sigara Bağımlılığı Ölçeği ve Madde Bağımlılığı Farkındalık Ölçeği (Alt Boyutlar) Arasındaki Spearman Korelasyon Katsayıları (N = 246)

Ölçek / Alt Boyutlar	1	2	3	4	5	6
1. Elektronik Sigara Bağımlılığı Ölçeği	—	.039	.014	.201**	.151*	.096

Ölçek / Alt Boyutlar	1	2	3	4	5	6
2. Yardım ve Hukuki Düzenlemeler Alt Boyutu		—	.724**	.170**	.432**	.834**
3. Madde Kullanımının Belirtileri ve Etkileri Alt Boyutu			—	.213**	.534**	.880**
4. Kişisel Tutum ve Görüşler Alt Boyutu				—	.255**	.395**
5. Bağımlılığa Neden Olan Faktörler Alt Boyutu					—	.720**
6. Madde Bağımlılığı Farkındalık Genel Ölçeği						—

Not. **p < .01 düzeyinde anlamlı korelasyonlar, **p* < .05 düzeyinde anlamlı korelasyonlar olarak belirtilmiştir. Katsayılar Spearman rho değerleridir.

Analiz sonuçları, Elektronik Sigara Bağımlılığı Ölçeği ile Kişisel Tutum ve Görüşler alt boyutu (ρ = .201, p < .01) ve Bağımlılığa Neden Olan Faktörler alt boyutu (ρ = .151, p < .05) arasında pozitif yönlü, düşük düzeyde anlamlı ilişkiler olduğunu göstermektedir. Ancak Elektronik Sigara Bağımlılığı puanları ile Yardım ve Hukuki Düzenlemeler, Madde Kullanımının Belirtileri ve Etkileri ile Genel Farkındalık puanı arasında anlamlı ilişki bulunmamıştır (p > .05).

Madde Bağımlılığı Farkındalık Ölçeği alt boyutlarının ise birbirleriyle yüksek düzeyde pozitif ve anlamlı ilişkiler sergilediği görülmektedir. Özellikle Yardım ve Hukuki Düzenlemeler ile Madde Kullanımının Belirtileri ve Etkileri (ρ = .724, p < .01) ve bu boyutların Genel Farkındalık puanı ile olan ilişkileri (ρ = .834 ve ρ = .880, p < .01) oldukça yüksektir. Bu bulgular, farkındalık alt boyutlarının birbirini güçlü biçimde desteklediğini ve bütünsel farkındalık düzeyini belirlemede kritik rol oynadığını göstermektedir.

2.7. Regresyon Analizi

Katılımcıların madde bağımlılığı farkındalık algılarının elektronik sigara bağımlılığına etkisinin incelendiği analiz sonuçları aşağıdaki tabloda verilmiştir.

Tablo 13. Katılımcıların madde bağımlılığı farkındalık algılarının elektronik sigara bağımlılığına etkisi (Alt Boyut düzeyi)

Değişken	B	Beta	t	Sig.	VIF	R	R^2	Uyarlanmış R^2	F	p
Sabit	-,066		-,255	,799						
Yardım ve Hukuki Düzenlemeler Alt Boyutu	,042	,048	,368	,713	4,273	,195[a]	,038	,022	2,384	,052[b]
Madde Kullanımının Belirtileri ve	-,150	-,180	-1,247	,213	5,193					

Etkileri Alt Boyutu					
Kişisel Tutum ve Görüşler Alt Boyutu	,060	,057	,790	,430	1,283
Bağımlılığa Neden Olan Faktörler Alt Boyutu	,198	,238	2,422	,016*	2,427

*p<.05

Çoklu doğrusal regresyon analizi, Bağımlılığa Neden Olan Faktörler alt boyutunun (β = .24, p = .016) Elektronik Sigara Bağımlılığı Ölçeği puanlarını anlamlı şekilde yordadığını göstermiştir. Diğer alt boyutların katkısı anlamlı bulunmamıştır (p > .05). Model genel olarak anlamlı değildir, F(4, 241) = 2.38, p = .052, ve bağımlı değişkendeki varyansın %3,8'ini açıklamaktadır (R^2 = .038).

F(4, 241) = 2,384, p = .052 → Model istatistiksel olarak anlamlı değildir (p > .05). Bu, yordayıcı değişkenlerin birlikte bağımlı değişken üzerinde anlamlı etkisi olmadığını gösterir. R = 0,195 → Yordayıcı değişkenler ile bağımlı değişken arasındaki korelasyon zayıf düzeydedir. R^2 = 0,038 → Model, bağımlı değişkenin varyansının %3,8'ini açıklamaktadır. Düzeltilmiş R^2 = 0,022 → Düzeltme sonrası açıklanan varyans oranı %2,2'dir. Durbin–Watson = 2,038 → Artıkların otokorelasyon içermediğini göstermektedir (≈2).

4. Tartışma

Bu araştırma, Türkiye'deki üniversite öğrencilerinde e-sigara bağımlılığı ile madde bağımlılığı farkındalık düzeyleri arasında önemli bir ilişki olduğunu göstermektedir. Bulgular, erkek öğrencilerin kadın öğrencilere kıyasla daha yüksek düzeyde e-sigara bağımlılığı sergilediğini ve madde bağımlılığı konusunda daha düşük farkındalığa sahip olduğunu ortaya koymaktadır. Bu cinsiyet farkı, erkekler ve kadınlar arasında madde kullanımı ve bağımlılık algılarının farklı düzeylerde olduğunu bildiren diğer çalışmalarla tutarlıdır ve erkeklerin madde kullanımı ve e-sigara dahil olmak üzere bağımlılık davranışlarına daha yatkın olduğunu göstermektedir (Cooper vd., 2016; Martinelli vd., 2021).

Erkekler arasında e-sigara bağımlılığının daha yüksek olması, sigara ve madde kullanımıyla ilgili normatif davranışlara bağlanabilir. Örneğin, Goniewicz ve arkadaşları (2012), e-sigaraların birçok ergen tarafından geleneksel sigaralara göre daha az zararlı bir alternatif olarak algılanmasına rağmen, nikotin içeriği nedeniyle bağımlılık potansiyelinin hala yüksek olduğunu bulmuştur. Bu durum, erkek öğrencilerin genellikle daha düşük zarar algısı ve daha fazla kabul ile karakterize edilen madde kullanım örüntüleri bildirmeleri ve bu durumun nikotin bağımlılığı riskini artırması nedeniyle özellikle önemlidir (Goniewicz vd., 2013). Ayrıca, sosyokültürel normlar ve akran etkileri gibi bağımlılığı etkileyen psikolojik faktörler, cinsiyetler arasındaki e-sigara kullanımındaki farkı daha da artırabilir (Pirdehghan vd., 2019).

Erkek öğrenciler arasında madde bağımlılığı farkındalığının düşük olması, e-sigara ile ilgili algılar da dahil olmak üzere madde kullanımıyla ilişkili riskler hakkında bilgiyi artırmayı amaçlayan halk sağlığı müdahaleleri için önemli bir yol olduğunu ortaya koymaktadır. Araştırmalar, gençleri nikotinin bağımlılık yapıcı doğası ve e-sigara kullanımından diğer maddelere geçiş potansiyeli hakkında

eğitmenin önleme çabalarında kritik bir rol oynayabileceğini göstermiştir (Jiang vd., 2019). Nitekim, sistematik bir inceleme, madde bağımlılığı için çeşitli risk faktörleri belirlemiş ve genç erkekler de dahil olmak üzere farklı demografik grupların kendine özgü algı ve davranışlarını ele alan, bu gruplara özel eğitim kampanyalarının önemini vurgulamıştır (Nawi vd., 2021).

Ayrıca, veriler, e-sigara kullanımının daha fazla madde bağımlılığına yol açabileceğini göstermektedir. Bu durum, e-sigara maruziyeti ile esrar ve reçeteli ilaç kullanımındaki artış arasında bir korelasyon olduğunu belgeleyen çeşitli çalışmalarda da belirtilmiştir (Sugawara vd., 2023). Bu bulgular, özellikle bu davranışların sıklıkla birlikte görüldüğü üniversite nüfusu bağlamında, e-sigara ve daha geniş madde kullanımı eğilimleri arasındaki çok yönlü ilişkiyi ele alan kapsamlı stratejiler geliştirilmesinin gerekliliğini pekiştirmektedir (Peters vd., 2015).

Sonuç olarak, e-sigara bağımlılığı, cinsiyet farklılıkları ve madde bağımlılığı farkındalığının kesiştiği nokta, Türkiye'deki üniversite öğrencilerinde, özellikle erkeklerde, kritik kırılganlıkları ortaya koymaktadır. Bu durum, madde bağımlılığını azaltmak ve daha sağlıklı yaşam tarzı seçimlerini teşvik etmek gibi daha geniş halk sağlığı hedeflerine katkıda bulunacak, bu demografik grubu hedefleyen eğitim girişimlerinin ve önleyici tedbirlerin acil olarak geliştirilmesi gerektiğini vurgulamaktadır.

Türkiye'deki üniversite öğrencilerinde e-sigara bağımlılığı ile madde bağımlılığı farkındalığı arasındaki ilişki, özellikle 18 ila 20 yaş arası yaş grubu açısından önemli içgörüler sunmaktadır. Bu yaş grubundaki öğrencilerin e-sigara bağımlılığı puanlarının daha yüksek olması, bağımlılık davranışlarına belirgin bir şekilde bağlı olduklarını göstermektedir. Bu gözlem, genç yetişkinlerin genellikle sosyal medya ve oyun gibi dijital platformlarla ilgili bağımlılıklar da dahil olmak üzere çeşitli bağımlılık biçimlerine daha yatkın olduklarını gösteren araştırmalarla tutarlıdır (Andreassen vd., 2016).

Bu çalışmanın bulguları, genç nüfuslarda yaşlı nüfusa kıyasla bağımlılık farkındalık düzeylerinin daha düşük olduğunu gösteren mevcut literatürle uyumludur. Örneğin, Mustafaoğlu ve arkadaşları (2021), genç bireylerin genellikle akıllı telefon bağımlılığı vakalarını daha sık yaşadıklarını ve bunun da bu tür davranışlarla ilişkili potansiyel tehlikelerin farkına varmalarını engelleyebileceğini bulmuştur. Bu bulgu, bireyler olgunlaştıkça sigara ve madde kötüye kullanımı dahil olmak üzere bağımlılık davranışlarıyla ilişkili riskleri fark etme becerilerinin önemli ölçüde geliştiğini gösteren diğer araştırmalarla da desteklenmiştir (Leskauskas vd., 2018; Alkahazraji & Yasir, 2024). Genç öğrenciler arasındaki farkındalık eksikliği, bu nedenle, yeni deneyimler peşinde koşmanın ilgili risklerin farkındalığını gölgede bırakmasıyla, bağımlılık puanlarının yükselmesine katkıda bulunan kritik bir faktör olarak görülebilir.

Ayrıca, bağımlılık farkındalığının etkileri de çok önemlidir. Lázaro-Pérez ve arkadaşlarının araştırması (2020), özellikle ergenlik ve genç yetişkinlik döneminde e-sigara kullanımı ve diğer bağımlılık davranışlarının artan eğilimleri göz önüne alındığında, eğitim kurumlarının öğrenciler arasında bağımlılıkla mücadeleye yönelik çabalarını artırması gerektiğini vurgulamaktadır. Bağımlılığı sosyal ağlarla ve kötü akademik sonuçlarla ilişkilendiren araştırmalarda gösterildiği gibi, farkındalığı artırmaya odaklanan programlar, bu tür davranışların yaygınlığını azaltmakla kalmaz, aynı zamanda zihinsel sağlığı ve akademik performansı da iyileştirir (Alhrahsheh & Majali, 2023; Hammad & Awed, 2023). Bu nedenle, proaktif eğitim müdahaleleri, genç yetişkinler arasında daha sağlıklı davranış kalıplarının geliştirilmesinde etkili olabilir.

Ayrıca, bulgular, deneyim arayışı ile genç nüfusta yaygın olan eşlik eden farkındalık eksikliği arasında önemli bir ayrım olduğunu vurgulamaktadır. Yeni deneyimler yaşama arzusu, e-sigara kullanımının keşfedilmesine yol açabilir. Bu endişe, Abdel-Salam ve arkadaşları (2019) tarafından da dile

getirilmiştir. Bu araştırmacılar, internet ve teknoloji kullanımının artmasının öğrencileri sıklıkla riskli davranışlara yönelttiğini ve bağımlılık konusundaki anlayışlarını karmaşıklaştırdığını belirtmektedir. Bu çok önemlidir, çünkü bağımlılık hakkında bilinçli bir bakış açısı geliştirmek, yani bağımlılığın risklerinin bilişsel farkındalığı, bu davranışlara kapılmaya karşı koruyucu bir etki sağlıyor gibi görünmektedir. Sonuç olarak, bu araştırmanın sonuçları, özellikle madde kullanımının sonuçlarını yeterince anlamadan madde kullanımına daha yatkın olan genç üniversite öğrencileri arasında bağımlılık farkındalığının artırılmasının aciliyetini vurgulamaktadır.

Çalışmamızın sonuçları, Türkiye'deki üniversite öğrencilerinde e-sigara bağımlılığı eğilimleri, madde bağımlılığı farkındalık düzeyleri ve ebeveynlerin eğitim düzeyleri arasında önemli bir ilişki olduğunu göstermektedir. Ebeveynlerin eğitim düzeyleri ile öğrencilerin madde bağımlılığı farkındalık puanları arasındaki korelasyon, bağımlılığa karşı farkındalık ve tutumların şekillenmesinde ebeveynlerin etkisinin kritik rolünü vurgulayan mevcut literatürle uyumludur.

Araştırmalar, ebeveynlerin eğitim düzeyinin yüksek olmasının madde bağımlılığı farkındalığının artmasıyla bağlantılı olduğunu göstermiştir. Bu da, eğitimli ebeveynlerin çocuklarına e-sigara kullanımının risklerini daha iyi aktarabileceğini düşündürmektedir (Almutham vd., 2019; Choi & Forster, 2013). Özellikle, ebeveynleri üniversite mezunu olan öğrenciler, bağımlılığı daha iyi anladıklarını göstermektedir. Bu durum, ebeveynlerin rehberliği ve eğitimi sayesinde elde edilen bilişsel kaynaklara bağlanabilir (Almutham vd., 2019; Bernat vd., 2018). Buna karşılık, eğitim düzeyi daha düşük ailelerden gelen öğrenciler, e-sigara bağımlılığına daha yatkın olma eğilimi ve madde kullanımının sonuçları konusunda farkındalık eksikliği sergileme eğilimindedir (Algassim vd., 2024; Choi & Forster, 2013).

Bu örüntü, gençler arasında e-sigaraların algılanan bağımlılık etkisini vurgulayan diğer çalışmalardan elde edilen bulguları yansıtmaktadır (Aly vd., 2022; Jiang vd., 2019). Örneğin, e-sigaraların zararları ve bağımlılık yapıcı özelliğine güçlü bir şekilde inanan genç yetişkinlerin e-sigara kullanma olasılığının daha düşük olduğu gösterilmiştir. Bu da, kişisel risk algısının e-sigara tüketim davranışlarında önemli bir rol oynadığı görüşünü güçlendirmektedir (Cooper vd., 2016; Rohde vd., 2018; Berry vd., 2017). Ayrıca, eğitim kampanyaları, gençlerin genellikle hafife aldığı e-sigaraların bağımlılık yapıcı özelliğinin anlaşılmasını önemli ölçüde artırmaktadır. Ergenler, e-sigaraları geleneksel sigaralardan daha az zararlı olarak algılamakta ve bu da kullanım oranlarının artmasıyla doğrudan ilişkilidir (Dobbs vd., 2016; Leventhal vd., 2015).

Ayrıca, e-sigaraların bağımlılık potansiyeli, öncelikle nikotin içeriğine atfedilen, araştırmacılar arasında tartışma konusu olmuştur. Bazı çalışmalar, e-sigaraların, özellikle gençler arasında, geleneksel sigaralarla karşılaştırılabilir bir bağımlılık riski taşıdığını savunurken, diğerleri bağımlılık düzeylerinin e-sigara kullanıcıları arasında yanlış bir şekilde daha düşük olarak bildirilme eğiliminde olduğunu savunmaktadır (Etter & Eissenberg, 2015; Jeon vd., 2016). Bu, bulgularımızın etkilerini anlamak için çok önemlidir, çünkü bağımlılık farkındalığının düşük olması, ebeveynleri daha az eğitimli öğrenciler arasında e-sigara kullanımının artmasına ve böylece kesilmesi zor bir madde kullanım döngüsünün devam etmesine neden olabilir.

Ayrıca, araştırmalar, e-sigaraların geleneksel sigaralar kadar veya daha az bağımlılık yapıcı olduğu yönündeki ortalama algının, ergenler arasında deneme ve kullanımı artırabileceğini göstermiştir (Kimber vd., 2018; sup vd., 2023). Etkili sağlık iletişim stratejilerinin rolü yeterince vurgulanamaz; halk sağlığı mesajları yoluyla bağımlılık riskinin algılanmasını artırmaya yönelik girişimler çok önemlidir. Bu tür kampanyalar, ebeveynlerin eğitimi ile gençlerin algıları arasındaki ilişkiyi kullanarak, e-

sigaralarla ilişkili bağımlılık riskleri hakkında bilinçli bir anlayış geliştirebilir (Agbonlahor vd., 2024; Andreas vd., 2024).

Özetle, araştırmamızın bulguları, üniversite öğrencileri arasında e-sigara kullanımının çok yönlü doğasını vurgulamakta ve aile faktörlerinin, eğitim faaliyetlerinin ve bağımlılığa ilişkin kişisel algıların hem farkındalığı hem de kullanım davranışlarını nasıl etkilediğini göstermektedir. E-sigaraların bağımlılık yapıcı özelliğine ilişkin yanlış algıları ele alan eğitim girişimlerinin, özellikle ebeveynlerin eğitim düzeyine göre daha yüksek risk altında olduğu belirlenen demografik grupları hedef alarak, güçlendirilmesi gerektiği açıktır.

Türk üniversite öğrencileri arasında e-sigara bağımlılığı ile madde bağımlılığı farkındalık düzeyleri arasındaki ilişkinin araştırılması, özellikle "Bağımlılığa Neden Olan Faktörler" alt boyutunda önemli bir pozitif korelasyon ortaya koymaktadır. Bu bulgu, bağımlılıkla ilgili faktörlere ilişkin farkındalığın, madde kullanımıyla ilgili algıyı ve fiili davranışı etkileyebileceğini ve bunun etkilerinin sadece nikotin tüketimiyle sınırlı kalmayıp daha geniş bağımlılık mekanizmalarını ve bilişsel etkileri de kapsadığını gösteren önceki araştırmalarla uyumludur (Saminathan vd., 2019; Callahan-Lyon, 2014) .

Sonuçlar, e-sigara bağımlılığının öncelikle nikotinle ilişkili olmasına rağmen, e-sigara kullanımı ile çeşitli psiko-sosyal boyutlar arasında çok yönlü bir ilişki olduğunu göstermektedir. Akran etkisi gibi faktörler, ergenler arasında e-sigara kullanımını etkileyen kritik unsurlar olarak belirlenmiştir. Araştırmalar, akranları e-sigara kullanan bireylerin bu cihazları deneme olasılığının önemli ölçüde daha yüksek olduğunu ve bu durumun, e-sigara tüketimine yönelik bireysel davranışların şekillenmesinde sosyal çevrenin rolünü pekiştirdiğini ortaya koymaktadır (Wang vd., 2022; Dobbs vd., 2016) . Ayrıca, e-sigaraların geleneksel sigaralardan daha az zararlı olduğu yönündeki yaygın yanlış kanı, gençler arasında olumlu bir algı yaratmıştır ve bu algı, akranların onayıyla birleştiğinde kullanımın artmasına yol açabilir (Phetphum vd., 2021; Dobbs vd., 2016) .

İlginç bir şekilde, çevresel ve psikolojik faktörler de dahil olmak üzere çeşitli bağımlılık yönlerine ilişkin farkındalık da e-sigaraya bağımlılığı etkilemektedir. Kanıtlar, genç yetişkinlerin e-sigarayı geleneksel sigaraya göre daha güvenli bir alternatif olarak gördüklerini göstermektedir. Bu durumun nedeni, büyük ölçüde e-sigara kullanımının steril bir imajını sunan yanıltıcı pazarlama ve ünlülerin desteğidir (Phua vd., 2017; Vassey vd., 2025). Bu algı, e-sigara kullanımına yönelik içsel tutumlar ve bunları çevreleyen sosyal normlarla birleşerek, belirli akran grupları içinde e-sigara kullanımını normalleştirerek bağımlılık olasılığını artırabilir (Chen-Sankey vd., 2019; Gorukanti vd., 2017) .

Dahası, e-sigara kullanımına yönelik bireysel tutumlar, algılanan riskler ve stres azaltma gibi çevresel etkiler arasındaki etkileşimler, üniversite öğrencilerinin bağımlılık sürecinde önemli etkilere sahiptir. Araştırmalar, psikolojik sıkıntıların genellikle e-sigara kullanım oranlarının artmasına katkıda bulunduğunu göstermiştir. Bu da, bireylerin stresli akademik ortamlarda başa çıkma mekanizması olarak vaping'i kullanabileceğini göstermektedir (Alanazi vd., 2020; Cabral, 2022). Ayrıca, e-sigaralarla ilgili pazarlama stratejileri ve kültürel anlatılar değiştikçe zarar algısı da değişmeye devam ettiğinden, efsaneleri çürütmek ve öğrencileri e-sigara tüketiminin riskleri hakkında bilgilendirmek amacıyla hedefli halk sağlığı müdahaleleri geliştirmek çok önemli hale gelmiştir (Hung vd., 2022; Bares vd., 2015) .

Sonuç olarak, e-sigara bağımlılığı düzeyleri ile madde bağımlılığı farkındalığı arasındaki önemli ilişki, Türkiye'deki üniversite öğrencilerinde bu davranışı etkileyen faktörlerin karmaşıklığını vurgulamaktadır. Bu zorluğun üstesinden gelmek için, yanlış algıları düzeltmeyi, e-sigaraların zararlı

etkilerini vurgulamayı ve stres ve akran etkisini yönetmek için daha sağlıklı başa çıkma stratejilerini teşvik etmeyi amaçlayan eğitim müdahalelerini kapsayan bütüncül bir yaklaşım gereklidir.

Araştırma bulgularında; "Yardım ve Yasal Düzenlemeler" ve "Madde Kullanımının Belirtileri ve Etkileri" alt ölçeklerinde elde edilen yüksek ortalama puanlar, bu demografik grubun bağımlılığı ve bununla ilişkili sağlık sonuçlarını düzenleyen yasal çerçeveye ilişkin övgüye değer bir anlayışa sahip olduğunu göstermektedir (Lépine vd., 2022; Roditis vd., 2019). Bu bulgu, genç yetişkinlerin madde kullanımının yasadışı niteliği, özellikle de yasal sonuçlarla kesiştiği noktada, belirli bir düzeyde bilgiye sahip olduğunu gösteren küresel araştırmalarla tutarlıdır (Lépine vd., 2022; Roditis vd., 2019). Genç yetişkinlerin, halk sağlığı mesajları ve sosyal yardım stratejilerinin bağlamına göre farkındalıklarının farklılık gösterdiği bilinmektedir. Bu durum, özellikle e-sigara gibi yeni ve gelişen madde türleriyle ilgili bağımlılık risklerini açıklığa kavuşturan hedefli sağlık eğitiminin potansiyel değerini göstermektedir (Cornacchione vd., 2016; Phan vd., 2020).

Bununla birlikte, "Kişisel Tutum ve Görüşler" alt ölçeğinde gözlemlenen düşük puanlar, bağımlılık yönetimi konusunda bireylerin kişisel inançları ve öz yeterlilikleri hakkında önemli endişeler ortaya çıkarmaktadır (Mee vd., 2022; Çimşir & Akdoğan, 2023). Bu durum, dış yasal çerçeveler ve sağlık etkileri konusunda sağlam bir anlayışa rağmen, müdahale stratejilerinin bağımlılık davranışlarına karşı daha güçlü kişisel inançlar ve öz yeterlilik geliştirmesi gerektiğini göstermektedir. Araştırmalar, kişisel tutumların sağlık teşvik edici davranışlara katılımı ve bağımlılık yapıcı maddelere direnme kapasitesini önemli ölçüde etkilediğini doğrulamaktadır (Kumar vd., 2024; Ajith vd., 2021). Farkındalık ve kişisel yeterlilik arasındaki bu kopukluk, özellikle eğitimde bir boşluk olduğunu gösterdiğinden endişe vericidir. Eğitim, sadece bilgi aktarmaya değil, aynı zamanda öz algı ve güçlendirme stratejileri yoluyla davranış değişikliğini teşvik etmeye de odaklanmalıdır (Liu vd., 2022; Mohsenpour vd., 2023).

Öz yeterlilik kavramı, bireyin bağımlılık sorunlarıyla başa çıkma becerisini doğrudan etkilediği için çok önemlidir. Araştırmalar, düşük öz yeterlilik ile bağımlılığa yatkınlığın daha yüksek olması arasında bir ilişki olduğunu göstermiş ve bağımlılık davranışlarının yönetilmesinde özgüvenin artırılmasına yönelik müdahalelerin gerekliliğini vurgulamıştır (Ryan vd., 2014; Thakur vd., 2021). Bu eksikliklerin giderilmesi, madde kullanımının yasal ve sağlıkla ilgili yönleri hakkında sürekli eğitimle birlikte, kişisel sorumluluk ve başa çıkma stratejileri unsurlarını içeren çok yönlü halk sağlığı iletişimini gerektirebilir (Chung vd., 2020). Ek olarak, topluluk destek mekanizmalarının entegre edilmesi, genç yetişkinler arasında bağımlılık yönetimi konusunda hem bireysel hem de toplu anlayışın artırılmasında önemli bir rol oynayabilir (Kuss & Griffiths, 2017; Wagner vd., 2018).

Sonuç olarak, Türkiye'deki üniversite öğrencileri madde kullanımıyla ilgili yasal ve sağlık konularında yüksek bir farkındalık sergilese de, bağımlılık davranışlarına karşı kişisel inançları ve başa çıkma stratejilerini güçlendirme ihtiyacı hala çok önemlidir. Sonuçlar, bağımlılıkla mücadele için daha kapsamlı bir çerçeve oluşturarak, öz yeterliliği artıran ve e-sigara ve diğer maddelere karşı daha sağlıklı tutumları teşvik eden, kişiye özel eğitim programlarının geliştirilmesini önermektedir.

5. Sonuç ve Öneriler

Bu araştırma, Türkiye'deki üniversite öğrencileri arasında e-sigara bağımlılığı ile madde bağımlılığı farkındalık düzeyleri arasındaki ilişkiyi incelemiş ve sonuçlar, bağımlılık davranışlarının çok boyutlu bir yapı sergilediğini ortaya koymuştur. Bulgulara göre, öğrencilerin e-sigara bağımlılık düzeyleri ile madde bağımlılığı farkındalık ve tutum puanları arasında anlamlı ilişkiler bulunmuş; bağımlılık farkındalık düzeyi arttıkça e-sigara bağımlılık eğiliminin azaldığı görülmüştür.

Cinsiyet değişkeni açısından, erkek öğrencilerin e-sigara bağımlılık düzeylerinin kadın öğrencilere kıyasla daha yüksek olduğu, buna karşın madde bağımlılığı farkındalık puanlarının daha düşük düzeyde seyrettiği belirlenmiştir. Bu durum, erkek öğrencilerin riskli madde kullanım davranışlarına daha açık olabileceğini düşündürmektedir.

Yaş değişkeni incelendiğinde, 18–20 yaş aralığındaki öğrencilerin e-sigara bağımlılığı puanlarının diğer yaş gruplarına göre daha yüksek olduğu; buna karşın yaş ilerledikçe bağımlılık farkındalık düzeyinin yükseldiği tespit edilmiştir. Bu bulgu, genç yaş grubunda hem deneyim arayışının hem de farkındalık eksikliğinin daha belirgin olduğunu göstermektedir.

Anne ve baba eğitim düzeyleri açısından yapılan analizler, ebeveyn eğitim düzeyi arttıkça öğrencilerin madde bağımlılığı farkındalık puanlarının anlamlı biçimde yükseldiğini ortaya koymuştur. Özellikle üniversite mezunu ebeveynlere sahip öğrenciler, hem bağımlılık konusunda daha bilinçli hem de riskli davranışlara daha mesafeli bir tutum sergilemektedir. Buna karşın, ebeveyn eğitim düzeyinin düşük olduğu gruplarda bağımlılık farkındalık puanlarının daha düşük olduğu ve e-sigara bağımlılığı eğiliminin daha yüksek seyrettiği görülmüştür.

Ayrıca, mevcut araştırma, Türkiye'deki üniversite öğrencilerinin e-sigara bağımlılığı düzeyleri ile madde bağımlılığı farkındalık ve tutumları arasındaki ilişkiyi incelemiştir. Elde edilen bulgular, e-sigara bağımlılığı ile özellikle "Bağımlılığa Neden Olan Faktörler" alt boyutu arasında anlamlı pozitif yönde bir ilişki bulunduğunu göstermektedir. Ayrıca madde bağımlılığı farkındalık ölçeğinin diğer alt boyutları ile e-sigara bağımlılığı arasındaki ilişkiler düşük düzeyde olsa da anlamlıdır. Bu durum, e-sigara bağımlılığının yalnızca nikotin tüketimiyle sınırlı bir davranış olmadığını; aynı zamanda bağımlılık mekanizmaları, bireysel tutumlar ve çevresel faktörler ile bağlantılı olduğunu ortaya koymaktadır.

Katılımcıların "Yardım ve Hukuki Düzenlemeler" ve "Madde Kullanımının Belirtileri ve Etkileri" alt boyutlarından yüksek ortalama puanlar alması, gençlerin bağımlılık konusundaki yasal düzenlemeler ve olası sağlık etkilerine dair farkındalıklarının görece yüksek olduğunu göstermektedir. Buna karşın, "Kişisel Tutum ve Görüşler" alt boyutundaki puanların daha düşük olması, bağımlılık karşıtı kişisel inançların ve öz-yeterlik algısının geliştirilmesi gerektiğine işaret etmektedir.

Genel olarak, çalışma bulguları, e-sigara kullanımının üniversite öğrencileri arasında belirli bir yaygınlığa ulaştığını ve bu kullanımın madde bağımlılığına ilişkin farkındalık düzeyleriyle çok boyutlu bir etkileşim içinde olduğunu ortaya koymuştur.

Öneriler

Uygulayıcılara Yönelik Öneriler

- Üniversitelerde bağımlılık farkındalığını artırmaya yönelik seminer, atölye ve kampanyalar düzenlenmelidir.
- Psikolojik danışma ve rehberlik birimleri, e-sigara ve diğer bağımlılık türlerine yönelik erken müdahale programları geliştirmelidir.
- Sağlık hizmet birimleri, e-sigara bağımlılığına dair tarama ve yönlendirme sistemlerini etkinleştirmelidir.

Politika Yapıcılara Yönelik Öneriler

- ❖ E-sigara satış ve reklamlarının daha sıkı denetimlerle sınırlandırılması gerekmektedir.
- ❖ Üniversiteler ve kamu kurumları, kapalı alanlarda e-sigara kullanımına yönelik net yasak ve yaptırımlar uygulamalıdır.
- ❖ Bağımlılık önleme stratejileri, genç nüfusu hedef alan medya kampanyaları ile desteklenmelidir.

Araştırmacılara Yönelik Öneriler

- ❖ Farklı yaş gruplarında ve sosyoekonomik düzeylerde e-sigara bağımlılığı ve madde bağımlılığı farkındalığı ilişkisi incelenmelidir.
- ❖ Nicel bulguların yanı sıra nitel araştırmalar ile gençlerin bağımlılığa yönelik algı ve deneyimlerinin derinlemesine incelenmesi önerilmektedir.
- ❖ Müdahale programlarının etkinliğini ölçen deneysel veya yarı-deneysel çalışmalar yapılmalıdır.

6. KAYNAKÇA

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A SURVEY-BASED EVALUATION OF TOTAL QUALITY MANAGEMENT DIMENSIONS AND THEIR INFLUENCE ON FINANCIAL AND NON-FINANCIAL PERFORMANCE IN HEIS

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ABSTRACT

This integrative study explores how Total Quality Management (TQM) principles serve as a dual-performance enabler—enhancing both financial and non-financial outcomes—in higher education institutions (HEIs). Drawing from recent empirical evidence and conceptual models from Uzbekistan and international contexts, the paper maps the alignment of TQM dimensions such as leadership commitment, continuous improvement, people management, and student focus with two critical outcome domains. Financial performance is considered in terms of operational efficiency, cost reduction, international student attraction, and strategic positioning, while non-financial performance encompasses student satisfaction, academic service quality, faculty engagement, and institutional reputation. The review reveals that TQM fosters internal service excellence and external stakeholder alignment, allowing HEIs to achieve sustainable performance. Moreover, the study proposes a synthesized framework that connects key TQM practices with outcome indicators and offers a roadmap for HEIs aiming to achieve balanced scorecard excellence. The findings contribute to academic discourse by validating TQM's role as a strategic performance catalyst in higher education systems facing increasing demands for quality, accountability, and global competitiveness.

Key words: Total Quality Management (TQM), Higher Education Institutions (HEIs), Financial and Non-Financial Performance, Institutional Effectiveness, Strategic Quality Framework

INTRODUCTION

In recent years, the quality of higher education institutions (HEIs) has become a critical driver of socio-economic development, particularly in emerging economies such as Uzbekistan. Universities are expected not only to deliver knowledge but also to enhance employability, foster innovation, and contribute to national competitiveness in the global academic arena. To achieve these goals, it is essential to integrate structured quality management approaches that address both academic and operational performance.

Total Quality Management (TQM) provides a holistic approach to institutional improvement by emphasizing continuous enhancement, stakeholder engagement, and efficiency in processes. When aligned with global university performance benchmarks such as the QS Ranking indicators, TQM can provide a comprehensive evaluation of both financial and non-financial outcomes in HEIs.

The integration of QS indicators and TQM dimensions creates an innovative framework that enables HEIs to assess institutional quality across multiple dimensions: academic reputation, employer reputation, internationalization, and sustainability. This combined perspective aligns quality practices with broader institutional performance goals. In the context of Uzbekistan, where ongoing reforms and Presidential decrees (PF-4947, PQ-2909, and PF-60) emphasize modernization and global competitiveness of education, such an approach has particular relevance and urgency.

The scientific novelty of this research lies in bridging established quality management models with international ranking criteria to create a multidimensional evaluation framework tailored for HEIs. Its economic significance emerges from guiding resource allocation, improving efficiency, and enhancing institutional reputation, which in turn supports student recruitment and employer trust. Moreover, the practical applicability of this model is evident in its potential to inform quality assurance strategies, accreditation processes, and policy-making in the higher education sector.

The objective of this study is to empirically evaluate the relationship between TQM practices and institutional performance, while considering the moderating influence of institutional type (public vs. private). By applying statistical techniques such as moderation analysis, the research provides insights into how quality management practices impact performance differently across institution types. The findings are expected to contribute both theoretically—by extending the body of knowledge on integrated quality frameworks—and practically—by offering actionable recommendations for HEI leaders and policymakers in Uzbekistan and Central Asia.

Based on the conceptual model developed, the study proposes the following hypotheses:

- **H1:** Soft Quality Management (QM) practices have a positive impact on the implementation of Hard Quality Management practices in higher education institutions.
- **H2:** Soft QM practices positively influence non-financial performance improvements, such as better communication, fewer complaints, improved staff engagement, and system efficiency.
- **H3:** Soft QM practices positively affect financial performance improvements, including dropout rate reduction, increased graduation rate, growth in admissions, and profit increase.

MATERIALS AND METHODS

Participants

The study involved a total of approximately 140 participants drawn from higher education institutions in Uzbekistan. The sample included academic and administrative staff (n = 110) and top management representatives (n = 30–40). This distribution ensured that diverse institutional perspectives were captured, particularly from those involved in operational processes and strategic decision-making, thereby reflecting the multi-level impact of Total Quality Management (TQM) practices in the higher education sector.

Data Collection

Data were collected using a structured questionnaire survey, specifically designed to measure perceptions of TQM dimensions and institutional performance. Each participant required an average of 15 minutes to complete the questionnaire. To guarantee comprehensive coverage, the questionnaire was distributed across both local and international universities in Uzbekistan. Ethical considerations were observed, with voluntary participation and confidentiality assured.

Instruments

The questionnaire included items related to soft and hard quality management practices, as well as performance indicators. Established scales were adapted to the higher education context, with modifications to ensure cultural relevance in Uzbekistan. The items were measured on a five-point Likert scale, ranging from “strongly disagree” to “strongly agree,” enabling the collection of nuanced data on perceptions and experiences.

Data Analysis

Collected data were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM), a robust multivariate statistical technique particularly well-suited for exploratory studies and complex models involving latent constructs. PLS-SEM was employed to evaluate the reliability and validity of measurement models, test hypothesized relationships, and explore potential moderation effects of

institutional type (public vs. private). The approach enabled both confirmatory and predictive analysis, ensuring a rigorous evaluation of the proposed framework.

Conceptual Framework

To guide the analysis, a conceptual framework was developed, illustrating the hypothesized relationships between soft and hard quality management practices and institutional performance outcomes in HEIs. As shown in Figure 1, the framework posits that Soft QM Practices influence both Hard QM Practices and institutional performance — categorized into **financial** (e.g., dropout rate reduction, profit increase) and **non-financial** outcomes (e.g., communication, staff engagement). This structure supports the empirical testing of the three hypotheses formulated in this study.

Figure 1. Conceptual framework of the study
This model presents the relationships among Soft QM Practices, Hard QM Practices, and institutional performance outcomes. It highlights direct and indirect effects from soft quality strategies on institutional effectiveness in higher education institutions.

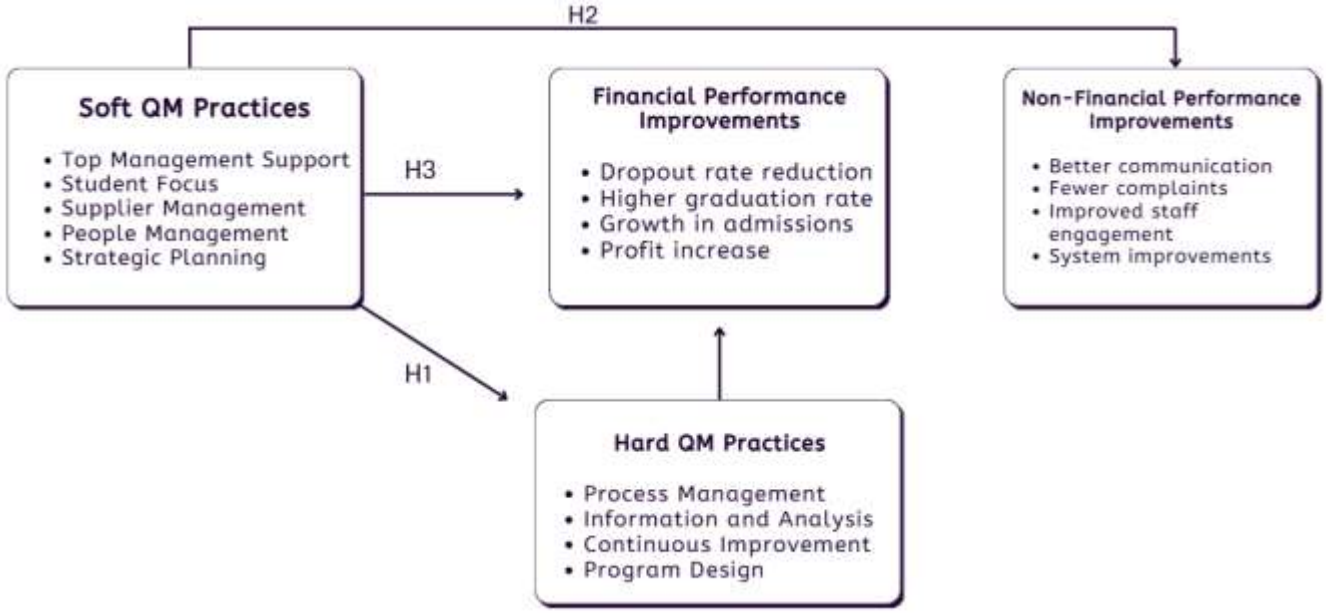


Figure 1. Conceptual model.

RESULTS

H1: Soft QM Practices → Hard QM Practices

A simple linear regression was conducted to examine the effect of **Soft Quality Management practices** on **Hard Quality Management practices**. Results revealed a strong positive relationship (R = .762), with **58.0% of the variance explained (R^2 = .580, Adjusted R^2 = .578)**. The model was statistically significant ($F(1, 209) = 288.519$, **p < .001**). The standardized beta coefficient (β = .762, **p < .001**) indicates that the implementation of soft practices such as top management support, student focus, supplier management, people management, and strategic planning strongly enhances the adoption of hard practices like process management, information and analysis, continuous improvement, and program design.

➞ H1 is supported.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.762[a]	.580	.578	.29055
a. Predictors: (Constant), Soft Quality (independent)				

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	24.356	1	24.356	288.519	.000[b]
	Residual	17.644	209	.084		
	Total	42.000	210			
a. Dependent Variable: Hard (Average)						
b. Predictors: (Constant), Soft Quality (independent)						

H2: Soft QM Practices → Non-Financial Performance Improvements

To test the influence of **Soft QM practices** on **Non-Financial Performance Improvements**, regression analysis showed a strong positive relationship (R = .645), explaining **41.6% of the variance (R^2 = .416, Adjusted R^2 = .413)**. The model was statistically significant (F(1, 209) = 148.715, **p < .001**). The standardized beta coefficient (β = .645, **p < .001**) confirms that higher adoption of soft QM practices significantly improves non-financial outcomes such as communication, complaint reduction, staff engagement, and system improvements.

➞ H2 is supported.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.645[a]	.416	.413	.76619759
a. Predictors: (Constant), Soft Quality (independent)				

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	87.305	1	87.305	148.715	.000[b]
	Residual	122.695	209	.587		
	Total	210.000	210			
a. Dependent Variable: NONFINPERF						
b. Predictors: (Constant), Soft Quality (independent)						

H3: Soft QM Practices → Financial Performance Improvements

Regression analysis was conducted to test the effect of **Soft QM practices** on **Financial Performance Improvements**. The results indicated a moderate positive relationship (R = .548), explaining **30.0% of the variance (R^2 = .300, Adjusted R^2 = .297)**. The model was statistically significant (F(1, 206) = 88.396, **p < .001**). The standardized beta coefficient (β = .548, **p < .001**) demonstrates that implementing soft QM practices leads to financial improvements, including reduced dropout rates, higher graduation rates, increased admissions, and profit growth.
➞ H3 is supported.

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.548[a]	.300	.297	.83853089
a. Predictors: (Constant), Soft Quality (independent)				

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	62.154	1	62.154	88.396	.000[b]
	Residual	144.846	206	.703		
	Total	207.000	207			
a. Dependent Variable: FINPERF						
b. Predictors: (Constant), Soft Quality (independent)						

Hypothesis	Relationship Tested	R	R^2	β	Result
H1	Soft QM → Hard QM	.762	.580	.762***	Supported
H2	Soft QM → Non-Financial Performance	.645	.416	.645***	Supported
H3	Soft QM → Financial Performance	.548	.300	.548***	Supported

*Note: *** $p < .001$*

The results provide strong empirical support for the conceptual framework. Soft QM practices emerged as a key driver for both Hard QM adoption and performance outcomes in HEIs. While the strongest relationship was observed between Soft QM and Hard QM (H1), notable positive effects were also confirmed on both financial (H3) and non-financial (H2) performance improvements, highlighting the holistic role of quality management in enhancing institutional effectiveness.

DISCUSSION

The findings of this study underscore the centrality of balancing soft and hard Total Quality Management (TQM) practices in higher education institutions (HEIs). The significant influence of soft practices—leadership, student focus, supplier management, people management, and strategic planning—on hard practices such as process management, information analysis, continuous improvement, and program design, reflects the socio-technical view of organizations. This confirms that human-centered practices create the enabling environment for technical practices to be successfully implemented (Calvo-Mora et al., 2005; Psomas & Antony, 2017).

A key contribution of this work lies in reinforcing the argument advanced by Utkirov (2024), who demonstrated that in Uzbekistan's HEIs, soft quality practices provide the foundation for effective deployment of hard practices. Our results complement his evidence, confirming that strategic leadership commitment and stakeholder engagement not only enhance process efficiency but also ensure institutional alignment with national educational reforms. This resonates with Sciarelli, Gheith, and Tani (2020), who found that the success of administrative and program design processes depends heavily on cultural and managerial readiness.

Equally relevant is the work of Tarigan and Widjaja (2014), who examined the relationship between non-financial and financial performance in Indonesian universities through the Balanced Scorecard (BSC) framework. Their findings revealed that faculty satisfaction, service quality, and student satisfaction directly shape financial sustainability. This perspective strengthens the present study's argument that soft TQM elements—such as leadership and people management—are not ends in themselves but vital drivers of long-term institutional viability. In other words, without strong human-centered practices, hard practices risk becoming isolated technical routines that fail to yield financial or strategic benefits (Tarigan & Widjaja, 2014).

International literature consistently highlights the interplay between soft and hard TQM practices. For instance, Flynn et al. (1995) and Rahman & Bullock (2005) established that soft practices such as leadership and people involvement are critical precursors to achieving technical excellence. Similarly, Zeng et al. (2017) noted that a failure to prioritize employee training and leadership commitment often limits the sustainability of continuous improvement programs. Our findings align with these perspectives, suggesting that without a culture of collaboration and support, hard practices risk becoming fragmented technical procedures rather than drivers of institutional excellence.

However, the results also reveal areas where Uzbekistan's higher education sector faces challenges. Despite relatively strong scores in leadership, student focus, and administrative processes, continuous improvement scored comparatively lower, reflecting limited capacity for adaptive change. This is consistent with Utkirov's (2023) observations on the challenges of implementing TQM in Uzbekistan, particularly regarding resource allocation and supplier collaboration. These shortcomings may

undermine the long-term sustainability of reforms if not addressed through systematic investments in infrastructure and human capital.

The discussion also points to a broader policy implication. The Presidential Decree on higher education reform in Uzbekistan (2019) emphasized raising institutional standards to meet international benchmarks. The evidence from this study suggests that while strategic planning and leadership commitment are progressing, there is a pressing need to translate these into systematic continuous improvement and innovation practices. International comparisons (e.g., Idrus, 1995; Rampa, 2004) indicate that countries achieving success in positioning HEIs globally have embedded TQM not only at the managerial level but also across teaching, research, and student engagement dimensions.

Taken together, this study contributes to the growing body of knowledge by validating the interdependence of soft and hard TQM practices in higher education, particularly within the Uzbek context. It also builds upon the Balanced Scorecard perspective articulated by Tarigan and Widjaja (2014), confirming that faculty and student satisfaction are essential mediators between quality practices and financial sustainability. Ultimately, the pathway to institutional excellence lies in cultivating leadership-driven cultures that empower technical improvements, while also addressing structural weaknesses in continuous improvement and supplier collaboration. Future research should extend this line of inquiry by integrating student perspectives—currently underrepresented in this study—as their lived experiences provide essential insights into service quality and institutional performance (Annamdevula & Bellamkonda, 2016; Hoque et al., 2023).

Integrated QS-TQM-SERVQUAL Framework 1

QS Lens (with %)	Indicator (with %)	TQM Principle (Type)	BrightBridge.uz Contribution	Presidential Decree Alignment	References
Research and Discovery (50%)	Academic Reputation (30%)	Leadership, Continuous Improvement (Soft Quality)	Research skills training, expert speaker webinars	PF-4947 – Scientific and academic development	QS Quacquarelli Symonds. (2024). President of the Republic of Uzbekistan. (2017). *Decree No. PF-4947* https://lex.uz/docs/3107036
	Citations per Faculty (20%)	Evidence-Based Decision Making (Hard Quality)	AI-powered video tutorials on citing, referencing, publishing articles, and reliable source usage with Uzbek voice translation	PF-60 – Open access science & research development	https://devedu.uz/asosiy/farmon-va-qarorlar/ https://lex.uz/docs/-5841063?ONDATE=21.04.2022&action=compare&utm_source
Employability and Outcomes (20%)	Employer Reputation (15%)	Customer Focus (Soft Quality)	AI-based CV creation and correction, job matching, employer engagement, providing	PF-4947 – Graduate employability improvement: **Fourth Priority Area** —	https://lex.uz/docs/3107036

			suitable candidates for employers	*"Developing the social sphere"*,	
	Employment Outcomes (5%)	Stakeholder Engagement (Soft Quality)	Talent pool platform for employers, alumni follow-up	PF-4947 – Higher education ↔ industry integration (Section **4.1**)	https://lex.uz/docs/3107036
Learning Experience (10%)	Faculty Student Ratio (10%)	Resource Planning, People Involvement (Soft Quality)	Academic helpdesk, mentorship, peer-support tools, video training on subscribed academic databases with AI voice translation to Uzbek	**Quality Monitoring and Analysis in Higher Education Institutions** (Presidential Decree of the Republic of Uzbekistan PF-4947, Clause 4.4: *"Further improvement of the higher education system, enhancement of education quality, and strengthening of the capacity of teaching and academic staff"*)	https://lex.uz/docs/3107036
Global Engagement (15%)	International Faculty Ratio (5%)	External Partnership (Soft Quality)	Support for global staff collaboration, bilingual training	PQ-2909 – Academic mobility and exchange	
	International Research Network (5%)	Strategic Alliances (Hard Quality)	Platform-driven international webinars and publication calls	PF-60 – Global research exchange programs	
	International Student Diversity (0%)	Diversity Focus (Soft Quality)	Multicultural events, English/Uzbek resources	PQ-2909 – Student diversity programs	
	International Student Ratio (5%)	Globalization Focus (Soft Quality)	Information access, multilingual onboarding materials,	PQ-2909 – Foreign student support	

			online orientation modules, pre-arrival video support in Uzbek/English with AI voiceover, cultural adaptation resources		
Sustainability (5%)	Sustainability (5%)	Environmental Responsibility (Hard Quality)	Training on green skills, SDG awareness workshops; helps to economize paper usage by storing documents digitally and reducing the need for printing through automated online saving on the platform	PF-60 – Green economy education	

The integrated QS–TQM–SERVQUAL framework 1 demonstrates that aligning international ranking indicators with quality management principles provides a multidimensional lens for evaluating higher education performance in Uzbekistan. The results confirm that research and discovery remain the most influential drivers of institutional reputation, where leadership, continuous improvement, and evidence-based decision making directly enhance academic reputation and citation impact (QS, 2024). This aligns with the national reform priorities outlined in PF-4947 and PF-60, which emphasize scientific development, open access to research, and innovation in higher education (President of the Republic of Uzbekistan, 2017; 2022). Furthermore, the framework highlights employability and outcomes as key areas where customer focus and stakeholder engagement are critical, reflecting global evidence that quality management systems strengthen graduate readiness and industry integration (Utkirov, 2024). Tools such as BrightBridge.uz's AI-driven CV creation, job-matching algorithms, and employer engagement platforms illustrate the practical role of technology in supporting PF-4947's goal of improving graduate employability and enhancing higher education–industry linkages.

Equally, the analysis of learning experience, global engagement, and sustainability underscores the necessity of resource planning, international collaboration, and environmental responsibility as part of modern higher education systems. The improvement of faculty–student ratios, mentorship initiatives, and peer-support tools resonates with PF-4947's call for enhanced teaching quality and staff capacity building, while global engagement through academic mobility and student diversity aligns with PQ-2909's emphasis on internationalization (President of the Republic of Uzbekistan, 2017; 2017b). Moreover, sustainability principles embedded in PF-60—particularly the promotion of green skills and digital efficiency—highlight the growing importance of environmentally responsible practices in higher education. Together, these findings suggest that an integrated QS–TQM–SERVQUAL framework not only enriches theoretical understanding of quality management in HEIs but also provides practical

pathways for policymakers and university leaders in Uzbekistan to strengthen institutional competitiveness, global reputation, and long-term resilience.

CONCLUSION

This study highlights the critical role of balancing soft and hard Total Quality Management (TQM) practices in enhancing the performance of higher education institutions (HEIs). The evidence confirms that soft practices—leadership, people management, student focus, and strategic planning—serve as foundational drivers that enable the successful implementation of hard practices such as process management, continuous improvement, and program design. In turn, this synergy positively impacts both non-financial outcomes, including staff and student satisfaction, efficiency, and reputation, as well as financial performance indicators such as enrollment growth and institutional sustainability.

The findings also reaffirm the moderating role of institutional type, suggesting that public and private HEIs may differ in how effectively they translate soft quality practices into measurable performance outcomes. This has important implications for policy, particularly in Uzbekistan, where ongoing reforms and Presidential decrees emphasize modernization, internationalization, and competitiveness in the global academic arena.

Beyond Uzbekistan, the results have wider application for higher education systems in other emerging economies where institutions face similar challenges of balancing quality assurance with global competitiveness. Integrating soft and hard TQM practices into higher education governance, supported by frameworks such as the QS indicators and Balanced Scorecard approaches, can serve as a roadmap for institutions seeking to enhance reputation, sustainability, and socio-economic contribution.

Finally, this study contributes theoretically by validating the interdependence of soft and hard quality practices, and practically by offering evidence-based insights for improving institutional performance. Future research should expand the model by incorporating student perspectives more fully and by comparing results across diverse regional and international contexts.

Recommendations

Based on the findings, the following recommendations are proposed:

- **For HEI Leaders:** Strengthen leadership commitment and communication to build a culture of continuous improvement that empowers academic and administrative staff.
- **For Policymakers:** Align national policies with institutional quality frameworks by incentivizing internationalization, innovation, and sustainability practices.
- **For Quality Assurance Units:** Prioritize soft practices (e.g., leadership and stakeholder engagement) before implementing technical quality tools to ensure long-term success.
- **For Researchers:** Extend the model by incorporating longitudinal data, cross-country comparisons, and additional moderating variables such as digital transformation or governance structures.

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THE DEVELOPMENT OF DIGITAL COMPETENCE IN THE EVERYDAY OPERATIONS OF BUSINESSES

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ABSTRACT

Today, the digital competencies of businesses are under continuous examination by researchers, policymakers, statisticians, educators, and scientists alike. Digitalization represents a new level of globalization, affecting ever-widening segments of both the economy and society—segments with which we might not have interacted previously. This transformation has been especially revolutionary in the field of communication: nowadays, we can connect and solve problems with almost anyone, anywhere, and virtually at any time.

The internet enables not only interaction but also access to a vast and previously unimaginable amount of valuable information (Juhász, 2016). According to researchers, digitalization can be defined as an online presence that permeates all areas of life, integrating seamlessly into them, and facilitating constant data and information exchange between ICT tools and people (Morgan and White, 2017).

In light of digitalization, a business's competitiveness is not only re-evaluated but may also be enhanced, gaining new significance. A frequently asked question is whether digitalization is a blessing or rather a curse in the life of a business. Within this context, the lack of proper digital competence often becomes apparent, making high-level digital expertise one of the most essential expectations in both education and the labor market.

In my research, I sought to explore this issue by reaching out to businesses and conducting in-depth interviews during a preliminary study. I asked entrepreneurs what kinds of digital skills they look for in potential employees, and specifically, what they expect from newly graduated university students. Based on the findings of this study, I intend to carry out a broader questionnaire-based research involving a larger sample, to answer my questions in a wider social context.

Keywords: hungarian digitallization, survey, dynamical changing, ability of businessers

INTRODUCTION

"A person who does not understand computers will be considered illiterate in the 21st century," stated Ede Teller in the previous century, expressing a thought that has since become widely quoted (Internet 1). Today, digital literacy has become a fundamental and expected competence. The concept emerged alongside the spread of information technology and computers, and its meaning has undergone numerous changes over time. According to one definition, “ICT literacy refers to an individual’s interest, attitude, and ability to effectively use digital technology and communication tools to access, organize, integrate, and evaluate information, to create new knowledge, and to share it with others through communication, in order to participate effectively in society” (Lennon et al., 2003, p. 8).

Várallyai and Herdon (2013) discuss a study conducted with the participation of six countries, which aimed to examine digital skills and competencies in disadvantaged regions, as well as to promote awareness and adoption of ICT. The ultimate objective was to reduce the isolation and developmental lag of both individuals and their respective regions. Due to the knowledge, as conceptualized in this context, encompasses behaviors and test situations that emphasize the ability to remember information, either through recognition or recall of ideas, materials, or phenomena.

The behavior expected from a learner during a recall task closely mirrors that demonstrated in the initial learning phase. During the learning process, the learner is required to store specific information, and

later, the corresponding behavior involves retrieving this information when needed. While some modifications in the form of the material to be recalled may occur, these adjustments represent a relatively minor aspect of knowledge-based behavior or assessment. As Bloom and the other researchers mentioned, the processes of association and judgment are implicitly involved, as lerners are often required to respond to questions or solve problems presented in a format different from that encountered during the original learning situation. Within the classification of knowledge objectives, the arrangement progresses from specific, relatively concrete behaviors toward more complex and abstract forms. Knowledge of specifics refers to discrete pieces of information that can be isolated and remembered independently. In contrast, knowledge of universals and abstractions emphasizes the recognition of interrelationships and structural patterns, enabling the organization and integration of information into a coherent framework. (Bloom et al.; 1956)

According to the definition of competency or competence, the Cambridge Dictionary's definition is the ability to do something well or an important skill that is needed to do a job the power of a person, business, court or government to deal with something or take legal decisions. In the meaning is competence than the skill, which employees need to make their work professional. as the European Qualification Framework (EQF) write according to this "competence means the proven ability to use knowledge, skills and personal, social and/or methodological abilities, in work or study situations and in professional and personal development." They are defined in terms of responsibility and autonomy. The term of competence refers typically to the ability of a person - facing new situations and unforeseen challenges - to use and apply knowledge and skills in an independent and self-directed way. (Internet 2)

My research focuses on business organizations and their employers. The term that is generally used in Hungarian civil law as a collective concept for economic entities. Since 2013, the Act on the Code of Civil Procedure has provided the precise and current definition; prior to this, the Civil Code (PTK) regulated the legal conceptual framework. According to Hollósy-Kiss (2023), a business organization is an economic unit that manages independently and separately with the resources at its disposal, while pursuing income generation, taking risks, and being profit-oriented.

Under the Accounting Act, business entities include all entrepreneurs, public sector organizations, other entities, the Hungarian National Bank (MNB), as well as institutions (healthcare, educational, social) established by them or by an individual. According to Kapronczai (2007), the following types of information are essential for successful economic management:

- ✓ Legal framework (general legislative regulations, taxation issues, etc.);
- ✓ Market prices of products, demand, and the sales framework (e.g., quality standards, quotas);
- ✓ Procurement opportunities for materials and equipment necessary for operations (e.g.-. energy carriers, raw materials, machinery, equipment);
- ✓ Specific information regarding the natural and economic environment (like weather and epidemiological data);
- ✓ Development resources (grants, subsidies, credit opportunities);
- ✓ Information related to economic activities originating from state and other organizations (chambers, authorities, product councils, advocacy groups, professional organizations, plant and animal health, etc.);
- ✓ Databases of actors operating in the sector (competitors, cooperation opportunities, advocacy bodies, raw material suppliers, buyers), etc.

It is expected that authors will submit carefully written and proofread material. Careful checking for spelling and grammatical errors should be performed. The number of pages of the paper should be 4 and 8 at least and at most.

Prepared papers should clearly describe the background of the subject, the authors work, including the methods used, results and concluding discussion on the importance of the work. Papers are to be prepared in English or Turkish and SI units must be used. Technical terms should be explained unless they may be considered to be known to the congress community.

MATERIALS AND METHODS

Every research activity is grounded on extensive methodological foundations, employing both primary and secondary research techniques to achieve its objectives. To attain the research goals, it was necessary to collect and process both primary and secondary data; therefore, developing an appropriate theoretical framework and uncovering interrelationships were my primary objectives. During the initial phase of the work, significant emphasis was placed on systematizing, analysing, and summarizing both domestic and international literature, as well as establishing a statistical foundation.

At the outset of the research, I formulated my hypotheses, which were linked to my objectives and specific assumptions. In the initial phase, I constructed a logical model that outlined the tasks and issues likely to arise during the research process. After defining the research framework, I recognized the necessity of developing a unified concept through the logical model to ensure the efficient and effective implementation of primary research.

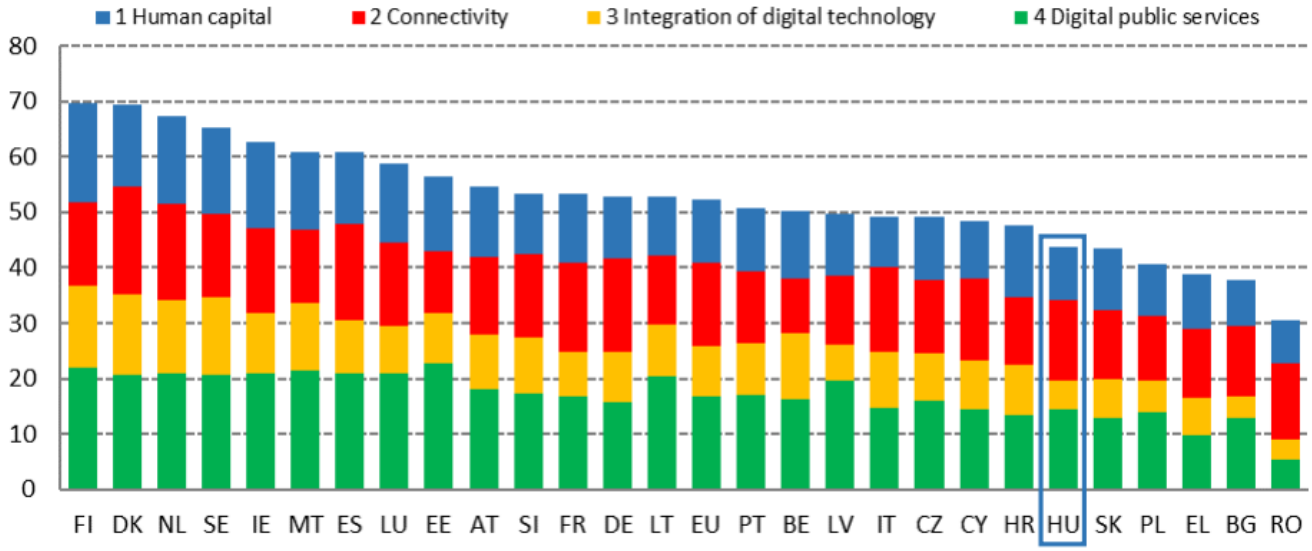


Figure 1 Digital Economy and Society Index (DESI) 2022

Source: Internet 3; https://digital-strategy.ec.europa.eu/hu/policies/desi-hungary

Hungary ranks at Figure 1 on the 22nd out of the 27 EU Member States in the Digital Economy and Society Index (DESI) 2022. Over the last few years, it tried to progress in line with the EU, but in the last few years the data deteriorated and our country slipped down in the ranking. Hungary ranks 23rd between EU countries on Human capital. My country scores below the EU average on the more skills indicators. Specifically only 49% of individuals have at least basic digital compared to the EU average of 54% and the Digital Decade target of 80% by 2030. The proportion of ICT specialists in the workforce has increased slightly to 3.9% but remains below the EU average (4.5%). There is a shortage of ICT specialists: 57% of enterprises reported difficulties in filling ICT vacancies in 2020. To reach the Digital Decade Compass target of 20 million ICT specialists in the EU, Member States should have, on average, about 10% of their workforce employed as ICT specialists. The proportion of female ICT specialists is still low (14%). In addition, the percentage of ICT graduates among all graduates stands at 3.1% in 2020, below the EU average of 3.9%. In 2020, 16% of enterprises provided ICT training to their employees, compared with 20% in the EU general. (Internet 3). According to the EU statistics digital culture is a compulsory subject in grades 3-11 (ages from 8 to 17), developing computational thinking, coding, programming and digital skills in general. In primary schools (grades 3-8), scholars become familiar with key applications, problem solving with computers and operative, innovative and safe use of internet and digital equipment. These skills are further developed in the secondary grades (9-11), including also algorithmic thinking and programming (from robot programming through block programming to coding basic algorithms). It shows of course a optimistic picture for the future, however our problem is not easy to solve, due to my researches.

The creation of the logical model helped me identify the thematic areas requiring focus and delineated the scope of questions to be posed during the primary research. Furthermore, the complexity of the problem and the limited scope of existing literature convinced me of the need to conduct preliminary in-depth interviews as part of the primary investigation. In assembling the logical model, I followed the approach recommended in the literature: I thoroughly reviewed the planned tasks, examined my objectives, and sought answers as to which research methods would be most effective and which factors would lead to the achievement of my goals (Szabóné, Berta; 2014).

My research focuses on business organizations that are legally required to use specific information technology software. However, these tools were introduced without any accompanying training or preparation, while these enterprises increasingly face challenges such as digital HR solutions, offices driven by data centers, artificial intelligence steering and generating changes, sustainable growth, and the associated security risks within the business environment (Internet 4).

The investigation was conducted through a questionnaire survey, structured according to major thematic groups, which also guided the presentation of the results. These thematic groups are as follows:

- The enterprise and its management:
- Key data and main activities (location, establishment date, organizational form)
- Economies of scale data
- Information about management (age, gender, educational background)
- Questions related to information management and the company's employee:
- Computer and internet usage and of information and usage habits
- Data security, IT development level, ICT proficiency of employees, managers, and owners
- Questions regarding the information system and strategic directions
- Attitudes toward IT
- Questions related to the existing system
- Questions regarding the company's plans, network, and management:
- Competitive advantage, utilization of funding opportunities
- Questions related to networking and the adoption of new technologies
- Aspects of sustainability in terms of IT and growth

In designing the questionnaire, I aimed to ensure the broadest possible opportunities for analysis and interpretation of responses. Accordingly, the questions were formulated to offer respondents a wide range of response options. The initial section of the questionnaire consisted of general, multiple-choice, and dichotomous questions. In the section related to information and information management, five-point Likert scale questions were included to capture managerial attitudes, along with standard scale questions that allow for clear answers.

To increase response willingness, I minimized the inclusion of unstructured, open-ended questions requiring elaboration, as prior experience indicated that respondents - especially executives - tend to devote little time to such questions. During the pilot interviews, entrepreneurs were reluctant to share confidential information; therefore, questions regarding general business operations were categorized rather than requiring precise figures (Babbie, 2008).

The investigation can be divided into several age groups, whose characteristics and main attributes fundamentally influence their attitude toward digital education and non-face-to-face learning. Based on the literature these characteristics are summarized in Table 1.

Table 1: Characteristics of Digital Natives and Digital Immigrants

Digital Natives	Digital Immigrants
The internet is the primary source of information	The internet is only a supplementary source of information
Rapid adaptation to new programs and technological developments	Preference for familiar programs and tools
Reception based on visual and audio effects	Reception based on texts
Low-intensity digital communication	High-intensity digital communication
Active presence on various social media platforms	Weekly or even less frequent visits to social media
Consume information rapidly in the online space, make quick decisions, and select information efficiently during searches	Acquire information mainly through traditional channels and make decisions more slowly after thorough consideration

Source: Based on Buda (2017), edited by the author; 2025.

A key component of the study was demographic analysis: how these factors influence attitudes toward the digitalization of businesses, and whether age, gender, or educational attainment have any significant impact in this regard. Furthermore, the research places particular emphasis on issues related to data security within enterprises and the level of digital professional competence among employees.

Based on the considerations presented by various authors, it is evident that digital competences have a impact on different aspects of professional and organizational performance. In particular, these skills are crucial for employees' occupational experience, performance optimization, and improvement of personal flexibility in response to changing work demands. Moreover, the relationship between digital skills and corporate culture, as well as their influence on balancing work responsibilities with personal goals, underscores their importance in technological adaptation and in fostering an inclusive and collaborative environment. Likewise, proficiency in digital competences contributes to an enhanced capacity for communication in a second language, particularly within the globalized business context.

Considering these aspects, and with the aim of analyzing the causal relationship between digital competences and employability dimensions - including second-language proficiency - in small and medium-sized enterprises within the sectors to explore the relationships between digital competences and the aforementioned factors.

RESULTS

In the initial phase of my research, my most important goal was to get to know the general literature, define the research goal and outline the hypotheses. I created a plan providing the background for the research and structured the research process. The next step is testing the compiled questionnaire, which I will carry out in the framework of an in-depth interview with 5-10 company managers and experts. After that, the questionnaire will be clarified and finalized, and with the help of professional organizations, I want to collect as many answers as possible, building a representative database if possible, so that the results can be taken into account at the level of society as a whole.

CONCLUSION

Hungary's National Digitalisation Strategy lists five priorities under its digital state pillar: (1) coordinated, user-centric digital development of central and regional administrations and professional systems on all platforms; (2) establishing a data-driven administration by further increasing

interoperable data links between public registries and relevant back-end systems, as well as e-government services; (3) developing smart settlements and smart areas; (4) increasing the information security of government electronic services; and (5) digital development of public services. (Internet 3). In this connection however, when reading the Hungarian government's strategic plans, it is striking that it does not focus much or not at all on the truly big challenges of the future, especially with regard to the difficulties facing businesses. Data security, AI, accelerating digital services and the rapid development of tools are already looming as major tasks for businesses. There is already a large variation in the use of digital tools and services by sector, but all this could result in a competitive disadvantage in our country in 10-20 years' time, which could set our development back by 20, 30-50 years. in view of the current economic challenges, I believe that very quick and drastic action would be necessary so that the pace of our backwardness does not increase further compared to not only the EU, but also the other developed states of the world.

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INVESTIGATION OF MULTI CRITERIA DECISION-MAKING METHODS IN THE DESIGN OF A MANNED FIGHTER AIRCRAFT FOR THE AFRICAN REGION

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ABSTRACT

The design of manned fighter aircraft tailored for specific regional markets is a complex engineering process that requires the simultaneous evaluation of numerous technical and operational factors. In this process, establishing an optimal balance among critical parameters such as Lifespan, Radar Visibility, Safety, Performance, Cost, and Maintainability is of utmost importance. Therefore, a structured and systematic decision-making approach becomes essential during the design phase. In this study, multi-criteria decision-making (MCDM) methods are employed to develop an optimized manned fighter aircraft design specifically for the African market. This method serves as an effective analytical tool that enables a balanced assessment of criteria with varying priorities.

The main objective of the research is to develop a cost-effective and sustainable aircraft concept compatible with the unique geographical, economic, and operational needs of the African continent. In this context, the opinions of participants of African origin with experience in aviation and engineering were sought. These participants evaluated various design scenarios based on the six fundamental criteria defined above. The data collected were analyzed using MCDM techniques, aiming to determine the most suitable design configuration. The analytical process addresses multidimensional optimization challenges, such as maintaining flight performance while targeting low radar visibility, balancing extended operational life with ease of maintenance, or evaluating the cost implications of enhanced safety levels.

Consequently, the MCDM approach offers a systematic, reproducible, and decision-supportive design methodology that is both strategically and technically valid for the African defense aviation market. In this regard, it contributes to the development of regional defense industry capabilities and supports the creation of aircraft platforms tailored to local conditions and operational demands.

Keywords: Aerospace, Aircraft, Design, Decision Making, Africa

1. Introduction

The design and development of aircraft for specific regional markets is a multifactorial process that extends beyond conventional engineering principles. It involves the integration of diverse and often conflicting parameters such as operational performance, life-cycle costs, survivability, and environmental adaptability. Particularly in underrepresented or logistically complex regions like Africa, the need for aircraft platforms that are tailored to the unique geopolitical, climatic, and infrastructural realities of the region is becoming increasingly critical. One of the key challenges in regional aircraft

design is the establishment of a balance among competing system attributes. The optimal configuration is rarely a product of isolated technical superiority in a single domain, as noted in systems engineering literature emphasizing holistic performance trade-offs (Kossiakoff et al., 2011); rather, it emerges from a carefully structured evaluation of trade-offs across multiple design dimensions. In such contexts, Multi-Criteria Decision-Making (MCDM) frameworks offer a robust analytical mechanism to facilitate rational and evidence-based design choices. These methods allow for the simultaneous consideration of qualitative and quantitative inputs, integrating stakeholder preferences, technical data, and operational requirements into a coherent decision-making model.

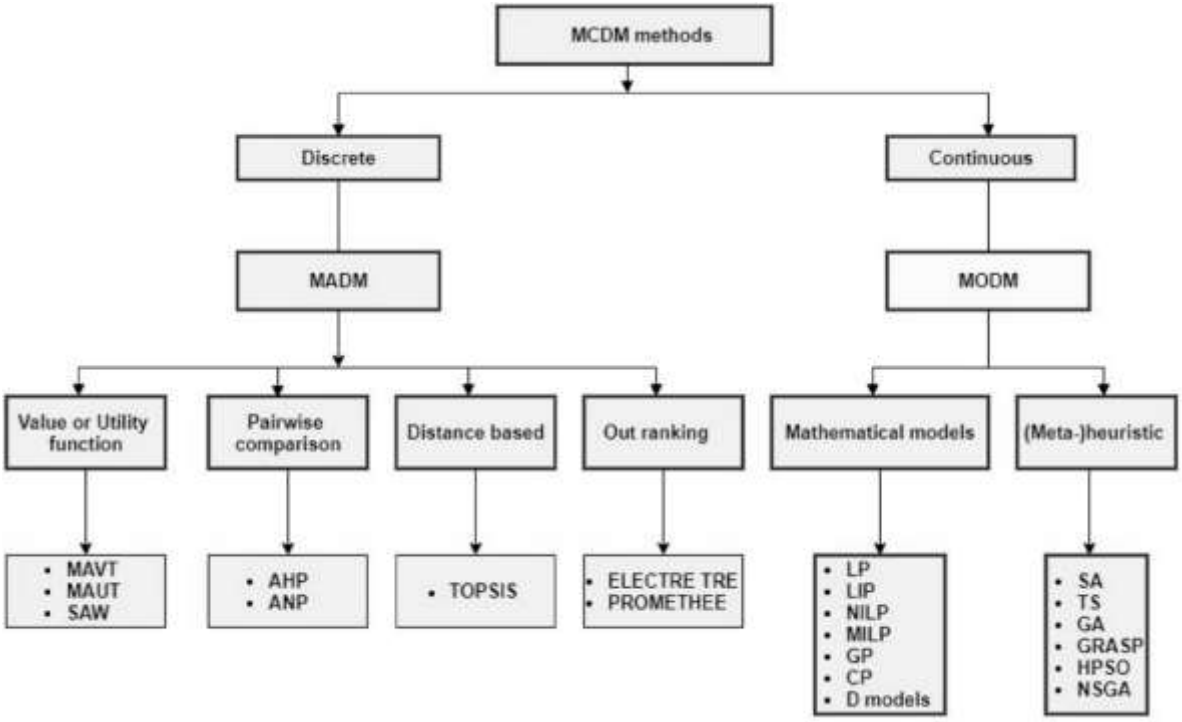


Figure 1 Classification of MCDM methods (Gebre et al., 2021)

While methods such as TOPSIS, PROMETHEE, and ELECTRE are commonly used in MCDM studies, AHP was selected due to its ease of use, consistency ratio calculation, and ability to handle both qualitative and quantitative data (Triantaphyllou, 2000; Behzadian et al., 2010). Analytic Hierarchy Process (AHP) was selected as the most suitable MCDM technique to evaluate and prioritize manned fighter aircraft design criteria. AHP's structured approach allows complex decision problems to be broken down into a hierarchical framework (Saaty, 1980), and has been widely adopted in aerospace and defense decision-making contexts (Forman & Gass, 2001). AHP's ability to capture both qualitative preferences and quantitative data makes it ideal for identifying balanced trade-off and ensuring methodological consistency in the evaluation process.

This study specifically focuses on the development of an aircraft concept optimized for the African operational theatre, incorporating design evaluations across six key parameters: Lifespan, Radar Visibility, Safety, Performance, Cost, and Maintainability & Repairability.

The research methodology involved structured assessments conducted by test pilots and engineers from Africa region that typify the environmental and logistical characteristics common to the broader Sub-Saharan region. The data gathered through these pilot assessments were analyzed using established MCDM techniques, enabling the identification of an aircraft configuration that strikes an optimal balance between technological capabilities and contextual relevance.

The focus on the African region in this study stems from the unique geographical, economic, technological, and military conditions that directly influence aircraft design requirements. Many African nations present a complex operational landscape, shaped by infrastructural limitations and diverse geographical challenges (African Development Bank, 2020; UNCTAD, 2019), characterized by vast

territories, harsh environmental conditions, limited infrastructure, and widely dispersed populations. These factors create a high demand for aircraft that are durable, easy to maintain, and cost-efficient to operate. Furthermore, the limited defence industry budgets and technological resources available in many African countries make it essential to develop solutions that are both affordable and logistically sustainable. The relatively limited local engineering expertise also necessitates systems that are easy to operate and maintain with minimal technical specialization. The resulting analysis aims to support not only technical design goals but also the user needs grounded in Africa's socioeconomic and operational context. As such, the study contributes to the development of an aircraft that is not only mission-capable and economically viable but also adapted to the unique challenges and constraints of the African continent.

2. Material and Methods

Multi-Criteria Decision-Making (MCDM) methods are systematic approaches that guide decision-makers toward the most appropriate alternative through an analytical process. These methods assist the decision-making mechanism by ranking, selecting, and classifying alternatives. Among MCDM methods, the Analytic Hierarchy Process (AHP) is known for its ability to reflect decision-makers' preferences into the solution in a straightforward manner. The method, developed by Thomas L. Saaty in 1977 (Saaty, 1990; Saaty, 2002). AHP is based on pairwise comparisons. The first step in AHP is to identify the goal of the decision-maker and determine the relevant criteria and sub-criteria, thus forming a hierarchical structure. The goal is defined, and criteria that influence the selection are established. Considering these criteria, potential alternatives are identified, and a hierarchical structure for the decision is formed (Kuruüzüm and Atsan, 2001). The decision-making process using the AHP method consists of six steps (Aktaş and Kabak, 2020).

2.1. Identification of the Problem & Parameters

To select the most effective design that will serve at African region design criteria are specified below.

2.1.1. Radar Visibility

Radar visibility refers to the detectability of an aircraft by radar systems. This characteristic is quantified by the radar cross section, where a lower radar cross section value indicates a reduced likelihood of detection. Especially in military platforms, minimizing radar visibility is critical for enhancing survivability.

2.1.2. Performance

Performance denotes the aircraft's ability to accomplish its intended mission. It encompasses flight characteristics such as maximum speed, rate of climb, range, service ceiling, and maneuverability. Additionally, payload capacity and fuel efficiency are also key performance indicators.

2.1.3. Cost

Cost includes all expenditures incurred throughout the aircraft's life cycle (Markatos & Pantelakis, 2023). These comprise expenses related to design, production, operation, maintenance, post-sale support, and testing. Cost-effectiveness is a fundamental consideration, particularly for users operating under constrained budgets. Increased system complexity and integration of advanced equipment typically escalate overall costs

2.1.4. Safety

Safety reflects the aircraft's capacity to minimize risks to passengers and the environment. This involves structural integrity, system redundancy, emergency systems, and adherence to flight safety protocols.

2.1.5. Lifespan

Lifespan refers to the total service duration or flight hours an aircraft can achieve (Markatos & Pantelakis, 2023). A longer operational life contributes to a higher return on investment and supports operational continuity by reducing maintenance demands over time.

2.1.6. Maintainability and Repairability

Maintainability and repairability pertain to the ease, speed, and cost-effectiveness of executing maintenance operations. Factors such as modular design, ease of fault detection, minimal part count, and accessibility of spare parts and fasteners play a crucial role in this domain.

2.2. Pairwise Comparison & Determination of Criteria

In the AHP approach, it is essential to define and prioritize the criteria that will guide the decision-making process. Each criterion is evaluated based on its relative importance in relation to the other criteria, providing a clear basis for the matrix. Values mentioned below:

Table 1 Pairwise Comparison Rating Scale

> 1	More Important
= 1	Equally Important
< 1	Less Important

Table 2 Pairwise Comparison Matrix

Criteria	**(A)**	**(B)**	**(C)**	**(D)**	**(E)**	**(F)**
(A)Radar Visibility	**1**	0,71	0,38	0,33	0,45	0,51
(B)Performance	1,40	**1**	0,54	0,47	0,64	0,71
(C)Cost	2,60	1,86	**1**	0,87	1,18	1,33
(D)Safety	3,00	2,14	1,15	**1**	1,36	1,53
(E)Lifespan	2,20	1,57	0,85	0,73	**1**	1,12
(F)Maintainability and Repairability	1,96	1,40	0,75	0,65	0,89	**1**
Total	12,16	8,68	4,67	4,05	5,52	6,2

Upon completion of the pairwise comparison matrix, a normalization procedure is implemented to enhance the consistency of judgments and to enable the extraction of relative weights. This procedure entails dividing each entry of the matrix by the sum of its corresponding column, thereby yielding the normalized comparison matrix. The resulting matrix serves as the basis for calculating the priority vector, which quantitatively expresses the relative significance of each criterion within the decision hierarchy.

Table 3 Normalized Comparison Matrix

Criteria	Normalized Matrix						Total	Weight	Percentage (%)
(A)Radar Visibility	0,08	0,08	0,08	0,08	0,08	0,08	0,492	**0,081777635**	8,1777
(B)Performance	0,11	0,12	0,12	0,12	0,12	0,11	0,690	**0,115413031**	11,5413
(C)Cost	0,21	0,21	0,21	0,21	0,21	0,21	1,284	**0,214222221**	21,4222
(D)Safety	0,25	0,25	0,25	0,25	0,25	0,25	1,482	**0,246595261**	24,6595
(E)Lifespan	0,18	0,18	0,18	0,18	0,18	0,18	1,086	**0,180976829**	18,0976
(F)Maintainability and Repairability	0,16	0,16	0,16	0,16	0,16	0,16	0,966	**0,161015023**	16,1015

2.3. Eigenvalues and Eigenvectors

To derive the final weights of the criteria, the principal eigenvector of the pairwise comparison matrix must be computed (Shiraishi & Obata, 2025). This vector represents the relative priorities associated with each criterion. The percentage distributions of the weightings have been visualized using Table 3.

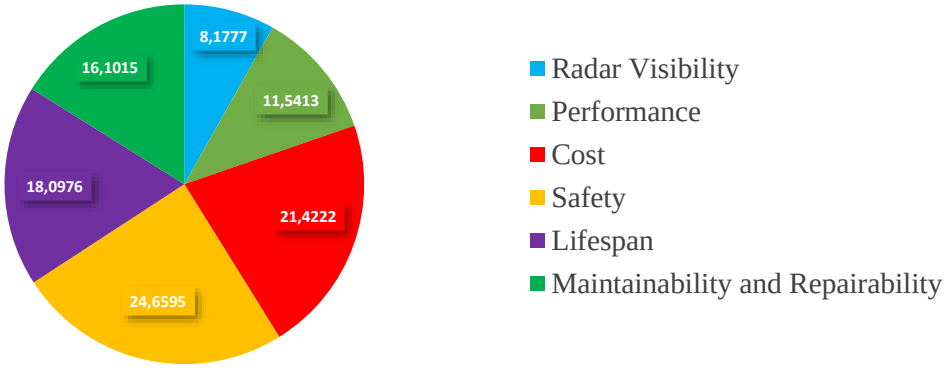


Figure 2 Pie Chart Illustrating the Weightings

2.4. Consistency Ratio Calculation

In the Analytic Hierarchy Process, consistency of the pairwise comparisons are essential to ensure the reliability of the derived priorities. The Consistency Ratio (CR) is calculated to assess the logical coherence of the decision-maker's judgments (Saaty, 1980). The Consistency ratio (CR) is calculated, and if it is below a threshold, the judgments are considered consistent. If the CR exceeds the acceptable threshold it may be necessary for the decision-maker to re-evaluate their pairwise judgments (Forman & Gass, 2001)

Table 4 RI (Random Index) Table (Saaty, 1980)

Matrix	RI
1	0.00
2	0.00
3	0.58
4	0.90
5	1,12
6	**1,24**
7	1,32
8	1,41
9	1,45
10	1,49

$$(\text{Each})\text{i} = \frac{(A * w)_i}{w_i} \quad (1)$$

$$\lambda_{max} = \frac{\sum_{i=1}^{6} \frac{(A * w)_i}{w_i}}{6} = 6 \quad (2)$$

$$CI = \frac{\lambda_{max} - n}{n-1} = \frac{6-6}{5} = 6{,}00 \quad (3)$$

$$CR = \frac{CI}{RI} = \frac{0{,}00}{1{,}24} = 0{,}00 \quad (4)$$

Given that the Consistency Ratio (CR) is 0.00, which is below the acceptable threshold of 0.10 (typically)(Malczewski, 1999), the AHP matrix demonstrates a satisfactory level of consistency. Consequently, the derived weights for the criteria are considered reliable and the decision-making process is based on consistent judgments.

2.5. Total Score and Weights of Conceptual Designs

In this final stage of the evaluation process, six predefined criteria are used to assess three different design concepts. Each concept is rated on a scale e.g., 1 to 3. These scores are then multiplied by the corresponding criterion weights, which were previously determined using the AHP. For each concept, the weighted scores across all six criteria are summed to calculate a final aggregated score. This score reflects the overall performance of each design concept with respect to the weighted importance of each criterion. The concept with the highest total score is considered the most favorable option, as it best satisfies the evaluation criteria in a balanced and consistent manner.

Table 5 Concept Decision Score Table

Criteria	Weight	Concept 1		Concept 2		Concept 3	
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
(A)Radar Visibility	0,081777635	**1**	0,08177763	**1**	0,08177763	**2**	0,16355527
(B)Performance	0,115413031	**1**	0,11541303	**2**	0,23082606	**2**	0,23082606
(C)Cost	0,214222221	**2**	0,42844444	**3**	0,64266666	**3**	0,64266666
(D)Safety	0,246595261	**3**	0,73978578	**3**	0,73978578	**2**	0,49319052
(E)Lifespan	0,180976829	**3**	0,54293048	**2**	0,36195365	**1**	0,18097682
(F)Maintainability and Repairability	0,161015023	**1**	0,16101502	**2**	0,32203004	**3**	0,48304506
Total Score	**1**		2,06936638		**2,37903982**		2,19426039

2.6. Final Decision and Results

Following the multi-criteria evaluation conducted using the AHP, three different aircraft design concepts were assessed based on six distinct criteria related to the manned fighter aircraft for the African region. The scores assigned to each concept were weighted according to the relative importance of the criteria, and the total scores were calculated accordingly.

These findings align with previous studies emphasizing the need for context-sensitive aerospace solutions for emerging regions (Zhao et al., 2018). As a result of this systematic evaluation, **Concept 2** emerged as the most favorable design alternative, achieving the highest overall score of **2,37903982**. This outcome indicates that Concept 2 provides the most balanced and optimal performance in terms of the defined concepts.

Concept 2 stands out as the most suitable option for a manned fighter aircraft intended for deployment in the African region, where cost-effectiveness is paramount and radar visibility holds relatively lower tactical importance. Its strong performance in critical areas such as safety, maintainability, and lifecycle efficiency indicates a technically sound and operationally sustainable solution, aligning well with the strategic and logistical realities of emerging defense environments. Its consistently high weighted scores across the key criteria suggest a well-balanced design that effectively integrates technical feasibility with long-term reliability.

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İlgili makama;

12. Uluslararası New York Kongresi 21-24 Ağustos 2025 tarihleri arasında New York6 ABD'de 26 farklı ülkenin akademisyen/araştırmacılarının katılımıyla gerçekleşmiştir. Kongre kapsamında sunumu yapılan 153 bildirinin 52 adeti Türkiye'den katılımcılar tarafından; 101 bildiri ise 26 ülkeden katılımcılar tarafından sunulmuştur. Kongre 16 Ocak 2020 Akademik Teşvik Ödeneği Yönetmeliğine getirilen "*Tebliğlerin sunulduğu yurt içinde veya yurt dışındaki etkinliğin uluslararası olarak nitelendirilebilmesi için Türkiye dışında en az beş farklı ülkeden sözlü tebliğ sunan konuşmacının katılım sağlaması ve tebliğlerin yarıdan fazlasının Türkiye dışından katılımcılar tarafından sunulması esastır.*" değişikliğine uygun düzenlenmiştir.

Bilgilerinize arz edilir,

Saygılarımla,

Muntazır Mehdi

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Sayı : BSE-2 20 Ocak 2025

İLGİLİ KURUMA

İçişileri Bakanlığı tarafından tahsis edilen 06-146-071 tescil kodu ile Tüzel Kişiliğe sahip olan İKSAD Enstitüsü 5253 sayılı kanuna uygun olarak "Bilimsel araştırmalar ve akademik çalışmalar" alanında ulusal ve uluslararası düzeyde faaliyetlerini yürütmektedir.

Kurumumuzun Yönetim Kurulu 15 Ocak 2024 tarihinde saat 10.30'da "Bilimsel Diplomasi Projesi" görüşmeleri ile "Bilimsel Kongreler Düzenlenmesi" gündemleri ile toplanmış ve alınan (2 numaralı) karara istinaden aşağıda detayları yazılı olan bilimsel etkinliğin düzenlenmesine ve etkinliğe ilişkin resmi görevlendirme konusunda karar vermiştir.

Bilgi ve gereğini rica ederim

Dr. Mustafa Latif EMEK
Yönetim Kurulu Adına

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