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Web-Based Time Series Analysis Tool: The Case of Health Expenditures and Economic Growth
Selena KANTARMACI ÖZKAN - Prof. Dr. İpek DEVECİ KOCAKOÇ
5 - 14

Bibliometric Analysıs of Academic Studes on Health Expenditures
Çağnur Sayal ŞERAMET
15 - 25

Bibliometric Analysis on the Concept of Financial Failure
İrem BOZBEŞPARMAK
26 - 38

Bibliometric Analysis on the Concept of Insurance and the Insurance Industry
Hilal ODABAŞ
39 - 54

Teachers' Views on the Use of Artificial Intelligence in Education
Akça Okan YÜKSEL
55 - 64

The Importance of Defining Actors' Income Models and Its Impact on the Professional Definition of Acting
Asst. Prof. Dr. Orkun ÖNGEN
65 - 71

Assessment of the Transition from Traditional to Innovative Management in the Tourism Sector: The Case of Turkey

Yavuz Tansoy YILDIRIM - Sertaç ERCAN - Tamerlan AKBAROV

72 - 83

A Study on the Boundaries of Al-Rawda Al-Mutahhara

Dr. Nilgün ÇEVİK

84 - 94

Aspects of Forced Labor of Prisoners of War in 1940-1945 in Sudetenland

Iva STURMOVÁ

95 - 102

The European Convention on Human Rights and the American Convention on Human Rights in A Comparative Mechanism System

Iacob Andra BIANCA

103 - 115

The Figure of the Scribe in the Albanian Area as Part of the Byzantine Heritage

Lect. Arta SULA

116 - 121

The Role of Islamic Banking to Increase Halal Industry in Indonesia: Bibliometric Approach

Atina SHOFAWATI

122 - 144

Extraordinary Events and Their Impact on Tourism Development in the Slovak Republic

Mária PETRUŠČÁKOVÁ

145 - 161

Transposition of the ECN+ Directive in the Candidate Country: The Case of Albania

Ph. D. Gentjan Skara LLM

162 - 168

An Energy Consumption Prediction Method Based on Verbal Artificial Intelligence Classification

Uğur TAŞKIRAN

169 - 178

On ⊕-g-Supplemented Lattices
Maryam BARADARAN - Prof. Dr. Celil NEBİYEV
179 - 182

Strongly ⊕-g-Supplemented Lattices
Maryam BARADARAN - Prof. Dr. Celil NEBİYEV
183 - 186

The Effect of Organic Salts $NaCH_3COO$, $Zn(CH_3COO)_2$, and $C_6H_5Na_3O_7$ on the Phase Diagram of the Peg-Dextran-Water Biphasic System
E. A. MESIMOV - Jale Z. TEYMUROVA
187 - 190

Stability or Instability of a Static Meniscus Appearing in Ribbon Single Crystal Growth from Melt using E.F.G. Method
Andreea V. COJOCARU - Adriana TANASIE
Prof. Dr. Stefan BALINT - Sorina M. D. LAITIN
191 - 204

On r-Small Elements in Lattices
Narmin BAYAT - Prof. Dr. Celil NEBİYEV
205 - 207

r-Supplemented Lattices
Narmin BAYAT - Prof. Dr. Celil NEBİYEV
208 - 211

Comparative Analysis of Selected Facial Emotion Recognition Methods as Potential Tool for Emotional Disorders Automated Assessment in Terms of Remote Work Application
Ilona Zimnoch - Aleksandra Rokita - Magdalena Matuła - Wiktor Kuczek - Michał Rydzik - Mateusz Pomianek
212 - 236

Environmental Impact of Contaminant Diffusion and Synergistic Effects on XLPE Insulation Cables
Priya Selvamany
237 - 247

Predicting Energy Dissipation in Stepped Spillways Using Feature Selection and Machine Learning
Zeroual Abdelatif - Abdellaoui Assia - Kaddour Rayane
248 - 256

Pervaporation Separation of Water-Ethanol Mixtures Using Blend Membranes of Poly (Ethylene Glycol) and Sodium Alginate
Saraswathi Mekala
257 - 270

Assessment of the Fishing Vessels and Marine Environment Protection in Albanian Coastal Areas
Shkëlqim SINANAJ
271 - 279

The Role and Impact of Information and Communication Technology (ICT) in Higher Education
Khursheed ALAM
280 - 285

Investigation of the Possible Role of CYP1A1 Gene M1(T>C) and M2(A>G) Polymorphisms in Bladder Cancer
İrem KÖSE - Dr. Ali NEBİOĞLU - Assoc. Prof. Dr. Şenay BALCI FİDANCI –
Prof. Dr. Murat BOZLU - Prof. Dr. Lülüfer TAMER
286 - 324

Relationship of Physiological Curvatures of the Spine with Demographic Characteristics, Balance, Postural Habit and Postural Awareness
Maryam SAMADI AZAR - Assoc. Prof. Dr. Burçin AKÇAY
324 - 334

Nursing Approaches in Diabetic Foot Wounds
Assoc. Prof. Dr. Sultan ÖZKAN - MSc. Abide Nur YAKANOĞLU
335 - 342

Nasotreachal Intubation
Dr. Mehtap BALCI
343 - 347

Web-Based Time Series Analysis Tool: The Case of Health Expenditures and Economic Growth

Web Tabanlı Zaman Serisi Analiz Aracı: Sağlık Harcamaları ve Ekonomik Büyüme Örneği

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Abstract

Time series analysis provides insights into how two variables move together over a long period. Unit root tests and cointegration analysis are widely used tools in fields such as finance, economics, and health. However, applying these methods typically requires specialized software and coding skills. This study introduces a web-based tool designed to make these tests more accessible to everyone.

To demonstrate how the tool works, data from Turkey between 1975 and 2023 were used. Two variables were selected: the share of health expenditures in the country's GDP and GDP per capita. The tool was used to generate graphical representations of the data. Then, unit root tests were applied to assess whether the data were stable over time. The results indicated that both series were non-stationary. Therefore, the Johansen cointegration test was conducted to check for a long-term relationship. The test results showed that there is a long-run relationship between the variables.

The findings were compared with results from popular time series software and were found to be consistent, confirming the accuracy of the tool. This tool is beneficial for users without coding knowledge and also supports experts who seek to perform fast and clear analyses. In the future, it is planned to include additional time series methods such as VAR, VECM, and Granger causality. It is believed that this web-based tool can contribute to a wide range of research across various fields.

Keywords: Web-Based Application, Time Series, Cointegration, Unit Root, Economic Growth, Health Expenditures

Özet

Zaman serisi analizi, iki değişkenin uzun bir süre boyunca nasıl birlikte hareket ettiği konusunda bilgi sağlamaktadır. Birim kök testleri ve eşbütünleşme analizi, finans, ekonomi ve sağlık gibi alanlarda yaygın olarak kullanılan araçlardır. Ancak bu yöntemlerin kullanımı özel yazılımlar ve kodlama becerileri gerektirmektedir. Bu çalışmada, bu testlerin herkes için daha kolay kullanılabilir hale getirilmesini amaçlayan web tabanlı bir araç tanıtılmıştır.

Aracın nasıl çalıştığını göstermek için, 1975 ile 2023 yılları arasındaki Türkiye verileri kullanılmıştır. İki değişken seçilmiştir: ülkenin GSYİH'sindeki sağlık harcamalarının payı ve kişi başına GSYİH. Araç aracılığıyla verilerin grafik çizimleri yapılmıştır. Ardından, birim kök testleri kullanılarak verilerin zaman içinde istikrarlı olup olmadığı test edilmiştir. Sonuçlar, her iki serinin de istikrarlı olmadığına işaret etmiştir. Bu nedenle, uzun vadeli bir bağlantı olup olmadığını kontrol etmek amacıyla Johansen eşbütünleşme testi uygulanmıştır. Test sonucunda, değişkenler arasında uzun dönemli bir ilişki olduğu gösterilmiştir.

Elde edilen sonuçlar, popüler zaman serisi programlarıyla karşılaştırılmış ve birebir örtüştüğü görülmüştür. Böylece aracın doğru çalıştığı doğrulanmıştır. Bu araç, kodlama bilgisi olmayan kullanıcılar için fayda sağlamaktadır. Ayrıca hızlı ve net analiz yapmak isteyen uzmanlara da yardımcı olmaktadır. Gelecekte, VAR, VECM ve Granger nedenselliği gibi daha fazla zaman serisi yönteminin araca eklenmesi planlanmaktadır. Bu web tabanlı aracın, farklı alanlardaki birçok araştırmaya katkı sağlayabileceği düşünülmektedir.

Anahtar Kelimeler: Web Tabanlı Uygulama, Zaman Serisi, Eşbütünleşme, Birim Kök, Ekonomik Büyüme, Sağlık Harcamaları

Giriş

Yatırım ve mühendislik verilerinden finansal verilere kadar birçok alanda zaman serisi analizleri önemli bir rol oynamaktadır ve ekonomik verilerin incelenmesinde serilerin durağanlığının belirlenmesini ve uzun vadeli ilişkilere odaklanılmasını son derece önemli kılar. Bu nedenle birim kök testleri ve eşbütünleşme analizleri zaman serisi ekonometrisinin temel taşları arasında yer almaktadır.

Zaman serilerinin durağan olup olmadığını test etmek için kullanılan birim kök testleri güvenilirlikte çok önemli bir role sahiptir çünkü serinin durağan olmayışı model tahminlerini yanıltabilir ve hatalı sonuçlar doğurabilir. Bu çalışmanın odak noktasında olan birim kök testlerinden Augmented Dickey-Fuller (ADF), Phillips-Perron(PP), ve Kwiatkowski-Phillips-Schmidt Shin (KPSS) birim kök testleri, 1975 ile 2023 yılları arasındaki Türkiye'nin gayri safi yurtiçi hasıladaki sağlık harcamalarının payı ve kişi başına gayri safi yurtiçi hasıla aracılığı ile tanıtılmıştır.

Zaman içinde birlikte hareket eden ve aralarındaki farkın sabit olduğu iki veya daha fazla durağan olmayan verilerin durumu eşbütünleşme olarak adlandırılır. Bu durum genellikle uzun vadeli bir denge ilişkisinin varlığını gösterir ve bu ilişkiyi belirlemek için yaygın olarak kullanılan testler arasında Engle-Granger ve Johansen testi

bulunur. Bu çalışma kapsamında Johansen eşbütünleşme testinin kullanılmasının sebebi simetrik yapısının avantajlarından ve sistemin gücünden kaynaklanır.

Bu projede geliştirilen web tabanlı uygulama; Angular kullanılarak Python ve R kütüphanelerinin entegrasyonuyla oluşturulmuştur. Web tabanlı bu araç sayesinde kullanıcılar kendi zaman serisi verilerini yükleyerek birim kök ve eşbütünleşme testlerini kolayca gerçekleştirebilirler. Kod bilgisi gerektirmeyen bu pratik araç sayesinde araştırmacılar ve öğrenciler zaman serisi analizlerini interaktif bir şekilde gerçekleştirme imkanına sahip olacaklar.

1. Birim Kök Testleri

Analiz edilecek zaman serilerinin ilk ve en önemli adımı durağan olup olmadığını belirlemektir ve bunun için birincil araçlar birim kök testleridir; ancak "serilerin yapısı doğrusal mı yoksa doğrusal değil mi? "sorusu seçilen test tipini doğrudan etki eder. Doğrusal serilerde kullanılan birim kök testleri ile doğrusal olmayan serilerde kullanılan testler farklıdır. Web tabanlı araca entegre edilen birim kök testleri aşağıda verilmiştir.

Tablo 1: Web Tabanlı Analiz Aracında Yer Alan Birim Kök Testleri

Klasik (Doğrusal) Birim Kök Testleri	
Test Adı	Açıklama
Augmented Dickey-Fuller (ADF)	Gecikmeli farklarla durağanlığı test eder. En yaygın kullanılan testtir.
Dickey-Fuller GLS (ERS Testi)	ADF'nin daha güçlü bir versiyonudur, seriyi GLS ile önceden düzenler.
Phillips-Perron (PP)	ADF gibi çalışır ama hata terimlerinde otokorelasyonu parametrik olmayan şekilde düzeltir.
Kwiatkowski-Phillips-Schmidt-Shin (KPSS)	Durağanlık varsayımını test eder. ADF ve PP'ye tamamlayıcı olarak kullanılır.
Doğrusal Olmayan (Non-Linear) Birim Kök Testleri	
Kapetanios, Shin and Snell (KSS)	STAR modeline dayalı doğrusal olmayan yapıda durağanlığı test eder.
Sollis (2009)	LSTAR modelinde asimetrik düzeltmeyi test eder.
Kruse (2011)	STAR yapısında daha gelişmiş bir test; özellikle küçük örneklemlerde güçlüdür.
Kılıç (2011)	Momentum etkileri içeren doğrusal olmayan yapılar için bir testtir.
Cuestas and Garratt	Eşikli doğrusal olmayan yapıları test eder.
Cuestas and Ordoñez (2014)	İleri düzey non-linear yapılar altında birim kök sınaması sunar.
Yapısal Kırılma İçeren Birim Kök Testleri	
Zivot & Andrews (1992)	Seride tek yapısal kırılma varsayımıyla birim kök test eder. Kırılma noktası endojen belirlenir.
Leybourne, Newbold and Vougas (1998)	Yapısal kırılma altında durağanlık testleri sunar.
Enders & Granger (1998)	TAR modellerde durağanlığı test eder. Rejim geçişlerini dikkate alır.
Hu & Chen	Yapısal kırılmaların olduğu serilerde birim kök testini doğrusal olmayan modellerle birleştirir.
Park and Shintani	Yapısal kırılma + doğrusal olmayanlık içeren modellerde test imkanı sağlar.

Kaynak: https://timeseriesanalysis.com/

Test seçimleri yapılırken serilerde, otokorelasyon, doğrusallık, yapısal kırılma durumları gmz önüne alınmalıdır. Klasik testler ADF, PP, KPSS, DF-GLS şeklinde olup eğer otokorelasyon varsa PP, DF-GLS, doğrusallığın olmadığı durumlarda KSS, Sollis, Kruse, Enders-Granger, Kılıç, asimetrik düzeltme varsa Sollis, Cuestas-Ordoñez, yapısal kırılma mevcutsa Zivot & Andrews, Leybourne-Newbold, Hu & Chen ve hem kırılma hem doğrusal olmama durumu mevcutsa Park & Shintani, Cuestas & Garratt testi kullanılabilir.

2. Eşbütünleşme Testleri

Zaman serilerindeki iki veya daha fazla değişken arasında uzun vadeli denge olup olmadığını test etmek için eşbütünleşme analizleri yapılır.Genellikle bu analizler serilerin her birinin ayrı ayrı durağan olmayabileceği ancak aralarındaki belirli lineer kombinasyonların durağan olabileceği varsayımına dayanır.Eğer seriler eşbütünleşikse,birbirleriyle uzun vadede hareket etme eğiliminde olduklarını ve aralarında bir denge ilişkisi olduğunu gösterir.Birim kök testleri gibi doğrusallık durumu bu analizde de önemlidir.Web sitesinde bulunan eşbütünleşme testleri Tablo 2'deki gibi sunulmuştur.

Tablo 2: Web Tabanlı Analiz Aracında Yer Alan Eşbütünleşme Testleri

Doğrusal Eşbütünleşme Testleri	
Test Adı	Açıklama
Engle-Granger (1987)	İki değişkenli modellerde kullanılır. Önce serilerin birim kök içerip içermediği test edilir, ardından regresyon kalıntılarının durağan olup olmadığı kontrol edilir. Eşbütünleşme varsa, hata düzeltme modeli (ECM) kurulabilir.
Phillips-Ouliaris	Engle-Granger'a benzer residual-based bir testtir. Seriler arasındaki denge ilişkisinin varlığı kalıntılar üzerinden test edilir. Bu testte test istatistiği farklılık gösterir ve genellikle daha güçlüdür.
Johansen (1988, 1991)	Çok değişkenli (VAR) sistemlerde eşbütünleşme vektörlerinin sayısını belirlemeye yarar. Trace ve maksimum özdeğer (max-eigen) test istatistikleri kullanılır. Johansen testi, Engle-Granger'ın çok değişkenli genişletilmiş halidir.
Doğrusal Olmayan Eşbütünleşme Testleri	
Kapetanios, Shin and Snell (2006)	Doğrusal olmayan birim kök testidir ancak eşbütünleşme analizlerinde kalıntıların doğrusal olmayan yapısını test etmekte de kullanılır. Bu sayede doğrusal olmayan hata düzeltme modelleri kurulabilir.
Hansen and Seo (2002)	Eşikli VECM (Threshold Vector Error Correction Model) yaklaşımını kullanır. İki farklı rejim altında eşbütünleşme ilişkisi test edilir. Regresyon parametrelerinin rejimlere göre değişmesine olanak tanır.
Enders ve Siklos (2001)	Eşikli Otoregresif Model (TAR ve M-TAR) tabanlı eşbütünleşme testidir. Kalıntıların eşik değerine göre asimetrik tepki verip vermediği analiz edilir. Pozitif ve negatif sapmalara farklı tepki gösteren serilerde güçlüdür.

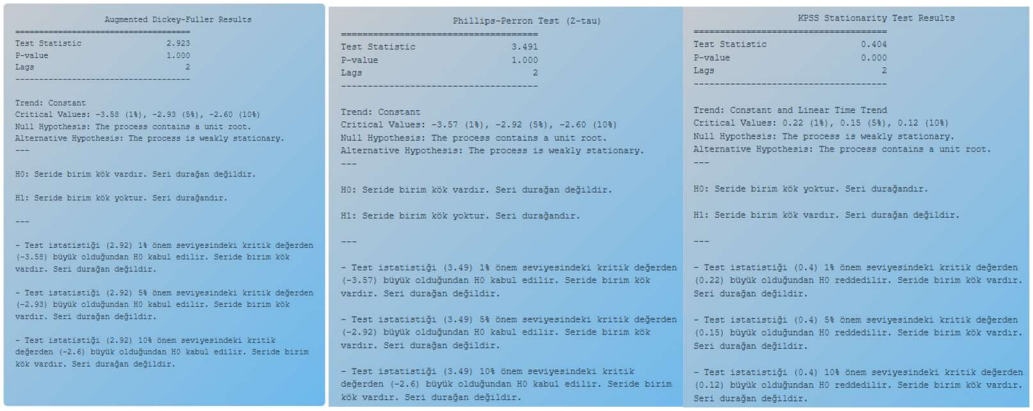
Kaynak: https://timeseriesanalysis.com/

Eşbütünleşme testleride aynı birim kök testlerinde olduğu gibi verilerin yapısına bağlı olarak değişir. İki değişkenli modellerde regresyona bağlı olarak kullanılan ve hataların durağanlığı ile eşbütünleşik ilişkiyi tespit eden Engle Granger yaygın kullanılan eşbütünleşme testidir. Phillips Ouliaris Engle Granger'a göre daha gülüdür. Johansen ise iki veya çok değişkenli sistemlerde kullanılması ve yönsüz analiz özelliği ile daha güçlüdür. Doğrusal olmayan eşbütünleşme testlerinden Kapetanios, Shin ve Snell doğrusal olmayan verilerde yine hata terimlerinin durağanlığına bağlı olarak analiz gerçekleştirilir. Hansen ve Seo eşikli hata düzeltme modelini kullanır. Son olarak Enders ve Siklos TAR ve M-TAR tabanlarını kullanmaktadır.

3. Yöntem

Web tabanlı zaman serisi aracının tanıtımı için 1975 ile 2023 yılları arasındaki Türkiye verileri kullanılmıştır. Analiz için, ülkenin GSYİH'sindeki sağlık harcamalarının payı ve kişi başına GSYİH arasındaki ilişki araştırılmıştır. İlk olarak verilerin durağanlığı araşırmak adına seriler ADF,PP ve KPSS birim kök testi ile sınanmış daha sonra Johansen eşbütünleşme testi ile değişkenler arasındaki ilişki araştırılmıştır. Amacımız aracı tanıtmak ve diğer popüler programlarla karşılaştırarak doğruluğunu göstermektir. Bu sebeple her testtin iki gecikmeli ve sabit terimli kombinasyonu E-views ve R görselleri ile teyit edilmiştir. Şekil 1'de sırasıyla kişi başına GSYİH için ADF, PP ve KPSS testlerinin web tabanlı analiz aracı sonuçları sabit terim ve iki gecikme için verilmiştir.

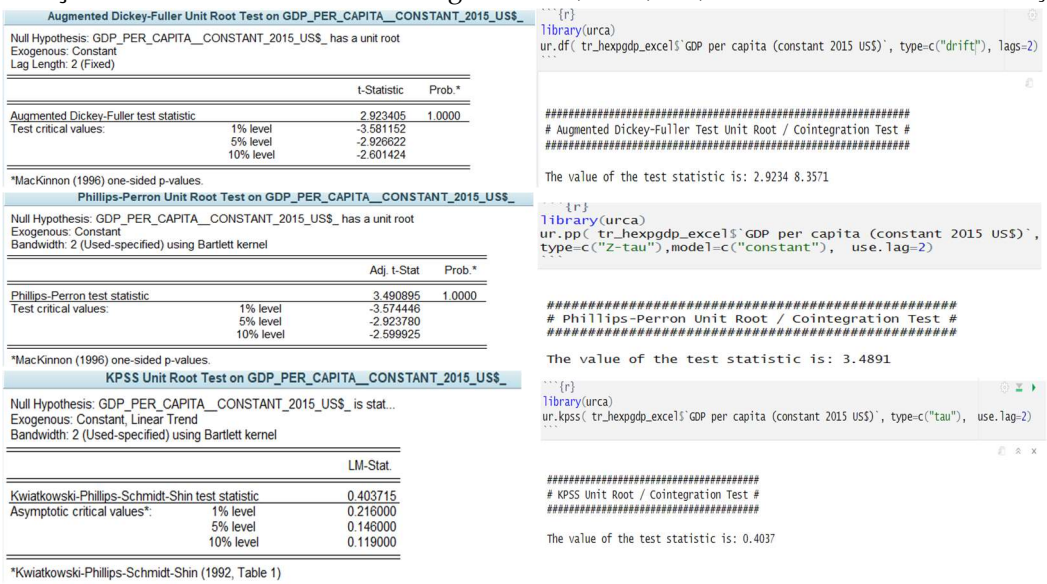
Şekil 1: GSYİH İçin Web Analiz Aracı ADF,PP ve KPSS Birim Kök Testi



Kaynak: https://timeseriesanalysis.com/

GSYİH için her üç testte iki gecikme ve ADF ve PP'de sabit terimli modelde KPSS'de sabit terimli trendli modelde serinin durağan olmadığını göstermektedir. Sırasıyla t istatisikleri 2.92, 3.49, 0.40'tır. ADF ve PP testinin temel hipotezi serinin durağan olmadığı iken KPSS testinin temel hipotezi seri durağandır şeklinde kurulmuştur. ADF ve PP testinde test istatistikleri kritik değerlerden büyük olduğundan H0 kabul edilir. Seri durağan değildir. KPSS testinde test istatistikleri kritik değerden büyün olduğundan H_0 reddedilir. Seri durağan değildir. Sonuçlar E-views ve R ile karşılaştırılacaktır.

Şekil 2 : Sol tarafta E-views 12 Sağ Tarafta R, ADF, PP , KPSS Birim Kök Testi Sonuçları



Augmented Dickey-Fuller Unit Root Test on GDP_PER_CAPITA__CONSTANT_2015_US$_

Null Hypothesis: GDP_PER_CAPITA__CONSTANT_2015_US$_ has a unit root
Exogenous: Constant
Lag Length: 2 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		2.923405	1.0000
Test critical values:	1% level	-3.581152	
	5% level	-2.926622	
	10% level	-2.601424	

*MacKinnon (1996) one-sided p-values.

Phillips-Perron Unit Root Test on GDP_PER_CAPITA__CONSTANT_2015_US$_

Null Hypothesis: GDP_PER_CAPITA__CONSTANT_2015_US$_ has a unit root
Exogenous: Constant
Bandwidth: 2 (Used-specified) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		3.490895	1.0000
Test critical values:	1% level	-3.574446	
	5% level	-2.923780	
	10% level	-2.599925	

*MacKinnon (1996) one-sided p-values.

KPSS Unit Root Test on GDP_PER_CAPITA__CONSTANT_2015_US$_

Null Hypothesis: GDP_PER_CAPITA__CONSTANT_2015_US$_ is stat...
Exogenous: Constant, Linear Trend
Bandwidth: 2 (Used-specified) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.403715
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

```{r}
library(urca)
ur.df( tr_hexpgdp_excel$`GDP per capita (constant 2015 US$)`, type=c("drift"), lags=2)
```

```
############################################################
# Augmented Dickey-Fuller Test Unit Root / Cointegration Test #
############################################################

The value of the test statistic is: 2.9234 8.3571
```

```{r}
library(urca)
ur.pp( tr_hexpgdp_excel$`GDP per capita (constant 2015 US$)`,
type=c("Z-tau"),model=c("constant"),  use.lag=2)
```

```
#################################################
# Phillips-Perron Unit Root / Cointegration Test #
#################################################

The value of the test statistic is: 3.4891
```

```{r}
library(urca)
ur.kpss( tr_hexpgdp_excel$`GDP per capita (constant 2015 US$)`, type=c("tau"),  use.lag=2)
```

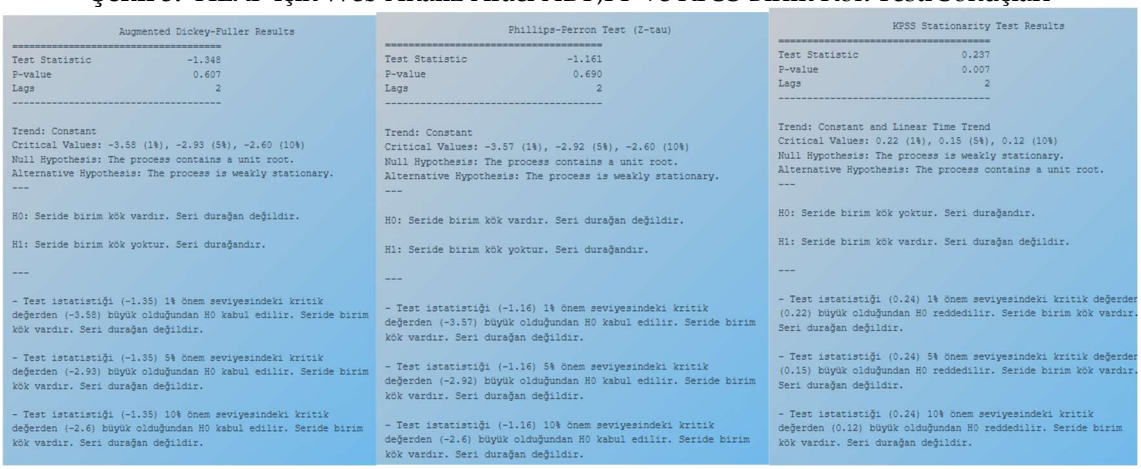
```
#######################################
# KPSS Unit Root / Cointegration Test #
#######################################

The value of the test statistic is: 0.4037
```

Kaynak: E-views 12, R

Şekil 2 'de web aracında sınaması yapılan GSYİH serisinin sol tarafta E-views sağ tarafta R çıktıları gösterilmiştir. Test istatistiklerinde birebir eşleşme sağlanmış olup entegreler doğrulanmıştır. Sağlık harcamaları için analiz aracı sonuçlar Şekil 3'te gösterilmiştir.

Şekil 3: HEXP İçin Web Analiz Aracı ADF,PP ve KPSS Birim Kök Testi Sonuçları



Augmented Dickey-Fuller Results

Test Statistic -1.348
P-value 0.607
Lags 2

Trend: Constant
Critical Values: -3.58 (1%), -2.93 (5%), -2.60 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.

H0: Seride birim kök vardır. Seri durağan değildir.

H1: Seride birim kök yoktur. Seri durağandır.

- Test istatistiği (-1.35) 1% önem seviyesindeki kritik değerden (-3.58) büyük olduğundan H0 kabul edilir. Seride birim kök vardır. Seri durağan değildir.

- Test istatistiği (-1.35) 5% önem seviyesindeki kritik değerden (-2.93) büyük olduğundan H0 kabul edilir. Seride birim kök vardır. Seri durağan değildir.

- Test istatistiği (-1.35) 10% önem seviyesindeki kritik değerden (-2.6) büyük olduğundan H0 kabul edilir. Seride birim kök vardır. Seri durağan değildir.

Phillips-Perron Test (Z-tau)

Test Statistic -1.161
P-value 0.690
Lags 2

Trend: Constant
Critical Values: -3.57 (1%), -2.92 (5%), -2.60 (10%)
Null Hypothesis: The process contains a unit root.
Alternative Hypothesis: The process is weakly stationary.

H0: Seride birim kök vardır. Seri durağan değildir.

H1: Seride birim kök yoktur. Seri durağandır.

- Test istatistiği (-1.16) 1% önem seviyesindeki kritik değerden (-3.57) büyük olduğundan H0 kabul edilir. Seride birim kök vardır. Seri durağan değildir.

- Test istatistiği (-1.16) 5% önem seviyesindeki kritik değerden (-2.92) büyük olduğundan H0 kabul edilir. Seride birim kök vardır. Seri durağan değildir.

- Test istatistiği (-1.16) 10% önem seviyesindeki kritik değerden (-2.6) büyük olduğundan H0 kabul edilir. Seride birim kök vardır. Seri durağan değildir.

KPSS Stationarity Test Results

Test Statistic 0.237
P-value 0.007
Lags 2

Trend: Constant and Linear Time Trend
Critical Values: 0.22 (1%), 0.15 (5%), 0.12 (10%)
Null Hypothesis: The process is weakly stationary.
Alternative Hypothesis: The process contains a unit root.

H0: Seride birim kök yoktur. Seri durağandır.

H1: Seride birim kök vardır. Seri durağan değildir.

- Test istatistiği (0.24) 1% önem seviyesindeki kritik değerden (0.22) büyük olduğundan H0 reddedilir. Seride birim kök vardır. Seri durağan değildir.

- Test istatistiği (0.24) 5% önem seviyesindeki kritik değerden (0.15) büyük olduğundan H0 reddedilir. Seride birim kök vardır. Seri durağan değildir.

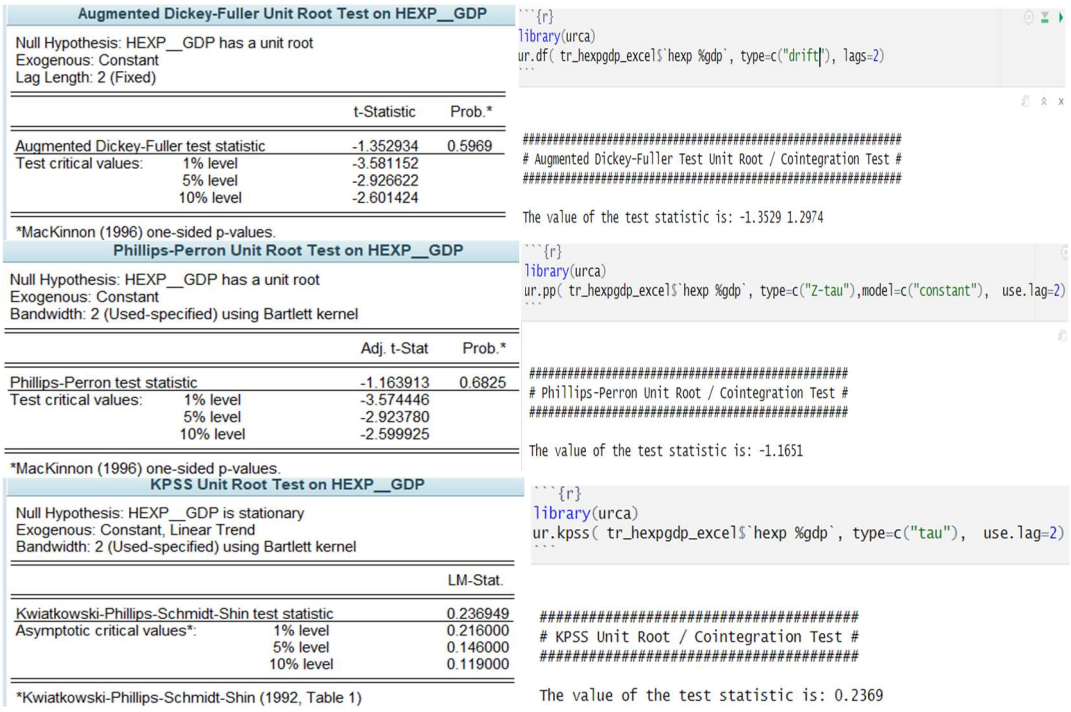
- Test istatistiği (0.24) 10% önem seviyesindeki kritik değerden (0.12) büyük olduğundan H0 reddedilir. Seride birim kök vardır. Seri durağan değildir.

Kaynak: https://timeseriesanalysis.com/

HEXP için her üç testte iki gecikme ve ADF ve PP'de sabit terimli modelde KPSS'de sabit terimli trendli modelde serinin durağan olmadığını göstermektedir. Sırasıyla t istatisikleri -1.35, -1.16, 0.23'tür. ADF ve PP testinin temel hipotezi serinin durağan olmadığı iken KPSS testinin temel hipotezi seri durağandır şeklinde kurulmuştur. ADF ve PP testinde test istatistikleri kritik değerlerden büyük olduğundan H0 kabul edilir. Seri durağan değildir. KPSS testinde test istatistikleri kritik değerden

büyün olduğundan H_0 reddedilir. Seri durağan değildir. Sonuçlar E-views ve R ile karşılaştırılacaktır.

Şekil 4: HEXP İçin Web Analiz Aracı ADF,PP ve KPSS Birim Kök Testi



Augmented Dickey-Fuller Unit Root Test on HEXP__GDP

Null Hypothesis: HEXP__GDP has a unit root
Exogenous: Constant
Lag Length: 2 (Fixed)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.352934	0.5969
Test critical values:	1% level	-3.581152	
	5% level	-2.926622	
	10% level	-2.601424	

*MacKinnon (1996) one-sided p-values.

```{r}
library(urca)
ur.df( tr_hexpgdp_excel$`hexp %gdp`, type=c("drift"), lags=2)
```

```
############################################################
# Augmented Dickey-Fuller Test Unit Root / Cointegration Test #
############################################################

The value of the test statistic is: -1.3529 1.2974
```

Phillips-Perron Unit Root Test on HEXP__GDP

Null Hypothesis: HEXP__GDP has a unit root
Exogenous: Constant
Bandwidth: 2 (Used-specified) using Bartlett kernel

		Adj. t-Stat	Prob.*
Phillips-Perron test statistic		-1.163913	0.6825
Test critical values:	1% level	-3.574446	
	5% level	-2.923780	
	10% level	-2.599925	

*MacKinnon (1996) one-sided p-values.

```{r}
library(urca)
ur.pp( tr_hexpgdp_excel$`hexp %gdp`, type=c("Z-tau"),model=c("constant"),  use.lag=2)
```

```
################################################
# Phillips-Perron Unit Root / Cointegration Test #
################################################

The value of the test statistic is: -1.1651
```

KPSS Unit Root Test on HEXP__GDP

Null Hypothesis: HEXP__GDP is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 2 (Used-specified) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.236949
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

```{r}
library(urca)
ur.kpss( tr_hexpgdp_excel$`hexp %gdp`, type=c("tau"),  use.lag=2)
```

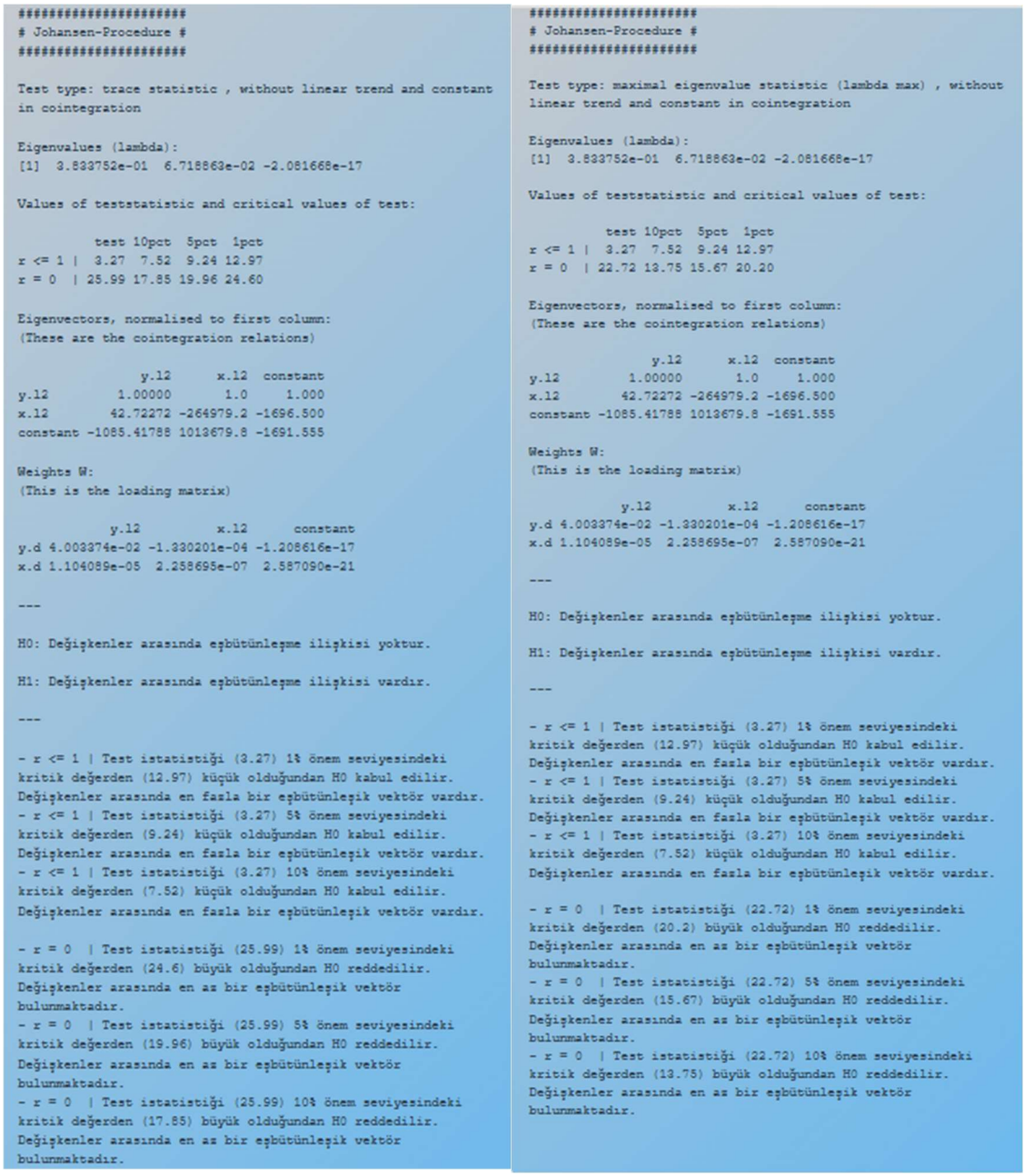
```
#######################################
# KPSS Unit Root / Cointegration Test #
#######################################

The value of the test statistic is: 0.2369
```

Kaynak: E-view 12, R

Şekil 4 'te web aracında sınaması yapılan HEXP serisinin sol tarafta E-views sağ tarafta R çıktıları gösterilmiştir. Test istatistiklerinde birebir eşleşme sağlanmış olup entegreler doğrulanmıştır. Serilerin levelde durağan olmadığı sonucuna varıldığı için aralarındaki uzun dönemli ilişkinin incelenmesi adına Johansen eşbütünleşme testi uygulanmıştır. Şekil 5'te web tabanlı araçta uygulanan Johansen eşbütünleşme testi sonuçları verilmiştir.

Şekil 5: Web Analiz Aracı Johansen Eşbütünleşme Testi Sonucu



```
######################
# Johansen-Procedure #
######################

Test type: trace statistic , without linear trend and constant
in cointegration

Eigenvalues (lambda):
[1]  3.833752e-01  6.718863e-02 -2.081668e-17

Values of teststatistic and critical values of test:

          test 10pct  5pct  1pct
r <= 1 |  3.27  7.52  9.24 12.97
r = 0  | 25.99 17.85 19.96 24.60

Eigenvectors, normalised to first column:
(These are the cointegration relations)

                y.12      x.12  constant
y.12         1.00000       1.0     1.000
x.12        42.72272 -264979.2 -1696.500
constant -1085.41788 1013679.8 -1691.555

Weights W:
(This is the loading matrix)

            y.12          x.12      constant
y.d 4.003374e-02 -1.330201e-04 -1.208616e-17
x.d 1.104089e-05  2.258695e-07  2.587090e-21

---

H0: Değişkenler arasında eşbütünleşme ilişkisi yoktur.

H1: Değişkenler arasında eşbütünleşme ilişkisi vardır.

---

- r <= 1 | Test istatistiği (3.27) 1% önem seviyesindeki
kritik değerden (12.97) küçük olduğundan H0 kabul edilir.
Değişkenler arasında en fazla bir eşbütünleşik vektör vardır.
- r <= 1 | Test istatistiği (3.27) 5% önem seviyesindeki
kritik değerden (9.24) küçük olduğundan H0 kabul edilir.
Değişkenler arasında en fazla bir eşbütünleşik vektör vardır.
- r <= 1 | Test istatistiği (3.27) 10% önem seviyesindeki
kritik değerden (7.52) küçük olduğundan H0 kabul edilir.
Değişkenler arasında en fazla bir eşbütünleşik vektör vardır.

- r = 0  | Test istatistiği (25.99) 1% önem seviyesindeki
kritik değerden (24.6) büyük olduğundan H0 reddedilir.
Değişkenler arasında en az bir eşbütünleşik vektör
bulunmaktadır.
- r = 0  | Test istatistiği (25.99) 5% önem seviyesindeki
kritik değerden (19.96) büyük olduğundan H0 reddedilir.
Değişkenler arasında en az bir eşbütünleşik vektör
bulunmaktadır.
- r = 0  | Test istatistiği (25.99) 10% önem seviyesindeki
kritik değerden (17.85) büyük olduğundan H0 reddedilir.
Değişkenler arasında en az bir eşbütünleşik vektör
bulunmaktadır.
```

```
######################
# Johansen-Procedure #
######################

Test type: maximal eigenvalue statistic (lambda max) , without
linear trend and constant in cointegration

Eigenvalues (lambda):
[1]  3.833752e-01  6.718863e-02 -2.081668e-17

Values of teststatistic and critical values of test:

          test 10pct  5pct  1pct
r <= 1 |  3.27  7.52  9.24 12.97
r = 0  | 22.72 13.75 15.67 20.20

Eigenvectors, normalised to first column:
(These are the cointegration relations)

                y.12      x.12  constant
y.12         1.00000       1.0     1.000
x.12        42.72272 -264979.2 -1696.500
constant -1085.41788 1013679.8 -1691.555

Weights W:
(This is the loading matrix)

            y.12          x.12      constant
y.d 4.003374e-02 -1.330201e-04 -1.208616e-17
x.d 1.104089e-05  2.258695e-07  2.587090e-21

---

H0: Değişkenler arasında eşbütünleşme ilişkisi yoktur.

H1: Değişkenler arasında eşbütünleşme ilişkisi vardır.

---

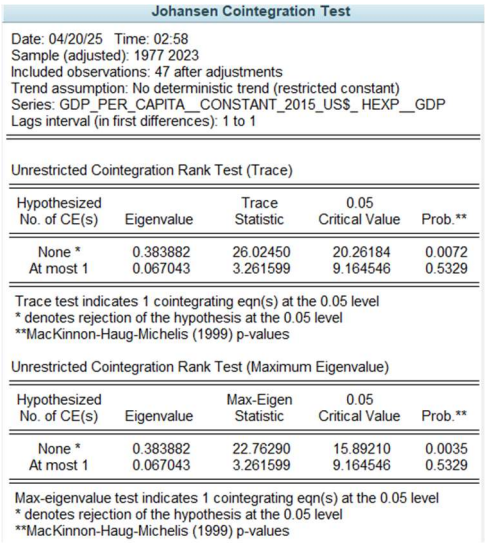
- r <= 1 | Test istatistiği (3.27) 1% önem seviyesindeki
kritik değerden (12.97) küçük olduğundan H0 kabul edilir.
Değişkenler arasında en fazla bir eşbütünleşik vektör vardır.
- r <= 1 | Test istatistiği (3.27) 5% önem seviyesindeki
kritik değerden (9.24) küçük olduğundan H0 kabul edilir.
Değişkenler arasında en fazla bir eşbütünleşik vektör vardır.
- r <= 1 | Test istatistiği (3.27) 10% önem seviyesindeki
kritik değerden (7.52) küçük olduğundan H0 kabul edilir.
Değişkenler arasında en fazla bir eşbütünleşik vektör vardır.

- r = 0  | Test istatistiği (22.72) 1% önem seviyesindeki
kritik değerden (20.2) büyük olduğundan H0 reddedilir.
Değişkenler arasında en az bir eşbütünleşik vektör
bulunmaktadır.
- r = 0  | Test istatistiği (22.72) 5% önem seviyesindeki
kritik değerden (15.67) büyük olduğundan H0 reddedilir.
Değişkenler arasında en az bir eşbütünleşik vektör
bulunmaktadır.
- r = 0  | Test istatistiği (22.72) 10% önem seviyesindeki
kritik değerden (13.75) büyük olduğundan H0 reddedilir.
Değişkenler arasında en az bir eşbütünleşik vektör
bulunmaktadır.
```

Kaynak: https://timeseriesanalysis.com/

Şekil 5 sonuçlarına göre, iz test istatistiği r=0 için 25.99 r≤1 için 3.27'dir. Özdeğer istatistiği ise r=0 için 22.72 , r≤1 için 3.27'dir. r=0 için her iki istatistik için kritik değerlerden büyük olduğundan H_0 reddedilir. Değişkenler arasında en az bir eşbütünleşik vektör bulunmaktadır. r≤1 için önem seviyesindeki kritik değerlerden küçük olduğundan H_0 kabul edilir. Değişkenler arasında en fazla bir eşbütünleşik vektör vardır. Son olarak Şekil 6'da Johansen eşbütünleşmenin E-views sonucu verilmiştir.

Şekil 4: E-views 12 Johansen Eşbütünleşme Testi Sonucu



Johansen Cointegration Test

Date: 04/20/25 Time: 02:58
Sample (adjusted): 1977 2023
Included observations: 47 after adjustments
Trend assumption: No deterministic trend (restricted constant)
Series: GDP_PER_CAPITA__CONSTANT_2015_US$_ HEXP__GDP
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.383882	26.02450	20.26184	0.0072
At most 1	0.067043	3.261599	9.164546	0.5329

Trace test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.383882	22.76290	15.89210	0.0035
At most 1	0.067043	3.261599	9.164546	0.5329

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Kaynak: E-view 12

Test istatistik değerleri hem iz hem özdeğer için birebir eşleşmiştir. Sonuca göre seriler arasında eşbütünleşik vektör bulunmaktadır. Bundan sonraki süreç ilişkinin yönü ve katsayısı adına VECM(Hata Düzeltme Modeli) ile devam ettirilebilir. İleri ki dönemlerde VAR, VECM, Nedensellik gibi yöntemlerin siteye eklenmesi planlanmaktadır.

Sonuç

Web tabanlı istatistiksel analiz araçlarının geliştirilmesinin, ekonomik ve sosyal bilimsel araştırmaların erişilebilirliğini ve hızını önemli ölçüde artırdığı günümüzde, bu platformun sunduğu imkanlar sayesinde zaman serisi analizlerinde sıklıkla kullanılan birim kök ve eşbütünleşme testlerinin doğrusal ve doğrusal olmayan yapılarını detaylı bir şekilde değerlendirmek mümkün hale gelmektedir. Bu sistem ile ekonometrik analizlerin çevrim içinde gerçekleştirilmesinin kolaylaşmasıyla beraber, kodlama becerisine ihtiyaç duymadan istatistiksel analizler yapabilme yeteneği de elde edilmektedir. Bu gelişmeler sayesinde uzman olmayan araştırmacılar dahi istatistiksel yöntemleri kolaylıkla kullanarak veriler üzerinde çalışma pratiklerini geliştirebilmekte ve bu alandaki tecrübelerini artırabilmektedir.

Doktora tez çalışmasında geliştirilen bu entegre sistemin sürdürülebilirliği ve bilimsel kapsamının genişletilmesi, gelecekte çok değişkenli modeller, yapısal kırılmalı analizler ve makine öğrenmesi tabanlı zaman serisi yöntemlerinin de platforma dahil edilmesiyle mümkün olacaktır. Bu doğrultuda, platformun dinamik bir şekilde geliştirilmesi ve kullanıcı geri bildirimleri doğrultusunda güncellenmesi, dijital bilimsel araçların yaygınlaşması adına önemli bir katkı sağlayacaktır.

KAYNAKÇA

Dickey, D. A., and Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association, 74*(366), 427–431. https://doi.org/10.1080/01621459.1979.10482531

Enders, W., and Granger, C. W. J. (1998). Unit-root tests and asymmetric adjustment with an example using the term structure of interest rates. *Journal of Business and Economic Statistics, 16*(3), 304–311. https://doi.org/10.1080/07350015.1998.10473717

Enders, W., and Siklos, P. L. (2001). Cointegration and threshold adjustment. *Journal of Business and Economic Statistics, 19*(2), 166–176. https://doi.org/10.1198/073500101316970395

Engle, R. F., and Granger, C. W. J. (1987). *Co-integration and error correction: Representation, estimation, and testing. Econometrica*, 55(2), 251–276. https://doi.org/10.2307/1913236

Hu, J., and Chen, Z. (2016). A unit root test against globally stationary ESTAR models when local condition is non-stationary. *Economics Letters, 146*, 89–94. https://doi.org/10.1016/j.econlet.2016.07.027

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control, 12*(2–3), 231–254. https://doi.org/10.1016/0165-1889(88)90041-3

Kapetanios, G., Shin, Y., and Snell, A. (2006). Testing for cointegration in nonlinear smooth transition error correction models. *Econometric Theory, 22*(2), 279–303. https://doi.org/10.1017/S0266466606060113

Kılıç, R. (2011). Testing for a unit root in a stationary ESTAR process. *Econometric Reviews, 30*(3), 274–302. https://doi.org/10.1080/07474938.2010.483885

Kwiatkowski, D., Phillips, P. C. B., Schmidt, P., and Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root. *Journal of Econometrics, 54*(1–3), 159–178. https://doi.org/10.1016/0304-4076(92)90104-Y

Park, J. Y., and Shintani, M. (2016). Testing for a unit root against transitional autoregressive models. *International Economic Review, 57*(2), 635–664. https://doi.org/10.1111/iere.12170

Phillips, P. C. B., and Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika, 75*(2), 335–346. https://doi.org/10.1093/biomet/75.2.335

Sollis, R. (2009). A simple unit root test against asymmetric STAR nonlinearity with an application to real exchange rates in Nordic countries. *Economic Modelling, 26*(1), 118–125. https://doi.org/10.1016/j.econmod.2008.06.003

Zivot, E., Andrews, K. (1992). Further Evidence On The Great Crash, The Oil Price Shock, and The Unit Root Hypothesis. Journal of Business and Economic Statistics,10(3), 251–270.

Bibliometric Analysıs of Academic Studes on Health Expenditures

Sağlık Harcamaları Hakkında Yapılmış Akademik Çalışmaların Bibliyometrik Analizi

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Abstract

The aim of this study is to examine the academic studies on health expenditures by bibliometric analysis method and to provide information to researchers on the subject.

In this study, 40 publications on health expenditures in various scientific databases (dergipark, google scholar) between 2010 and 2024 were analyzed bibliometrically. The publications aim to reveal the research dynamics in the field of health expenditures by examining the most cited studies, most frequently used keywords, number of authors and collaboration networks.

According to the results of the study, research on health expenditures has increased significantly in recent years and various interdisciplinary approaches have been adopted. In particular, it has been observed that the cost of chronic diseases, the impact of aging population on health expenditures and the economic evaluation of health technologies have also attracted increasing attention, and health expenditures and access to health services in developing countries have also attracted increasing attention.

Keywords: Health, Health Expenditures, Health Economics and Bibliometric Analysis

Özet

Bu çalışmanın amacı, sağlık harcamaları ile ilgili yapılmış olan akademik çalışmaları bibliyometrik analiz yöntemiyle inceleyerek, araştırmacılara konu ile ilgili bilgiler sunmaktır. Çalışmada çeşitli bilimsel veri tabanlarında (dergipark, google scholar) yer alan, 2010-2024 yılları arasında sağlık harcamaları başlıklı çalışmaların bibliyometrik analiz yapılarak değerlendirilmesi amaçlanmıştır. Çalışma kapsamında başlığında sağlık harcamaları kelimesi bulunan 35 yayın tespit edilmiştir. Yayınlar; en çok atıf alan çalışmalar, en sık kullanılan anahtar kelimeler, yazar sayıları, unvanları ve çalışmanın dili gibi parametreleri inceleyerek sağlık harcamaları alanındaki araştırma dinamiklerini ortaya koymayı amaçlamaktadır. Araştırmanın sonuçlarına göre, çalışmaların hem bireysel hem de ortak işbirliği ile yapıldığı, sağlık harcamaları konusundaki araştırmaların son yıllarda önemli bir artış gösterdiği ve çeşitli disiplinler arası yaklaşımların benimsendiğini ortaya koymaktadır. Özellikle kronik hastalıkların maliyeti, yaşlanan nüfusun sağlık harcamaları üzerine etkisi ve sağlık teknolojilerinin ekonomik değerlendirilmesi konularının da giderek artan bir ilgi gördüğü ayrıca gelişmekte olan ülkelerdeki sağlık harcamaları ve sağlık hizmetlerine erişim konularının giderek artan bir ilgi gördüğü gözlemlenmiştir.

Anahtar Kelimeler: Sağlık, Sağlık Harcamaları, Sağlık Ekonomisi ve Bibliyometrik Analiz

GİRİŞ

Sağlık, sürdürülebilir kalkınmanın temel bileşenlerinden biri olarak, organizasyonel ve finansal bir sistemin desteğine ihtiyaç duyar. Bu sistemin yapı taşlarını oluşturan kurumlar sağlık sektörünü oluştururken, bu sektöre yönelik yapılan harcamalar sağlık harcamaları kavramı içinde değerlendirilmektedir.(Filiz Ersöz, 2008).

Sağlığı geliştirmek ve iyileştirmek için hammadde ve emek gibi kaynaklar etkili bir şekilde kullanılmalıdır. Etkili üretimin temel unsurlarından biri son yıllarda tüm ülkeler için önemli insan sermayesi birlikte, yatırımlarda insan sermayesini artıran faktörlerdeki değişim, devletin ana politikalarından biriydi. İnsan sermayesi kavramı geçmişten beri, özellikle 1980'lerden beri iş literatüründe kullanılır (F. Ersöz, 2008).

Sağlık harcamalarının önemi, aslında insan hayatına verilen değeri gösterir; sağlıklı olmayan bir bireyin ne çalışması, ne üretmesi, ne de hayattan tam olarak keyif alması mümkündür. Bu yüzden bireylerin ve devletlerin sağlık alanına yaptığı harcamalar bir lüks değil zorunluluktur Öte yandan sağlık harcamalarının ekonomi üzerine de etkileri çok büyüktür. Çünkü bir toplumda , hastalıkların görülme sıklığı yüksek ve tedavisiz oluşu nedeniyle iş gücü azalır, üretkenlik düşer,eğitim ve gelişim sekteye uğrar buda

doğrudan ekonomik büyümeyi etkiler.

Sağlık harcamaları, yalnızca ekonomik boyutuyla değil aynı zamanda insan neslinin geleceğini ilgilendiren yönüyle de stratejik öneme sahiptir. Kalkınmanın temel göstergelerinden biri olarak değerlendirilen sağlık harcamaları, ülkelerin gelişmişlik düzeyinden bağımsız olarak tüm toplumlar için kritik bir konumda yer almakta; her ülke, farklı düzeylerde sağlık sorunlarıyla mücadele etmek zorunda kalmaktadır(Öztürk & Uçan, 2017).

Sağlık harcamaları, ülkelerin sosyokültürel etmenleri ve ülkede uygulanan sağlık politikaları ile şekillenen değişkelerdir. Özellikle ikinci dünya savaşından sonra beşeri sermayenin öneminin artması, sağlık ve sağlık harcamalarına verilen önemi de artırmıştır. Ülkeler sosyal devlet anlayışı çerçevesinde vatandaşlarının sağlığını korumak ve geliştirmek için gerekli sağlık hizmetlerinin sunumu ve finansmanının sağlanması amacıyla kendi yönetim biçimlerine göre sağlık sistemlerini oluşturmuşlardır. Bu dönemde ulusal sağlık hizmetleri sağlık alanına büyük ölçüde kamusal nitelik kazandırmıştır(Yılmaz & Yentürk, 2015).

Bununla birlikte,son yıllarda küresel ölçekte yaşanan demografik dönüşümler,sağlık harcamalarının yapısını ve düzeyini doğrudan etkilemektedir. Özellikle yaşlı nüfus oranındaki artış, beraberinde kronik hastalıkların yaygınlaşmasını getirmekte ve sağlık sistemleri üzerinde ciddi bir mali yük oluşturmaktadır. Bu durum, yaşlanma ile sağlık harcamaları arasında güçlü bir korelasyon olduğunu göstermektedir. Yalçın Balçık ve Konca'nın (2021) panel veri analizi ile ortaya koydukları gibi, yaşlı nüfus oranındaki artışın sağlık harcamaları üzerinde istatistiksel olarak anlamlı ve pozitif bir etkisi bulunmaktadır. Bu bulgu sağlık politikalarının yaşlanan nüfusun ihtiyaçlarını göz önünde bulundurarak şekillendirmesinin gerekliliğine işaret etmektedir.

Bu bağlamda, sağlık harcamalarına yönelik akademik ilginin nasıl bir seyir izlediğini anlamak; bu alandaki bilimsel üretimin geleceği hakkında fikir verebilir.

YÖNTEM

Bibliyometri, bir araştırma alanına katkıda bulunan yazarları ve kurumları belirlemek, yaygın olarak atıfta bulunulan çalışmaları ve sıkça kullanılan anahtar kelimeleri göstermek ve belirli bir bilimsel araştırma alanındaki ülkeler, kurumlar ve yazarlar arasında iş birliğini kurmak gibi yayınların çeşitli özelliklerini ortaya çıkarabilen içerik analizi türüdür.

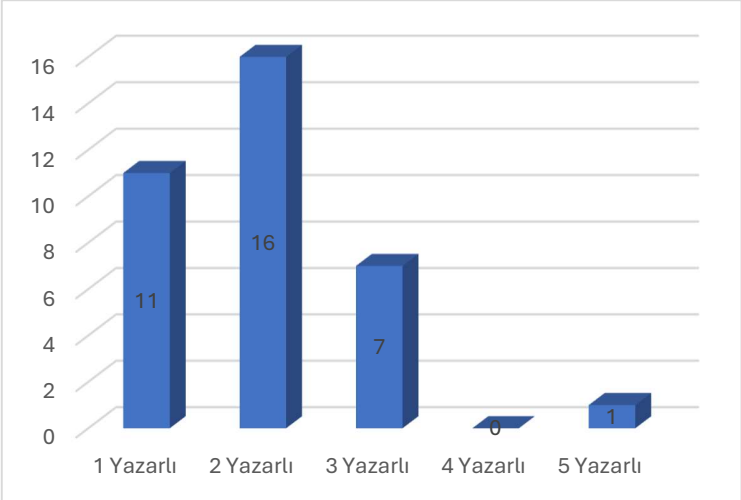
Bibliyometrik analiz, belirli bir alandaki yayınların sayısal veriler üzerinden değerlendirilmesini sağlayarak literatürdeki eğilimlerin, araştırma yoğunluklarının ve yazar profillerinin belirlenmesine olanak tanıyan sistematik bir yaklaşımdır.Bu yöntem, özellikle sınırlı sayıda çalışma üzerinden bilgi edinilmek istendiğinde, araştırmacıya disiplinin yapısını anlamada pratik bir çerçeve sunmaktadır.Literatürde de vurgulandığı üzere, bibliyometrik analiz, bilimsel yayınların niceliksel özelliklerini inceleyerek,araştırma alanlarının gelişimini ve eğilimlerini ortaya koymada etkili bir araçtır(Gülmez & Özteke & Gümüş,2020).

Bu çalışmada, Dergipark ve Google Scholar veri tabanlarında yer alan 2010-2024 yılları arasında yayımlanan, 'sağlık harcamaları' konusunu ele alan makalelerin taranması ile elde edilen 35 makale dikkate alınmıştır. Makaleler, yayın yılı, yazar sayısı, yazar ünvanı, çalışmanın dili,alıntılanma sayısı, anahtar kelimeler ve sırası gibi çeşitli parametrelere göre literatür incelenmiştir. Toplanan veriler, Microsoft excel programı aracılığıyla sistematik şekilde kodlanmış ve analiz edilmiştir,bulgular tablo ve grafiklerle desteklenerek sunulmuştur.

BULGULAR

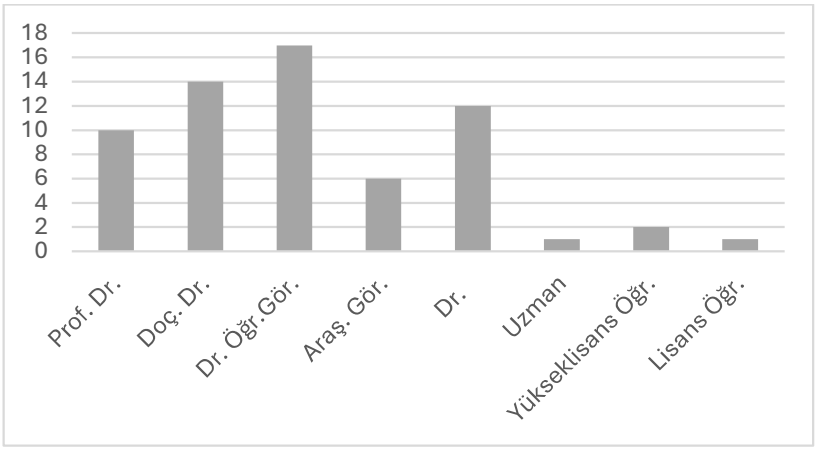
Çalışma kapsamında incelenen makalelerin yazar sayılarına göre dağılımı Grafik 1'de gösterilmektedir. Makaleleri yazar sayılarına göre incelediğimizde iki yazarlı makalelerin toplamı dikkate alındığında önemli bir oranı teşkil ettiği görülmektedir (16 adet). Aynı zamanda toplamda 35 adet yayında, bunların 11 adeti tek yazarlı olup, dikkat çeken durum ise iki yazar sonrası yayınlardaki düşüştür. Grafik 2'nin incelenmesinde araştırmacıların hem bireysel hem de ortak işbirliği alanlarında sağlık harcamaları konulu çalışmaları yaptıkları sonucuna varılabilir.

Grafik.1 Makalelerin Yazar Sayılarını Göre Dağılımı



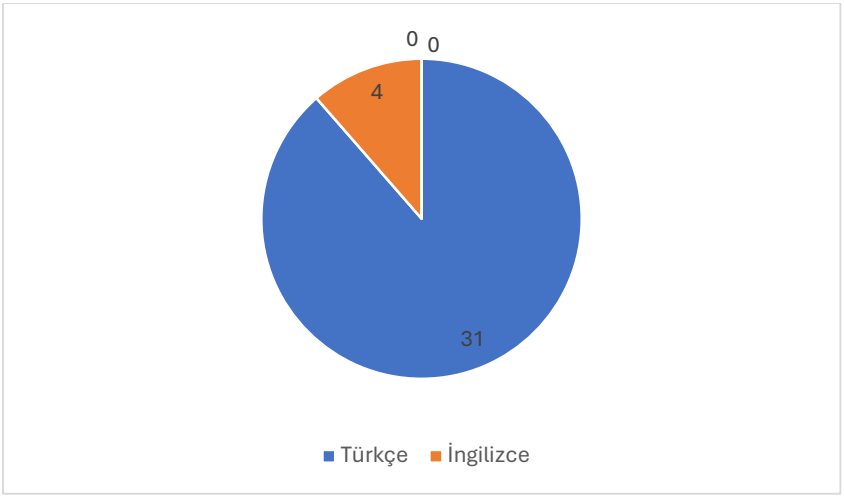
Sağlık harcamaları konulu çalışmaları incelediğimizde oluşan grafik.1'de makalelerin büyük çoğunluğu 2 yazarlı(16 adet), bunu tek yazarlı çalışmalar (11 adet) ile takip etmektedir.3 yazarlı makaleler ise 7 adet olarak tespit edilmiştir. Dört yazarlı makale tespit edilmemiş olup, beş yazarlı yalnızca bir çalışma yer almıştır. Araştırmacıların hem bireysel hem de ortak işbirliği içinde sağlık harcamaları konulu çalışma yaptıkları sonucuna varabiliriz.

Grafik.2 Yazarların Unvana Göre Dağılımı



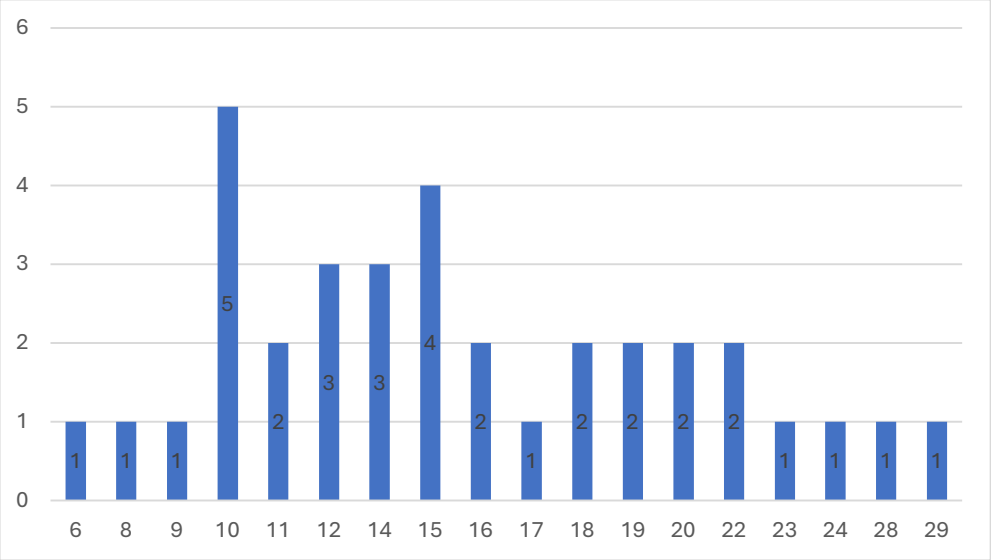
Bunlar içerisinde Doç. Dr., Dr. Öğr. Üyesi ve Dr. ünvanlarında belirgin bir yoğunluk yer almaktadır. Yine Prof.Dr. ünvanlı yazarların ve diğer tüm araştırmacıların Sağlık Harcamaları konulu çalışmalara ilgi gösterdiği ve bütün ünvanlar itibariyle ilgili çalışmaların araştırmacıların alanlarına göre yapıldığı değerlendirilebilir. Tüm araştırmacılar kendileri ile bireysel çalışma yaptıkları gibi ortak çalışmalar yapmaları da söz konusudur.

Grafik.3 Kullanılan Dile Göre Dağılım



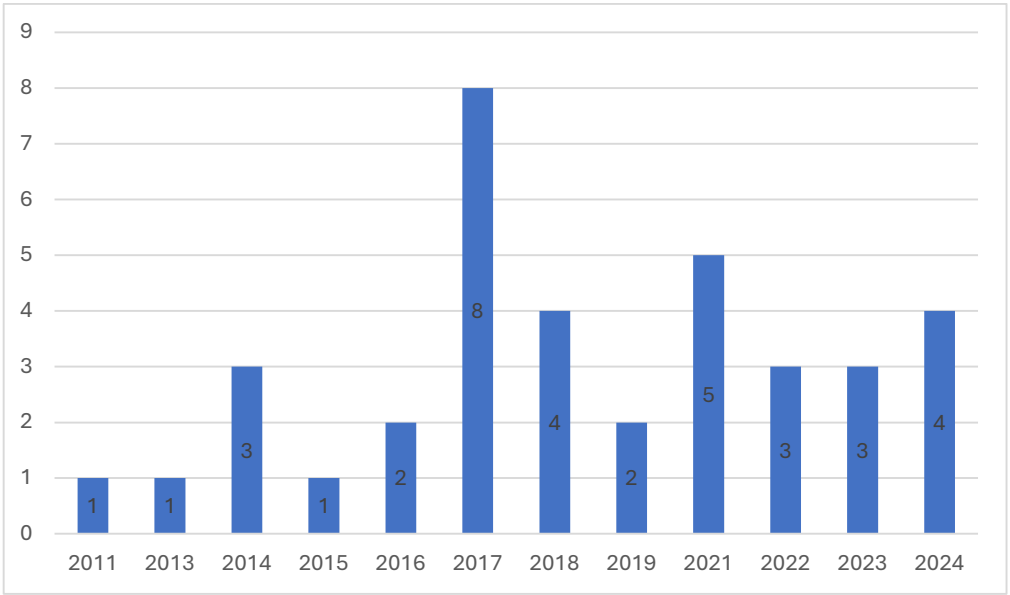
Araştırmacıların 31'i Türkçe dil kullanımını tercih ederken, 4 araştırmacının İngilizce çalışma yaptığı görülmektedir.

Grafik.4 Sayfa Sayısına Göre Dağılım



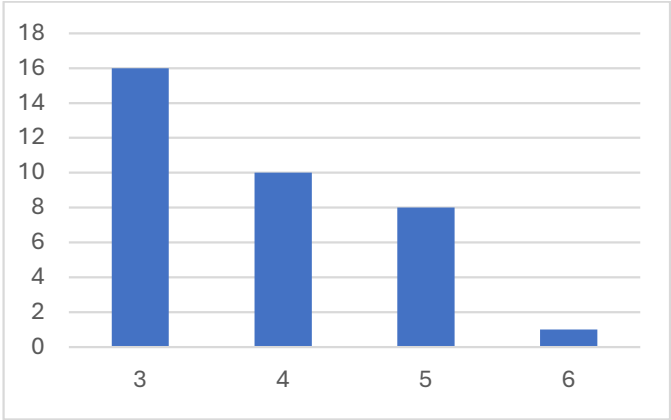
Yapılan çalışmalar sayfa sayıları itibarı ile değerlendirildiğinde araştırmacılar tarafından ortalama 10 ile 20 sayfa arasında araştırmaların daha fazla yer aldığı, 20 sayfadan fazla çalışmanın ise daha az yapıldığı değerlendirmesine ek olarak dergilerin makale kabul ve yazım kuralları çerçevesinde ortaya çıkmaktadır.

Grafik.5 Makalelerin Yıllara Göre Dağılımı



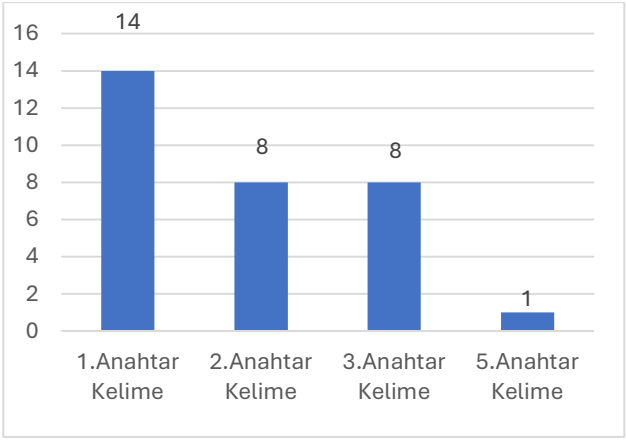
Yıllara göre dağılıma bakıldığında 2017 yılında en fazla çalışmanın yapıldığı, pandemi sürecine denk gelen yıllarda azaldığı ardından seyreden yıllarda ise tekrar sağlık harcamaları ile ilgili çalışmalara önem görüyoruz.

Grafik.6 Anahtar Kelime Sayısına Göre Dağılımı



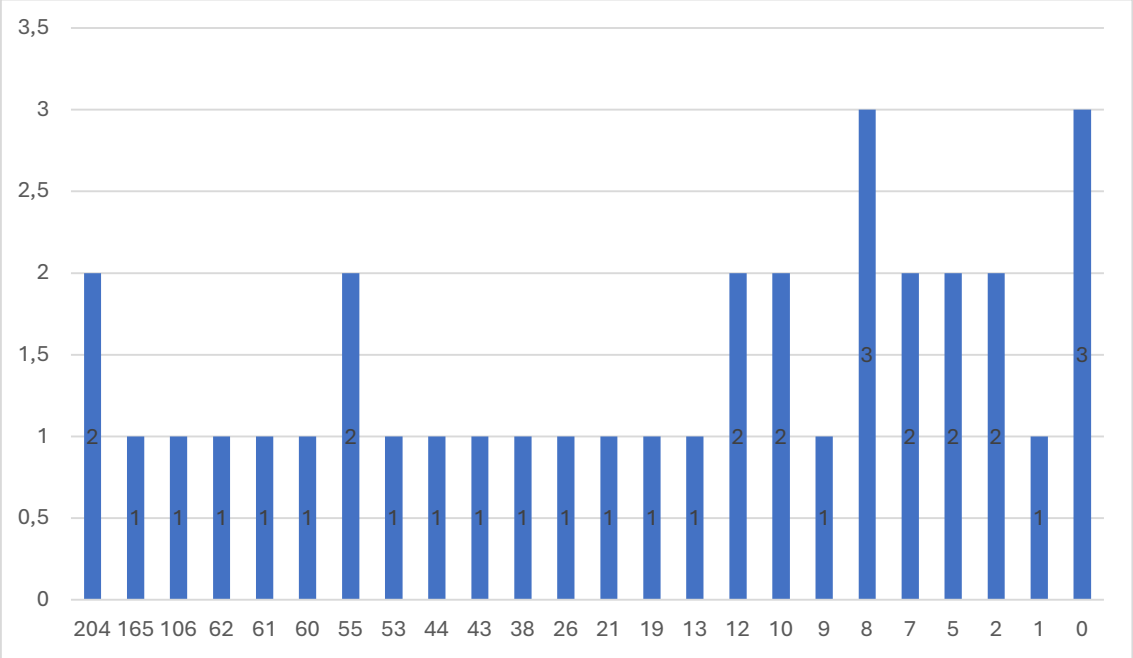
Kullanılan anahtar kelime sayısı çalışmanın içeriğine göre yahut araştırmanın gönderildiği derginin yayın politikasına göre farklılık gösterebilmektedir. Bu noktada 3 anahtar kelime kullanımı en fazla,4-5 anahtar kelime kullanımı nispeten daha az olup, 6 anahtar kelime kullanılan araştırma sayısı ise birdir.

Grafik.7 Sağlık Harcamaları Kelimesinin Anahtar Kelime Olarak Kullanılma Sayısına Göre Dağılımı



Sağlık harcamaları anahtar kelimesi 1.anahtar kelime olarak 14 çalışmada, 2. ve 3.anahtar kelime olarak ise 8'er çalışmada kullanılmıştır. Sadece bir çalışmada anahtar kelime olarak kullanılmış 4 çalışmada ise hiç kullanılmamış olarak tespit edilmiştir.

Grafik.8 Atıf Sayısına Göre Dağılımı



Grafikte, sağlık harcamaları konulu seçilmiş 35 akademik makalenin atıf sayılarına göre dağılımı yer almaktadır. Grafik incelendiğinde yayınların büyük çoğunluğunun atıf aldığı görülmektedir.

SONUÇ

Bu çalışma, 2010-2024 yılları arasında yayımlanmış sağlık harcamaları konulu 35 akademik makalenin bibliyometrik analizini sunmaktadır. Yapılan analizler neticesinde, söz konusu yayınların büyük çoğunluğunun birkaç yazarla işbirliğiyle yazıldığı, yazarların çoğunlukla akademik unvana sahip olduğu ve çalışmaların ağırlıklı olarak Türkçe dilinde kaleme alındığı tespit edilmiştir. Yıllara göre dağılım incelendiğinde sağlık harcamaları konusuna yönelik ilginin zamanla arttığı gözlemlenmiştir. Anahtar kelime analizinde 'sağlık harcamaları' teriminin sıklıkla tercih edilen ilk anahtar kelimelerden biri olduğu, ancak bazı çalışmalarda daha alt sıralarda yer aldığı görülmüştür. Bu durum, sağlık harcamaları konusunun yalnızca tek bir başlık altında toplanmadığını aksine çok boyutlu ve farklı bakış açılarıyla ele alınan geniş bir araştırma alanı olduğunu göstermektedir.Elde edilen veriler, seçilen 35 makalenin büyük çoğunluğunun azda olsa atıf aldığını göstermiştir.Bu durum akademik camiada yeterince ilgi görmediğinden değil, bu çalışmanın sınırlı sayıda yayınla gerçekleştirilmiş olmasından kaynaklanmaktadır.

Sağlık harcamaları, sadece ekonomik bir gösterge değil; aynı zamanda bir toplumun sağlık sistemine, vatandaşların yaşam kalitesine ve sürdürülebilir kalkınmasına yaptığı yatırımında bir ölçütüdür .Özellikle son yıllarda pandemi gibi küresel krizler,

yaşlanan nüfus, kronik hastalıkların artışı ve sağlık hizmetlerine erişimdeki eşitsizlikler gibi küresel sorunlar düşünüldüğünde, sağlık harcamaları üzerine yapılan çalışmaların ne kadar önemli olduğunu anlaşılmaktadır.

Bu yöntem ile, yeni araştırmacılara belirli bir araştırma alanının evrimi ve gelişim sınırları hakkında uygun bir genel bakış sağlayabilir. Sonuç olarak bu analiz bize sağlık harcamaları konusundaki yayınların akademik etki düzeyine dair sınırlı ama anlamlı bir ön değerlendirme sunmaktadır. Daha kapsamlı bir analiz için daha geniş bir yayın havuzuna ihtiyaç vardır.

KAYNAKÇA

Ersöz, F. (2008). Türkiye ile OECD ülkelerinin sağlık düzeyleri ve sağlık harcamalarının analizi. *İstatistikçiler Dergisi: İstatistik ve Aktüerya, 1*(2), 95-104.

Ersöz, F. (2008). Türkiye ile OECD ülkelerinin sağlık düzeyleri ve sağlık harcamalarının analizi. [Türkiye ile OECD ülkelerinin sağlık düzeyleri ve sağlık harcamalarının analizi]. *İstatistikçiler Dergisi:İstatistik ve Aktüerya, 1*(2), 95-104. Retrieved from https://dergipark.org.tr/tr/pub/jssa/issue/10038/123854

Öztürk, S., & Uçan, O. (2017). TÜRKİYE'DE SAĞLIK HARCAMALARINDA ARTIŞ NEDENLERİ: SAĞLIK HARCAMALARINDA ARTIŞ–BÜYÜME İLİŞKİSİ. *Süleyman Demirel Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 22*(1), 139-152.

Yılmaz, V., & Yentürk, N. (2015). Türkiye'de sağlık harcamalarına tarihsel bir bakış. *İstanbul Bilgi Üniversitesi Sivil Toplum Çalışmaları Merkezi, 2*.

Yalçın Balçık,P.,&Konca, M.(2021).Yaşlı Nüfus ile Sağlık Harcamaları Arasındaki İlişkinin İncelenmesi:Panel Veriye Dayalı Bir Uygulama.Iğdır Üniversitesi Sosyal Bilimler Dergisi,26,317-324.

Schneider, M. T., Chang, A. Y., Chapin, A., Chen, C. S., Crosby, S. W., Harle, A. C., ... & Dieleman, J. L. (2021). Health expenditures by services and providers for 195 countries, 2000–2017. *BMJ Global Health*, *6*(7), e005799.

Mchenga, M., Chirwa, G. C., & Chiwaula, L. S. (2017). Impoverishing effects of catastrophic health expenditures in Malawi. *International journal for equity in health*, *16*, 1-8.

Nghiem, S. H., & Connelly, L. B. (2017). Convergence and determinants of health expenditures in OECD countries. *Health economics review*, *7*, 1-11.

Güven, D., Şimşek, T., & Güven, A. (2018). Sağlık yönetimi kapsamında sağlık harcamalarının ekonomik büyüme üzerine etkisi: MENA ülkeleri üzerine bir panel regresyon analizi. *Sosyoekonomi*, *26*(37), 33-55.

Akar, S. (2014). Türkiye'de sağlık harcamaları, sağlık harcamalarının nisbi fiyatı ve ekonomik büyüme arasındaki ilişkinin incelenmesi. *Yönetim ve Ekonomi Dergisi*, *21*(1), 311-322.

AYAS, I. Türkiye'de Sağlık Harcamaları-Ekonomik Büyüme İlişkisi: Alan Taraması.

Tunçsiper, Ç., & Bakar, A. (2023). SAĞLIK EKONOMİSİ ÇERÇEVESİNDE SAĞLIK HARCAMALARI: TÜRKİYE ÖRNEĞİ. *Biga İktisadi ve İdari Bilimler Fakültesi Dergisi*, *4*(1), 20-28.

Orhaner, E. (2017). SAĞLIK HARCAMALARININ FİNANSMANINDA ÖZEL SAĞLIK SİGORTALARININ ROLÜ. *Uluslararası Sağlık Yönetimi ve Stratejileri Araştırma Dergisi*, *3*(3), 398-412.

Öztürk, S., & Uçan, O. (2017). TÜRKİYE'DE SAĞLIK HARCAMALARINDA ARTIŞ NEDENLERİ: SAĞLIK HARCAMALARINDA ARTIŞ–BÜYÜME İLİŞKİSİ. *Süleyman Demirel Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, *22*(1), 139-152.

Kurşun, A., & Rakıcı, C. (2014). Türkiye ve sosyal refah devletlerindeki sağlık harcamalarının analizi. *İnsan Hakları Yıllığı*, *32*, 77-105.

Acar, T., & Topdağ, D. (2022). OECD ülkelerinde sefalet endeksi ve ekonomik kalkınma ekseninde sağlık harcamalarının belirleyicileri: Toplamsal olmayan sabit etkili panel kantil regresyon yaklaşımı. In *Journal of Social Policy Conferences* (No. 82, pp. 267-286). Istanbul University.

Uyanık, Y., & Yüksel, A. (2017). Türkiye'de sağlık harcamalarının ekonomik büyümeye etkisi: bir meta-sentez çalışması. *Gazi Üniversitesi Sosyal Bilimler Dergisi*, *5*(12), 42-51.

Akıncı, A., & Tuncer, G. (2016). Türkiye'de Sağlik Harcamalari İle Ekonomik Büyüme Arasindaki İlişki. *Sayıştay Dergisi*, (102), 47-61.

Bozma, G., Başar, S., & Künü, S. (2016). Eğitim ve sağlık harcamalarının ekonomik büyüme üzerine etkisi: Türkiye üzerine bir uygulama. *Iğdır Üniversitesi Sosyal Bilimler Dergisi*, (10), 189-204.

Çalışkan, Ş., Karabacak, M., & Meçik, O. (2018). Türkiye'de uzun dönemde eğitim ve sağlık harcamaları ile ekonomik büyüme ilişkisi. *Dokuz Eylül Üniversitesi İktisadi İdari Bilimler Fakültesi Dergisi*, *33*(1), 75-96.

Hayaloğlu, P., & Bal, H. Ç. (2015). Üst orta gelirli ülkelerde sağlık harcamaları ve ekonomik büyüme ilişkisi. *İşletme ve İktisat Çalışmaları Dergisi*, *3*(2), 35-44.

SAYILI, U., Sayman, Ö. A., Vehid, S., & Köksal, S. S. (2017). Türkiye ve OECD ülkelerinin sağlık göstergeleri ve sağlık harcamalarının karşılaştırılması. *Online Türk Sağlık Bilimleri Dergisi*, *2*(3), 1-12.

Çelik, Y. (2011). Türkiye sağlık harcamalarının analizi ve sağlık harcama düzeyinin uygunluğunun değerlendirilmesi. *Sosyal Güvenlik Dergisi*, *1*(1).

Akar, S. (2014). Türkiye'de sağlık harcamaları, sağlık harcamalarının nisbi fiyatı ve ekonomik büyüme arasındaki ilişkinin incelenmesi. *Yönetim ve Ekonomi Dergisi*, *21*(1), 311-322.

Eryer, A. (2024). Yaşlı Nüfus ve Sağlık Harcamaları Arasındaki İlişkinin Belirlenmesi: Panel Veri Analizi. *Econder Uluslararası Akademik Dergi*, *8*(2), 192-209.

Sağır, M., & Kaplan, S. (2024). Türkiye'de Sağlık Harcamaları ile Ekonomik Büyüme İlişkisi. *İstanbul Gelişim Üniversitesi Sosyal Bilimler Dergisi*, *11*(1), 157-175.

Sever, Erşan & İğdeli, Arif. (2019). SAĞLIK HARCAMALARI, SAĞLIK ÇIKTILARI VE EKONOMİK BÜYÜME İLİŞKİSİ: TÜRKİYE ÖRNEĞİ. Akademik Araştırmalar ve Çalışmalar Dergisi (AKAD). 11. 246-259. 10.20990/kilisiibfakademik.533164.

Diğer, H. (2022). Sağlık Harcamaları Hakkında Yapılmış Akademik Çalışmaların Bibliyometrik Analizi. *Finans Ekonomi ve Sosyal Araştırmalar Dergisi*, *7*(4), 669-688.

Çetinkaya, Ş. (2023). TÜRKİYE'DE SAĞLIK HARCAMA VE YATIRIMLARININ MİLLİ GELİR İLE İLİŞKİSİ. *Dumlupınar Üniversitesi İİBF Dergisi*, (12), 177-190.

Bolukçu, F. (2019). Türkiye sosyal güvenlik harcamalarının kapsamı ve finansman yapısı. *Türkiye Sağlık Bilimleri ve Araştırmaları Dergisi*, *2*(2), 11-27.

Konca, M., & Balçık, P. Y. (2021). Yaşlı nüfus ile sağlık harcamaları arasındaki ilişkinin incelenmesi: Panel veriye dayalı bir uygulama. *Iğdır Üniversitesi Sosyal Bilimler Dergisi*, (26), 314-324.

Bölükbaşı, N., Işık, H., & Söyler, S. (2021). SAĞLIK HARCAMALARI VE İLAÇ HARCAMALARI İLİŞKİSİ: TÜRKİYE VE OECD ÜLKELERİ AÇISINDAN BİR KARŞILAŞTIRMA. *Uluslararası Sağlık Yönetimi ve Stratejileri Araştırma Dergisi*, *7*(1), 47-56.

Hayran, O. (2019). Koruyucu hizmetler sağlık harcamalarını azaltabilir mi?. *Journal of Biotechnology and Strategic Health Research*, *3*(3), 170-175.

Manavgat, G., Daştan, İ., & Abbasi, A. (2021). COVID-19 pandemisinin Türkiye'de hanehalkı yoksulluğu, sağlık harcamaları ve sağlıkta finansal koruma üzerindeki olası etkileri. *Eurasian Journal of Health Technology Assessment*, *5*(1), 27-44.

Kenanoğlu, M. E., & Aydın, M. (2022). Cepten yapılan sağlık harcamaları ile yoksulluk ilişkisi üzerine bir değerlendirme. *Uluslararası Sosyal Siyasal Ve Mali Araştırmalar Dergisi*, *2*(2), 80-101.

Piscopo, J., Groot, W., & Pavlova, M. (2024). Determinants of public health expenditure in the EU. *Plos one*, *19*(3), e0299359.

Iliman, T., & Tekeli, R. (2017). YAŞLILIK VE SAĞLIK HARCAMALARI ARASINDAKİ İLİŞKİ: LİTERATÜR TARAMASI. *Adnan Menderes Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *4*(4), 277-291.

Atılgan, D., & Günay, E. (2024). Yenilenebilir Enerji Tüketimi Sağlık Harcamaları Üzerinde Etkili Mi? AB Ülkeleri Örneği. *Hitit Sosyal Bilimler Dergisi*, *17*(1), 39-53.

Zeybek, D. Ö. (2021). Sağlıkta Dönüşüm sonrası sağlık harcamaları ve sağlık enflasyonu: Zaman serisi analizleri. *Süleyman Demirel Üniversitesi Vizyoner Dergisi*, *12*(32), 1078-1093.

Ağır, H., & Tıraş, H. H. (2018). Türkiye'de sağlık harcama türlerinin değerlendirilmesi. *Kahramanmaraş Sütçü İmam Üniversitesi Sosyal Bilimler Dergisi*, *15*(2), 643-670.

Gülmez, D., Özteke, İ., & Gümüş, S. (2020). Uluslararası dergilerde yayımlanan Türkiye kaynaklı eğitim araştırmalarının genel görünümü: Bibliyometrik analiz. *Eğitim ve Bilim*, *46*(206).

Bibliometric Analysis on the Concept of Financial Failure

Finansal Başarısızlık Üzerine Bibliyometrik Analiz

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Abstract

The state of failure can be defined as the inability of businesses operating at a certain level to maintain their operations and order, in short, their inability to fulfill previous obligations. Financial failure, on the other hand, refers to the inability to meet short-term debt obligations on time or the insufficiency of cash inflows to cover such debts. This study aims to explain the conceptual framework of the terms 'failure' and 'financial failure', addressing the emergence of the term financial failure as well as its internal and external causes. Within this context, a literature review was conducted and presented through the method of bibliometric analysis. Based on the concept of financial failure in various businesses and sectors, a bibliometric analysis was carried out on 30 studies that included the term "financial failure" and were published between 2014 and 2024 — the last ten years The articles were evaluated based on criteria such as the name of the journal in which the article was published, the year of publication, the number of authors, the authors' academic titles, the language of the study, the research method, the keywords, and their order. According to the findings, the years in which the concept of financial failure was studied more frequently, the order and frequency of its appearance as a keyword, and whether the studies were conducted collaboratively or individually were examined. The results indicate that studies on financial failure have increased in recent years. Most of the studies were conducted collaboratively, and the term "financial failure" generally appeared among the first two keywords.

Keywords: Failure, Financial Failure, Bibliometric Analysis

Özet

Başarısızlık durumu, belirli düzeyde iş yapan işletmelerin artık işleyişi, düzeni sağlayamama kısacası önceki yükümlülüklerini yerine getirememe durumu olarak da ifade edilebilir. Finansal başarısızlık ise kısa süre içerisinde ödenmesi gereken borç yükümlülüklerinin zamanında ödenememesi ya da elde edilen nakit gelirlerin borçları kapatmaya yetmemesi durumudur. Bu çalışmada, 'başarısızlık' ve 'finansal başarısızlık' kavramlarının kavramsal çerçevesini açıklayarak, finansal başarısızlık kelimesinin

ortaya çıkışına, finansal başarısızlıkların iç ve dış nedenlerine değinilmektir. Bu bağlamda literatür taraması yapılarak, yapılan literatür çalışması bibliyometrik analiz çalışması yöntemi ile aktarılmıştır. Çeşitli işletme ve sektörlerdeki finansal başarısızlık kavramı baz alınarak yapılan literatür taramasından 2014/ 2024 yılları arasında yani son 10 yılda finansal başarısızlık kelimesini baz alan 30 adet çalışma üzerinden bir bibliyometrik analiz çalışması yapılmıştır. Makaleler, makalenin yayınlandığı derginin adı, yayın yılı, yazar sayısı, yazar unvanı, çalışmanın dili, araştırma yöntemi, anahtar kelimeler ve sırası gibi kriterlere göre değerlendirilmiştir. Elde edilen bulgular doğrultusunda finansal başarısızlık kavramının hangi yıllarda daha çok çalışmaya konu olduğuna ve anahtar kelime olarak ne sıklıkla, hangi sırada olduğuna bakılarak, çalışmaların ortak mı bireysel olarak mı daha fazla yürütüldüğüne bakılmıştır.

Elde edilen sonuçlara göre finansal başarısızlık üzerine son yıllarda yapılan çalışmalar giderek artış göstermektedir. Çalışmalar genellikle ortak olarak yürütülmüş olup, finansal başarısızlık kavramı anahtar kelime olarak genellikle 1.ve 2.sıralarda yer almaktadır.

Anahtar Kelimeler: Başarısızlık, Finansal Başarısızlık, Bibliyometrik Analiz

GİRİŞ

Finansal başarısızlık kavramı ilk defa, uluslararası derecelendirme kuruluşlarından biri olan Dun & Bradstreet tarafından tanımlanmıştır.

Başarısızlık işletmeler için olası bir durum olmakla beraber pek çok durumdan da bağımsız olarak gerçekleşmektedir. İşletmenin bulunduğu ülke ya da içinde bulunduğu sektör gibi durumlar başarısızlık oranındaki artışı ya da azalışı etkilemez. Başarısızlık durumu belirli düzeyde iş yapan işletmelerin artık işleyişi, düzeni sağlayamama kısacası eski yükümlülüklerini yerine getirememe durumu olarak da ifade edilebilir.

Finansal başarısızlık ise kısa süre içerisinde ödenmesi gereken borç yükümlülüklerinin zamanında ödenememesi ya da elde edilen nakit gelirlerin borçları kapatmaya yetmemesi durumudur. Bir diğer ifadeyle beklenen karın beklentinin altında kalması durumudur. Bu duruma göre işletmelerin vadesi gelmiş yükümlülüklerini yerine getirememesi durumu, işletmenin teknik likiditesini kaybetmesi olarak tanımlanmaktadır (Gönenli, 1994; 647). İşletmelerin artık tamamen borçlarını ödeyemeyecek, giderinin gelirini aştığı noktaya gelmesi durumu da iflas olarak adlandırılmaktadır. Finans teorisinde finansal başarısızlık her ne kadar iflas olarak adlandırılmış olsa da finansal başarısızlık kavramı daha geniş bir kavram olup işletmelerin yaşadığı küçük olumsuzluklardan iflasa kadar gerçekleşen tüm olumsuz aşamaları kapsamaktadır.

İflas kavramını da içerisine alan finansal başarısızlık kavramı; alacaklılara borçların ödenmemesi, tahvil faizlerinin ve anaparasının ödenmemesi, karşılıksız çek yazılması, firmaya kayyum atanması veya işletmenin üç yıl üst üste zarar etmesi şeklinde tanımlanmıştır (Aktaş, 1997; 6).

Finansal başarısızlıklar işletmenin sektör içerisindeki imajı açısından da oldukça olumsuz bir durumdur. İşletmenin itibarını zedeleyen bu durum iş birliği içerisinde olunan diğer işletmeler ile arasında güven sorunları yaşanmasına sebebiyet vermektedir.

Bütün başarısızlıklarda olduğu gibi finansal başarısızlıkları da tetikleyen ve etkileyen birçok etmen vardır. Bu etmenler işletmelerin faaliyet gösterdiği her alanda ve aşamada işletmeleri başarısızlığa sürükleyebilmektedir. Yazın incelendiğinde işletmelerin gerek kendinden kaynaklanan gerekse işletme dışı aktörlerin (ekonomik koşullar, rakipler, devlet vb.) uygulamaları sonucu finansal başarısızlıkla neticelenen faaliyetler içine girdikleri belirlenmiştir (Yücel, 2001).

Yani finansal başarısızlığı temel olarak etkileyen iki neden vardır. Bunlar işletme içi nedenler ve işletme dışı (çevresel) nedenler olarak adlandırılabilir.

İşletme içi nedenler; işletmenin kendi içerisinde gerçekleşmektedir. Firmaların finansal başarısızlıkları genellikle firma içi etmenlerden kaynaklanmaktadır. Bu konuda yapılan bir çalışmada işletmelerin başarısızlığını %60 oranında yönetim yetersizliği etkilemektedir (Çelik, 2010: 415). İşletmenin gerçekleştirilen pazarlama faaliyetlerindeki alınan yanlış kararlar, yönetim sürecinde verilen yanlış kararlar ve yanlış stratejiler ve finansal faaliyetlerin yönetim ve denetimindeki kullanılan yöntem ve kararlar işletmelerin finansal başarısızlığı da kaçınılmaz bir hale getirmektedir. Ayrıca çalışma sermayesi yetersizliği ve aşırı borçlanma da firma içi finansal başarısızlık nedenleri olarak görülmektedir (Selimoğlu ve Orhan, 2015: 26).

İşletmelerin finansal olarak yaşadığı başarısızlıklara işletmenin içerisindeki olumsuzlukların yanı sıra işletmenin dışında gerçekleşen yani çevresel etmenler de neden olabilmektedir. İşletme dışı nedenler işletmelerin elinde olmayan sebeplerden dolayı yani kontrolü dışında meydana gelmektedir. İşletme dışı nedenler işletmenin dış çevresinde yaşanan gelişmelere bağlı olarak ortaya çıkmaktadır. Ani sermaye hareketleri, faiz ve döviz kurlarındaki ani değişmeler, finansal krizler, enflasyon, küresel rekabet gibi etmenler işletme dışı finansal başarısızlığa neden olmaktadır (Taşpınar Cengiz vd., 2015: 66).

İşletmeler için büyük bir risk teşkil eden finansal başarısızlık, tahmin edilmesi zor olsa da finansal zararı en aza indirgemek için literatürde bazı tahmin modelleri geliştirilmiştir. Bu tahmin modellerinden en yaygın olanları şu şekildedir;

Oran Analizi (Rasyolar): Klasik yaklaşımdır. Karlılık, likidite, kaldıraç gibi finansal oranlar analiz edilir (Beaver, 1966; 71).

Altman Z-Score Modeli: Beş farklı finansal oran kullanılarak geliştirilen bu model iflas riskini tahmin etmede yaygın olarak kullanılır (Altman, 1968; 593).

Logit/Probit Modelleri: Olasılık temelli tahmin yöntemleridir (Ohlson, 1980; 111).

Makine Öğrenmesi / Yapay Zekâ: Karar ağaçları, yapay sinir ağları, destek vektör makineleri gibi algoritmalar son yıllarda sıkça kullanılmaktadır (Sun et al., 2014; 1643).

YÖNTEM

Bu çalışmada Finansal başarısızlık kavramını baz alan çalışmalar incelenerek bu bağlamda literatür taraması yapılarak, yapılan literatür çalışması bibliyometrik analiz çalışması yöntemi ile aktarılmıştır. Çeşitli işletme ve sektörlerdeki finansal başarısızlık kavramı baz alınarak yapılan literatür taramasından 2014/ 2024 yılları arasında yani son 10 yılda finansal başarısızlık kelimesini baz alan 30 adet çalışma üzerinden bir bibliyometrik analiz çalışması yapılmıştır. Makaleler, makale adı, yayın yılı, yazar sayısı, yazar unvanı, çalışmanın dili, araştırma yöntemi, anahtar kelimeler ve sırası gibi kriterlere göre değerlendirilmiştir. Elde edilen bulgular doğrultusunda finansal başarısızlık kavramının hangi yıllarda daha çok çalışmaya konu olduğuna ve anahtar kelime olarak ne sıklıkla, hangi sırada olduğuna bakılarak, çalışmaların ortak mı bireysel olarak mı daha fazla yürütüldüğüne bakılmıştır.

Bibliyometrik analiz, bilimsel çalışmaların sayısal olarak sunulan veriler aracılığıyla sistemli bir şekilde incelenmesini hedefleyen bir yöntemdir. Bu analiz biçimi temelde, bilimsel bilginin ortaya çıkışını, üretim sürecini, dağılımı ve etkisinin ölçülmesinde kullanılır. Bir başka deyişle bu analiz yöntemi tüm aşamaları kapsayan bir bütündür.

Literatür incelendiğinde Bibliyometrik konulu çalışmaların ilk olarak 1917 yılında Cole ve Eales tarafından 1550-1860 yılları arasını konu alan karşılaştırmalı anatomi alanındaki çalışmaların istatistiki bir analizinin yapılmasıyla ortaya konulduğu görülmektedir. Türkiye' de ise Özinönü tarafından 1970 yılında yayınlanan ve biyoloji, astronomi, kimya, fizik, matematik ve yer bilimleri alanlarındaki bilimsel verimliliği ölçen çalışma, bibliyometrik anlamda yapılan ilk çalışma olarak kabul edilmektedir (Hotamışlı & Erem, 2014: 3-5).

Yayın sayısı, atıf sayısı, yazar, dergi, kurum, ülke ve anahtar kelime analizleri gibi çeşitli ölçütlerle gerçekleştirilir. Bu sayede bir alandaki araştırma eğilimleri, iş birlikleri ve etkili yapılar ortaya konulabilir (Bayrak ve Söylemez, 2021: 182-204).

Bibliyometrik analiz belirli bir alandaki yapılan çalışmanın zaman içerisindeki gelişim sürecini inceleyerek, öne çıkan özelliklerini gözler önüne sermek için kullanılır. Çalışmaların performanslarının değerlendirilmesi açısından araştırmaların nicelik ve nitelik itibarı ile gelişiminin bilim dalları için önemli bir yere sahip olması bakımından bibliyometrik araştırmaları, bilimsel çalışmaların niceliksel ve niteliksel olarak değerlendirmesine olanak sağlamaktadır. (Yılmaz, 2017: 66).

Bibliyometrik analiz çalışmaları, yapılan bilimsel araştırma ve çalışmalarının değerlendirilmesi ve araştırma yöntem ve politikalarının şekillendirilmesi bakımında oldukça faydalı bir analiz yöntemidir.

BULGULAR

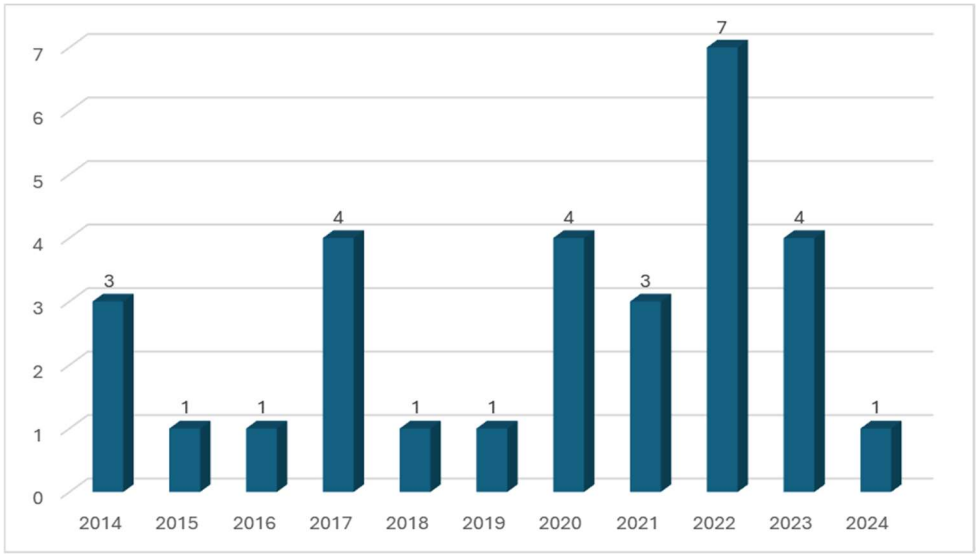
Bu çalışma da ele alınan ve çeşitli yönleri ile bibliyometrik analiz yöntemi uygulanan makalelerin yayınlandığı dergilerin isimleri Tablo 1' de yer almaktadır. Tablo 1 incelendiğinde Finansal başarısızlık kavramının gerek ulusal gerekse uluslararası alanda, birbirine bağlantılı ya da farklı sektörlerde çalışmalarda ele alındığını görülmektedir. Pek çok kamu ve özel sektörde yerli dergilerin yanı sıra uluslararası dergilerde de yayınlanan çalışmalar konun geniş bir alanda kendisine yer bulabildiğini kanıtlar niteliktedir.

Tablo 1. Makalelerin Yayınlandığı Dergiler

Dergi adı	Sayı
International Academic Journal [Econder]	1
Hacettepe Sağlık İdaresi Dergisi	1
Akademik Bakış Dergisi	2
MANAS Sosyal Araştırmalar Dergisi	1
Uluslararası Yönetim İktisat ve İşletme Dergisi	1
Abant Sosyal Bilimler Dergisi	1
Muhasebe ve Finansman Dergisi	2
Uluslararası Sağlık Yönetimi ve Stratejileri Araştırma Dergisi	1
Adıyaman Üniversitesi Sosyal Bilimler Enstitüsü Dergisi	1
Anatolia: Turizm Araştırmaları Dergisi	1
Finans Ekonomi ve Sosyal Araştırmalar Dergisi (FESA)	2
İstanbul Nişantaşı Üniversitesi Sosyal Bilimler Dergisi	1
Güncel Turizm Araştırmaları Dergisi	1
Alanya Akademik Bakış Dergisi	1
Journal Of Emergıng Economıes And Polıcy	1
VI. International Symposium on Accounting and Finance ISAF	1
Mali Çözüm Dergisi	1
Uluslararası Ekonomi ve Yenilik Dergisi	1
Journal of Forestry	1
Business and Economics Research Journal	1
Ömer Halisdemir Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi	1
Seyahat ve Otel İşletmeciliği Dergisi	1
Risk ve Finansal Yönetim Dergisi	1
İşletme Araştırmaları Dergisi	1
Indian Journal of Fundamental and Applied Life Sciences	1
E-Proceeding of Management	1

Aşağıda Grafik 1′ de rastgele seçme yöntemi elde ettiğimiz ve çalışmanın evrenini oluşturan 30 adet çalışmanın son 10 yıl içerisindeki dağılımının yıllar içerisindeki durumunu gösterilmektedir. Çeşitli aralıklarla artış ya da azalış gösteren grafikte son 10 yılda konu ile alakalı her yıl en az 1 çalışmanın yapıldığı görülmektedir. Konu ile alakalı yapılan çalışmada 2022 yılında bir artış meydana gelmektedir. Bunun sebebini ise Covıd-19 süreci ile ilişkilendirmek mümkündür.

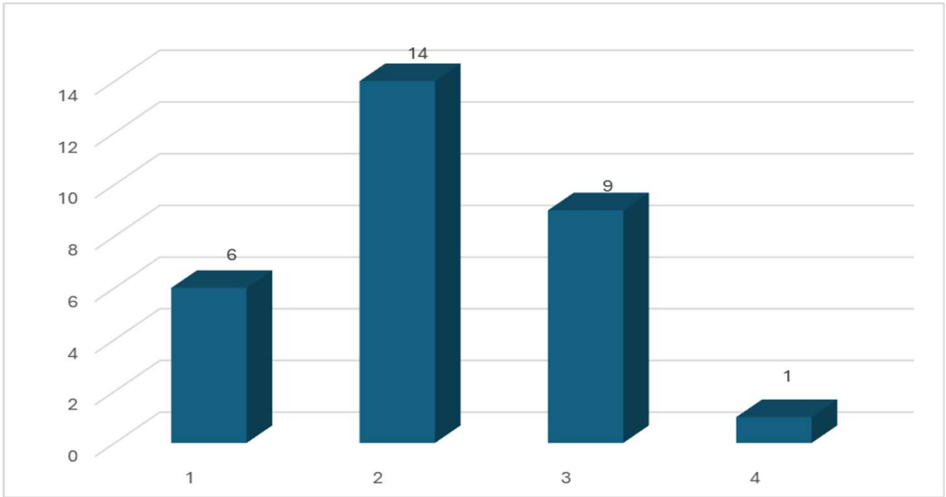
Grafik 1. Çalışmaların Yayınlandığı Yıllara Göre Dağılımı



Pandemi sürecinden etkilenen işletmelerin finansal başarısızlık oranları hızla yükselirken çalışmalara da bu durumun yansıdığı görülmektedir. 2019 pandemi süreci ile şirketler finansal başarısızlık sürecine girmiştir. Pandemi gibi ön görülemeyen durumlar pek çok şirketi finansal açıdan sarsıntıya uğratmıştır. 2020 itibarı ile konu üzerinde çalışmalar da sayı olarak artışa geçmiştir.

Aşağıda bulunan Grafik 2 çalışmaların yazar sayısına göre dağılımlarını göstermektedir. Grafik 2' ye bakıldığında çalışmaların genellikle çok yazarlı olarak yürütüldüğü görülmektedir.

Grafik 2. Çalışmaların Yazar Sayısına Göre Dağılımı

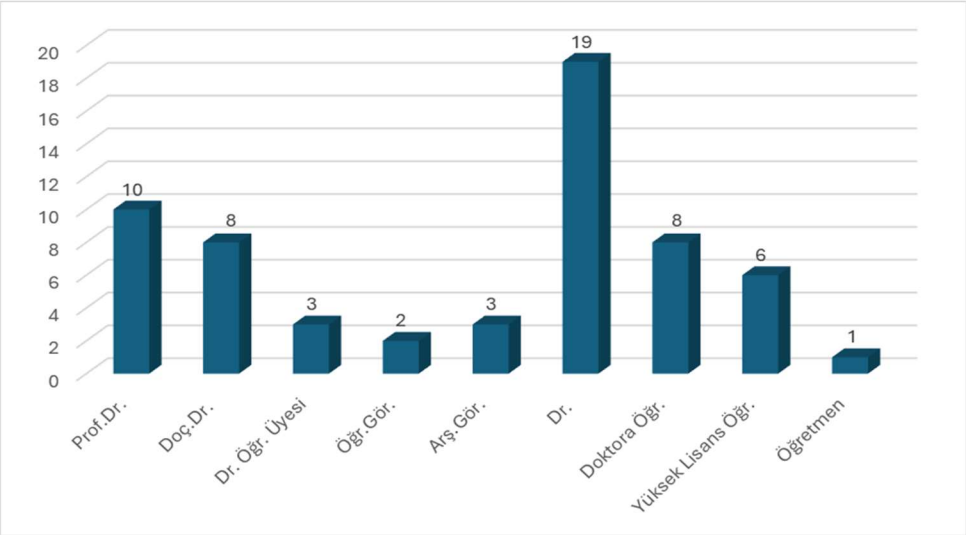


Grafiğe göre çoğunlukla 2 ya da 3 yazarlı olarak yürütülen çalışmalar genellikle 2 yazarlı olarak yürütülmesinin yanı sıra çalışmaların bireysel olarak da yapıldığı görülmektedir.

Grafiğe bakıldığında 4 yazarlı çalışmaların ise nerdeyse yok denecek kadar az olduğu görülmektedir.

Aşağıda yer alan Grafik 3 çalışmaları yürüten yazarların unvanlarının dağılımı hakkında bilgi vermektedir. Grafik' e göre araştırmacıların çoğunluğunu Dr. unvanlı araştırmacılar oluşturmaktadır. Dr. unvanlı kişilerin ardından Prof. Dr. unvanlı araştırmacıların da sayısının fazla olduğu görülmektedir.

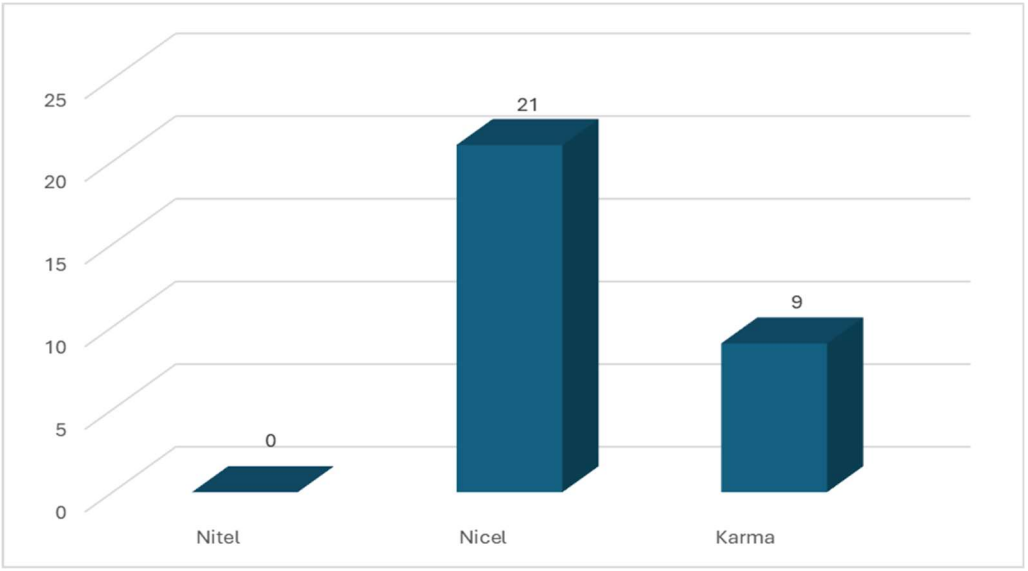
Grafik 3. Çalışmaların Yazar Unvanına Göre Dağılımı



Diğer unvanlara olan çalışma sayısı grafikte belirtilmiştir. Grafik 3'e göre birçok alandan ve unvandan çalışmalar yürüten araştırmacılar olduğu görülmektedir.

Çalışmalarda kullanılan çalışma yöntemi aşağıdaki Grafik 4. gösterilmiştir.

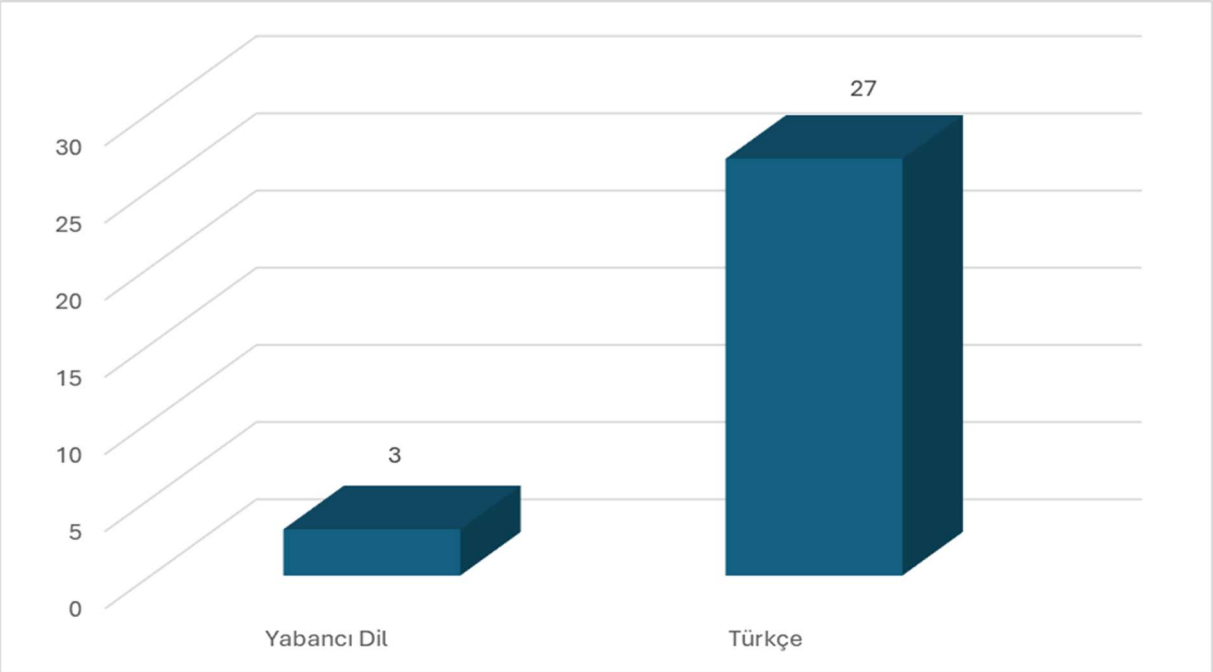
Grafik 4. Çalışmaların Yöntemlerine Göre Dağılımı



Grafik 4′ e bakıldığında çalışmaların büyük çoğunluğunu nicel çalışmaların aldığını görmek mümkündür. Araştırmacıların genellikle nicel araştırma yönteminin kullanılmasının sebebi finansal başarısızlık kavramının doğrudan finans ile ilişkili olmasından kaynaklıdır. Nicel çalışmalar sayısal bulguların elde edildiği çalışma yöntemidir. Dolayısıyla finansal bir konuda sayısal olmayan çalışmalara rastlamak pek mümkün değildir. Bunun için de çalışma evrenimizdeki çalışmalar da çoğunlukla nicel verilerden oluşmakla birlikte nitel ve nicel verilerin bir arada kullanıldığı karma yöntem olarak da görülmektedir.

Aşağıda bulunan Grafik 5′ te çalışmalarda araştırmacıların kullandığı dil dağılımı gösterilmektedir.

Grafik 5. Çalışmanın Kullanılan Yazım Diline Göre Dağılımı

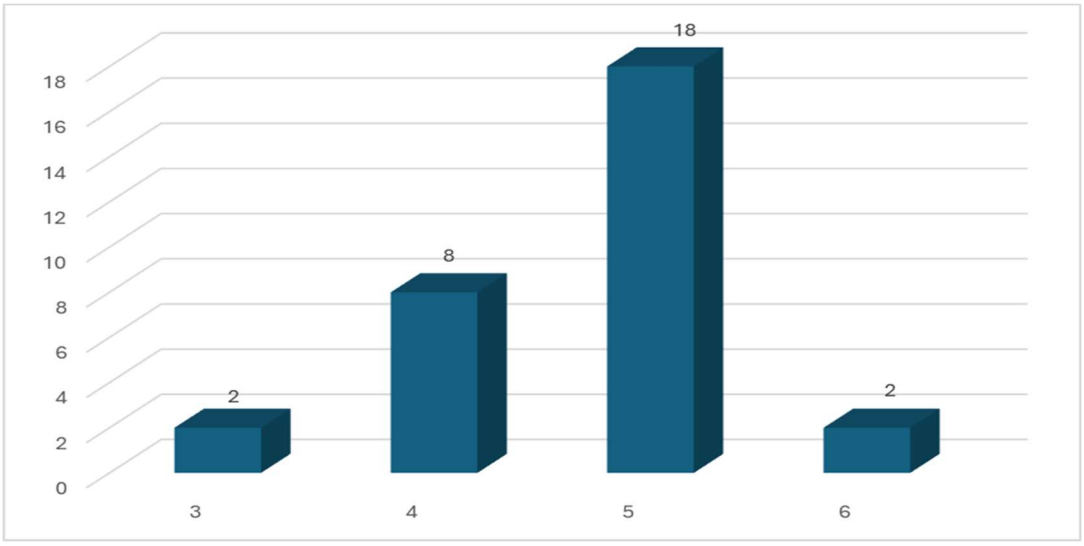


Grafik 5′e bakıldığında araştırmacıların genellikle Türkçe dilinin kullanıldığı yapılan 27 çalışmada yazım dili olarak Türkçeyi tercih ettikleri sadece 3 çalışmada çalışma dili olarak yabancı dillerin kullanıldığı görülmektedir.

Aşağıda yer alan Grafik 6′ da çalışmalarda kullanılan anahtar kelime sayıları yer almaktadır.

Araştırmacıların çalışmalarında genellikle anahtar kelime sayısı olarak 5 kelimelik tercihlerde bulunduğu görülmektedir.

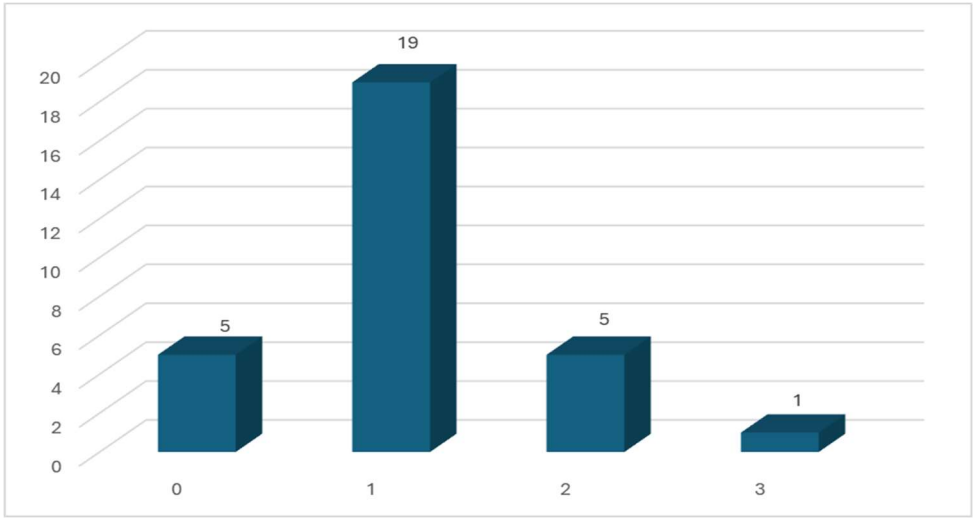
Grafik 6. Çalışmada Kullanılan Anahtar Kelime Sayısına Göre Dağılımı



Çalışmalarda genellikle 5 kelimelik anahtar kelime tercihinin yanın sıra araştırmacıların 4 kelimelik tercihlerde de bulundukları görülmektedir. Grafik 6' a göre 3 kelimelik anahtar kelime kullanımı ve 6 kelimeden oluşan anahtar kelime kullanımı çok tercih edilmeyen anahtar kelime kullanım sayıları olduğu söylenebilir.

Aşağıdaki bulunan Grafik 7' de araştırmacıların çalışmalarında kullandığı anahtar kelimelerin içerisindeki finansal başarısızlık kavramının anahtar kelime sırasında kaçıncı sırada yer aldığını göstermektedir.

Grafik 7. Finansal Başarısızlık Kelimesinin Anahtar Kelime Olarak Kullanılma Sırası



Bu grafiğe göre araştırmacıların finansal başarısızlık kavramına genellikle 1. sırada yer verdiği görülmektedir. Bunun sebebi olarak araştırmacıların genel olarak çalıştıkları konuya göre sıralama belirliyor olmaları gösterilebilir.

Bu grafiğe göre yaygın olarak 1. sırada yer alan finansal başarısızlık kavramı bazı çalışmalarda finansal başarısızlık üzerine araştırmalar yapılmasına rağmen anahtar kelimeler içerisinde yer almamıştır. Bunun sebebi olarak ise araştırmacının çalışmasındaki doğrudan amaç ya da çalışma konusunun finansal başarısızlık olmaması olarak gösterilebilmektedir.

SONUÇ

Finans sektörü için oldukça önemli bir yere sahip olan finansal başarısızlık kavramı son dönemlerde çalışmalara da sık sık konu olmakla birlikte literatürde de yer edinmektedir.

Finansal başarısızlık kısaca finansal yükümlülüklerine yerine getiremeyen işletmeler için kaçınılmaz bir sondur. İşletmelerin içerisindeki yaşanan küçük olumsuzluklardan iflasa kadar geçen bütün süreci kapsayan finansal başarısızlık süreci işletme dışarısında meydana gelen yani çevresel olan müdahalesi mümkün olmayan olayları da kapsamaktadır.

İşletmeler rekabet ortamı içerindeki konumunu korumak ve daha da büyük paylara sahip olabilmek için finansal başarısızlıklara karşı her zaman planlı ve hazırlıklı olmalıdır. Finansal başarısızlık risklerini uygun strateji ve yöntemlerle hesaplamalıdırlar.

İşletmeler tarafından finansal başarısızlıklar her zaman tahmin edilebilir olmasa da önlemler alarak, işletme içerisinde etkin stratejiler uygulayarak ve finansal başarısızlık risklerini göz önünde bulundurarak başarısızlıkların en aza indirilmesi hedeflenmektedir.

Finansal başarısızlıkları erkenden fark edip önlem alamayan işletmeler finansal olarak zorluklarla karşılaşabilmektedir. Ayrıca bu durum şirket içi çalışanları olumsuz etkileyeceği gibi ortaklalar arası güveni ve iş dünyasındaki konumuna da zedelemektedir.

Bu çalışmada finansal başarısızlık kavramını konu alan 30 adet çalışma çeşitli yönleri ele alınarak bibliyometrik analiz yöntemine göre incelenmiştir.

Çalışmaların yer aldığı dergiler analiz edilerek finansal başarısızlık kavramının pek çok sektörde gerek yerli dergilerde gerekse uluslararası dergilere konu olabileceği görülmüştü.

Bibliyometrik analiz yöntemine göre elde edilen 30 adet çalışmanı;

Çoğunun 2022 yılında yayınlandığı ve yıllara göre dağılımının değişkenlik gösterdiği tespit edilmiştir. 2017, 2020 ve 2023 yıllarında 4’ er çalışma yayınlanarak eşit bir dağılım gösterdiği görülmüştür.

Çalışmaların genellikle 2 kişi ile yürütüldüğü fakat 3 kişilik araştırma ekipleri ile de sıklıkla çalışmalar yapıldığı görülmüştür. Ayrıca bireysel olarak yapılan çalışmaların da mevcut olduğu görülmektedir.

Çalışmaları yürüten araştırmacıların büyük çoğunluğunu Dr. unvanlı araştırmacılar olduğu tespit edilmiştir. Prof. Dr. ve Doç. Dr. unvanlı araştırmacıların da sayıca fazla bulunduğu araştırmacıların içinde yüksek lisans öğrenciler, doktora öğrencileri ve öğretmenler gibi çeşitli unvanlardan araştırmacılar da bulunduğu

görülmüştür. Finansal başarısızlık kavramı pek çok unvandan kişinin araştırma konusu olabilecek türden bir kavram olduğunu göstermektedir.

İncelenen çalışmalarda yöntem olarak sayısal veri analizleri yapıldığı ve finansal bir konu olduğu için genellikle nicel yöntemler kullanıldığı tespit edilmiştir. Nitel verilere çok yer verilmese de nicel verilerle birlikte kullanılarak karma yöntem olarak çalışmalarda yer aldığı görülmektedir.

Araştırmacıların çalışmalarında çoğunlukla Türkçe dilini tercih ettiği yalnızca 3 adet çalışmanın dilinin yabancı dil olduğu tespit edilmiştir. Bu çalışmaya göre finansal başarısızlık kavramının Türkçe literatürde daha çok yer edindiği söylenebilmektedir.

Çalışmalarda kullanılan anahtar kelime sayısı genellikle 5 kelimelik anahtar kelime kullanımı olarak görülürken 4 kelimelik anahtar kelime kullanımı da yaygın olarak yer almıştır.

3 ve 6 kelimelik anahtar kelime kullanımına sahip ise 2'şer adet çalışma olduğu tespit edilmiştir.

İncelenen çalışmalar içerisinde anahtar kelimelerin içerisinde finansal başarısızlık kavramının kullanım sırasına bakıldığında ise çoğunlukla 1. sırada yer alan bu kavramın 2. ve 3. sıralarda da yer aldığı görülmüştür. Bazı çalışmalarda ise finansal başarısızlık kavramı incelenmesine rağmen anahtar kelime olarak yer verilmemiş olması yapılan çalışmaların doğrudan finansal başarısızlık kavramı ile ilgilenmiyor oluşu olarak değerlendirilebilir.

Bu çalışma sınırlı sayıda rastgele seçilen 2014/2024 arası yıllardaki yapılan 30 çalışmayı baz alarak yürütülmüştür. Çeşitli sınırlılıkları bulunması dolayısıyla araştırma kapsamına alınmayan çalışmalar bulunmaktadır. Yapılan incelemeler sonucu ulaşılan sonuçlar farklı çalışma evrenlerinde değişiklik gösterebilmektedir. Yapılan bu çalışma diğer evrenlerle sonuçları karşılaştırabilme olanağı sağlamaktadır. Araştırma sınırlılıkları değiştirilerek ya da genişletilerek çalışma yeniden yapılabilir ve bu çalışma ile kıyaslamalar yapılarak yeni tartışma konuları ve bulgular oluşturulabilir.

Ayrıca finansal başarısızlık kavramını konu alan çalışmalar arttırılarak literatür zenginleştirilebilir, artan çalışmalar sayesinde işletmeler daha kapsamlı bilgilere ulaşabilir ve bu doğrultuda stratejiler geliştirebilirler.

KAYNAKÇA

Aker, Y., Karavardar, A. (2022). Türkiye'deki Kobilerin Finansal Başarılı ve Başarısız Olma Durumlarının Altman, Springate ve Yapay Sinir Ağları Modeli ile Tahmin Edilebilirliği, Mali Çözüm Dergisi, 32, 151-169.

Akyüz, F. (2020). Taş ve Toprağa Dayalı Sektörde Faaliyet Gösteren Şirketlerin Finansal Başarısızlık Risklerinin Tahmin Edilmesi. Ömer Halisdemir Üniversitesi İİBF Dergisi, 13(1).

Akyüz, K. C., Yıldırım, İ., Akyüz, İ., Tugay, T. (2017). Borsa İstanbul'da İşlem Gören Kâğıt ve Kâğıt Ürünleri Sanayi İşletmelerinin Finansal Başarısızlık Düzeyleri. Düzce Üniversitesi Orman Fakültesi Dergisi, 13(1), 60-74.

Altman, E. I. (1968). Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. The Journal of Finance, 23(4), 589–609.

Arslan, M., Tutkavul, K. (2024). Yakın İzleme Pazarında İşletmelerin Finansal Başarısızlık Risklerinin Tahmini. MANAS Sosyal Araştırmalar Dergisi, 13(4), 1299-1319.

Arslantürk Çöllü, D., Akgün, L., Eyduran, E. (2019). Karar Ağacı Algoritmalarıyla Finansal Başarısızlık Tahmini. Uluslararası Ekonomi ve Yenilik Dergisi, 6(2), 225-246.

Ashraf, S., Félix, E. G. S., Serrasqueiro, Z. (2019). Do Traditional Financial Distress Models Predict Early Warning Signs? Journal of Risk and Financial Management, 12(2), 55.

Bağcı, H., Sağlam, Ş. (2020). Sağlık ve Spor Kuruluşlarında Finansal Başarısızlık Tahmini. Hacettepe Sağlık İdaresi Dergisi, 23(1): 149-164.

Bayrak, T., Söylemez, M. (2021). Yönetim ve Organizasyon Alanında Bibliyometrik Çalışmalar. Avrasya Sosyal ve Ekonomi Araştırmaları Dergisi, 8(5), 182-204.

Beaver, W. H. (1966). Financial Ratios as Predictors of Failure. Journal of Accounting Research, 4, 71–111.

Beyazgül, M., Öcek, C., Karadeniz, E. (2022). Ulaşım Sektöründe Covid-19'un Finansal Etkisi. Güncel Turizm Araştırmaları Dergisi, 6(1), 282-300.

Büyükarıkan, U., Büyükarıkan, U. (2014). Bilişim Sektöründe Finansal Başarısızlık. Akademik Bakış Dergisi, (46), 160-172.

Çam, İ. (2023). Kurumsal Sosyal Sorumluluk ve Finansal Başarısızlık. Abant Sosyal Bilimler Dergisi, 23(2), 923-938.

Çelik, M. K. (2010). Bankaların Finansal Başarısızlıklarının Öngörüsü. Celal Bayar Üniversitesi YED, 17(2), 129-143.

Civan, M., Dayı, F. (2014). Sağlık İşletmelerinde Finansal Başarısızlık Tahmini. Akademik Bakış Dergisi, (41).

Ekinci, G., Bakır, İ. (2021). Sağlık Kurumlarında Performans Analizi. Uluslararası Sağlık Yönetimi ve Stratejileri Araştırma Dergisi, 7(1), 1-18.

Fidan, M. E. (2021). Perakende Sektöründe Finansal Başarısızlık. VI. ISAF 2021 Sempozyumu, s. 229.

Gönenli, A. (1994). İşletmelerde Finansal Yönetim. İstanbul.

Hotamışlı, M., Erem, I. (2014). Bibliyometrik Analiz. Muhasebe ve Finansman Dergisi, (63), 1-19.

Karadeniz, E., Öcek, C. (2020). Finansal Başarısızlık Modellerinin Geçerliliği. Seyahat ve Otel İşletmeciliği Dergisi, 17(3), 394-406.

Kahraman, Y. E., Tepeli, Y. (2023). Yabancı Paranın Etkisi. JOEEP, 8(1), 316-324.

Kendirli, S., Çıtak, F. (2022). Altman Modeli ile Tahmin. Econder Dergisi, 6(1), 86-97.

Kulalı, İ. (2016). Altman Z-Score Uygulaması. Uluslararası Yönetim İktisat ve İşletme Dergisi, 12(27), 283-292.

Moghadas, H. B. A., Salami, E., Baradaran, H. (2014). Prediction in Tehran Stock Exchange. Indian J. of Fund. & App. Life Sci., 4, 200-207.

Ohlson, J. A. (1980). Financial Ratios and the Probabilistic Prediction. Journal of Accounting Research, 18(1), 109–131.

Öcek, C., Beyaz, F. S., Karadeniz, E. (2022). Restoran Zincirlerinin Riski. Anatolia: Turizm Araştırmaları Dergisi, 33(2), 65-76.

Öcek, C., Beyazgül, M., Karadeniz, E. (2023). Turizm Sektöründe Covid-19'un Etkisi. Alanya Akademik Bakış, 7(1), 169-186.

Öcek, C., Ünlübulduk, S. N., Karadeniz, E. (2021). Kurumsal Sosyal Sorumluluk ve Başarısızlık. Muhasebe ve Finansman Dergisi, (92), 21-46.

Selimoğlu, S., Orhan, A. (2015). Oran ve Diskriminant Analiziyle Ölçümleme. Muhasebe ve Finansman Dergisi, 66, 21-40.

Simanjuntak, C. E. B., Krist, F. T., Aminah, W. (2017). Pengaruh rasio keuangan terhadap financial distress. eProceedings of Management, 4(2).

Söylemez, Y., Türkmen, S. Y. (2017). Yapay Sinir Ağı ile Tahmin. Finans Ekonomi ve Sosyal Araştırmalar Dergisi, 2(4), 270-284.

Sun, J., Li, H., & Huang, Q. (2014). Predicting financial distress and corporate failure: A review from the state of the art definitions, modeling, sampling, and featuring techniques. Expert Systems with Applications, 41(1), 1639–1646.

Şahin, T., Özkan, N. (2022). Covid-19'un Otomotiv Sektörüne Etkisi. Finans Ekonomi ve Sosyal Araştırmalar Dergisi, 7(3), 516-527.

Taşpınar Cengiz, D., Turanlı, M., Bağdatlı Kalkan, S., Köse, İ. (2015). Faktör ve Diskriminant Analizi. İÜ Ekonometri ve İstatistik Dergisi, 23, 62-79.

Tekin, B., Gör, Y. (2022). Bankacılık Sektörü Uygulaması. Adıyaman Üniversitesi SBED, (40), 373-404.

Turaboğlu, T. T., Yıkılmaz Erko, A., Topaloğlu, E. E. (2017). Sermaye Yapısı ve Başarısızlık. Business and Economics Research Journal, 8(2), 247-258.

Türkcan, Z. (2018). AB Ülkelerinde Bankalarda Başarısızlık Tahmini. İşletme Araştırmaları Dergisi, 10(2), 554-569.

Ural, K., Gürarda, Ş., Önemli, M. B. (2015). Lojistik Regresyonla Tahminleme. Muhasebe ve Finansman Dergisi, (67), 85-100.

Yılmaz, G. (2017). Bahşiş Üzerine Bibliyometrik Analiz. Seyahat ve Otel İşletmeciliği Dergisi, 14(2), 65-79.

Yücel, T. (2001). Ekonomik Kriz Dönemlerinde Firma Davranışları. ODTÜ Ekonomi Kongresi V, Ankara.

Bibliometric Analysis on the Concept of Insurance and the Insurance Industry

Sigorta ve Sigortacılık Kavramı Üzerine Bibliyometrik Analiz

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Abstract

Insurance is a bilateral contract made to financially protect against risks. Insurance companies are the organizations that provide this protection and manage risks. The insurance sector is an important area where risks are shared to provide financial protection and support economic development. This study discusses the conceptual definition of insurance and the insurance industry, types of insurance, the historical development of insurance, the insurance sector and its structure in Turkey, the measures that need to be taken for its development, and current developments. In this context, literature related to insurance and the insurance industry is examined using bibliometric analysis. Bibliometric analysis is the quantitative examination of academic literature. A total of 27 articles published between 2010 and 2025, containing the word "insurance" in their title, were analyzed. The articles were evaluated based on their title, publication year, number of authors, author institutions, and keywords. The purpose of this study is to comprehensively examine the research conducted in the field of insurance, evaluate the current state and development of insurance in the literature. As a result of the study, it was observed that the number of insurance-related articles has increased after 2018, with studies being conducted both individually and through joint collaborations in various fields.

Keywords: Insurance, Industry, Insurance Sector, Bibliometric Analysis

Özet

Sigorta, riskleri finansal yönden koruma altına almak için iki taraflı yapılan bir sözleşmedir. Sigortacılık ise bu korumayı sağlayan ve riskleri yöneten kuruluşlardır. Sigorta sektörü, risklerin paylaşılarak finansal koruma sağlandığı ve ekonominin gelişimini destekleyen önemli bir alandır. Bu çalışmada, sigorta ve sigortacılığın kavramsal tanımı, sigorta türleri, sigortanın tarihsel gelişim, Türkiye'de sigorta sektörü ve yapısı, gelişimi için alınması gereken önlemler ve güncel gelişmeler ele alınmaktadır. Bu kapsamda, sigorta ve sigortacılığa ilişkin literatür, bibliyometrik analiz yöntemiyle incelenmektedir. Bibliyometrik analiz, akademik literatürün nicel bir şekilde incelenmesidir. Çalışma kapsamında 2010 -2025 yılları arasında yayınlanan ve başlığında sigorta kelimesi bulunan 27 makaleye ulaşılmıştır.

Makaleler, dergi adı, yayın yılı, yazar sayısı, yazar kurumu, yazar ünvanı, araştırma yöntemi, çalışmanın dili, anahtar kelimeler ve sırasına göre değerlendirilmiştir. Çalışmanın amacı ise sigorta alanındaki yapılan araştırmaların detaylı şekilde ele alınması, literatürdeki sigorta hakkında mevcut durum ve gelişim değerlendirmesi yapmaktır. Çalışmanın sonucu olarak sigorta konulu makalelerin sayısında 2018 yılından sonra yükselme olduğu, çalışmaların hem bireysel hem de ortak iş birliği ile farklı alanlarda yapıldığı görülmüştür.

Anahtar Kelime: Sigorta, Sigortacılık, Sigorta Sektörü, Bibliyometrik Analiz

GİRİŞ

Sigorta, yaşamda karşılaşılan belirsizliklere karşı koruma sağlamak amacıyla gelişmiş ve ekonomik olduğu kadar toplumsal açıdan da kritik bir sektör haline gelmiştir. Sigortacılık faaliyetleri, bireylerin ve kuruluşların karşı karşıya kalabileceği riskleri azaltmayı, beklenmedik kayıpları telafi etmeyi ve ekonomik dengeyi desteklemeyi hedefler. Bu alanda yapılan sözleşmeler, kişilere belirli risklere karşı koruma sunarak, yaşamın pek çok alanında güven duygusunu pekiştirir. Sigorta sektörü yalnızca bireyleri güvence altına almakla kalmaz, aynı zamanda ekonomik kalkınma süreçlerinde ve kriz anlarında önemli görevler üstlenir. Sigorta şirketleri; risk değerlendirmesi, prim hesaplama, poliçe oluşturma ve müşteri hizmetleri gibi çok yönlü alanlarda faaliyet gösterir. Bu makale, sigorta ve sigortacılıkla ilgili temel kavramları, sektördeki gelişmeleri ve gelecekteki eğilimleri incelemeyi amaçlamaktadır. Bu çalışmada ilk olarak sigorta ve sigortacılık kavramları detaylı bir şekilde ele alınacak, sigortanın türlerine değinilecek ve literatürde yer alan sigorta başlıklı çalışmalar bibliyometrik analiz ile incelenecektir. Öncelikle sigorta kavramının tanımlarına bakalım.

Tarihsel süreç içerisinde insanlar hem doğal afetler hem de toplumsal kaynaklı tehditlerle karşı karşıya kalmışlardır. Bu tür mevcut ya da muhtemel risklere karşı bireylerin kendilerini koruma ve güvence altına alma eğilimleri, sigorta kavramının ortaya çıkmasına zemin hazırlamıştır. Kelime anlamı itibarıyla güvenceyi ifade eden sigorta, yaşam süreci içerisinde ortaya çıkması kesin ya da muhtemel olan risklerin neden olabileceği ekonomik kayıpları hafifletmek amacıyla düzenlenen; sigortalı ile sigorta sağlayıcı yani sigortacı arasında yapılan hukuki bir sözleşme türü olarak tanımlanabilir.

Literatürde sigorta kavramına dair farklı tanımlar mevcuttur. Özüdoğru (2017:2), sigortayı "daha önceden varlığı bilinmeyen, fakat ortaya çıkma olasılığı bulunan tehlikelere karşı varlıkları ve kişileri, belli bir prim karşılığında güvence altına alan bir sistem" olarak tanımlamaktadır. Benzer şekilde Aydın (2005:66), sigortayı riskin ortaya çıkması hâlinde ekonomik zararın telafisini sağlayan bir araç olarak ifade eder. Kocayusufpaşaoğlu (1998:33) ise sigortayı hukuki bir sözleşme ilişkisi bağlamında ele alarak, rizikonun gerçekleşmesi durumunda sigortacının zararı karşılamayı taahhüt ettiği bir yapı olarak tanımlar.

Tanrıvermiş (2009:55-72), sigortayı sosyal ve ekonomik güvenliği sağlayan kurumsal bir sistem olarak değerlendirirken; Genç (2011:19), bu yapıyı risklerin mali sonuçlarını paylaşma esasına dayalı bir mekanizma olarak tanımlar. Ertürk (2004:25) ise sigortayı, bireylerin karşılaştıkları risklere karşı dayanışma esasına göre oluşturulmuş fonların yönetildiği bir yapı olarak sunar. Baysal (2010:7) da sigortayı, ekonomik tehditlere karşı bireylerin ve kurumların korunmasını sağlayan bir araç şeklinde açıklamaktadır.

Türkiye Sigorta ve Reasürans Şirketleri Birliği'nin (TSB), yapmış olduğu tanıma göre ise sigorta; "aynı türden tehlikeyle karşı karşıya olan kişilerin, belirli bir miktar para ödemesi

yoluyla toplanan tutarın, sadece o tehlikenin gerçekleşmesi sonucu fiilen zarara uğrayanların zararını karşılamada kullanıldığı, bir risk transfer sistemidir. Bu uygulama sayesinde kişiler, karşı karşıya bulundukları tehlikelerin neden olabileceği, parayla ölçülebilen zararlarını, nispeten küçük miktarlarda ödemiş oldukları primler yoluyla paylaşmaktadırlar" (TSB, 18.05.2020 tsb.org.tr).

Bu tanımlar ortak olarak, sigortanın temelde belirsizliklerin ekonomik etkilerini hafifletmeye yönelik bir güvence sistemi olduğunu ortaya koymaktadır.

İnsanlık, belirsizliklerle ve çeşitli risk unsurlarıyla çevrili bir dünyada yaşamını sürdürmektedir. Bu durum, bireylerin hem refah düzeylerini artırma hem de güvenliklerini sağlama amacıyla riskleri en aza indirme yönünde çeşitli stratejiler geliştirmelerine neden olmuştur. Sigorta sistemi ise tam da bu ihtiyaçtan doğmuş; risklerin meydana getireceği olası zararları önleme, azaltma ya da telafi etme amacıyla gelişim göstermiştir.

Toplumsal yapıdaki dönüşümler ve bireysel ihtiyaçların çeşitlenmesi, kamu politikalarının da değişmesine yol açmakta; bu durum sigorta hizmetlerinin kapsam ve tür bakımından çeşitlenmesini beraberinde getirmektedir. Literatürde sigorta türleri temelde **sosyal sigortalar** ve **özel sigortalar** olarak iki ana başlık altında ele alınmaktadır (Aydın, 2005:66).

Sosyal sigortalar, kamu otoriteleri tarafından yürütülen ve zorunlu katılım esasına dayanan sigorta sistemleridir. Bu sistemlerin temel amacı, bireylerin yaşamlarında karşılaşabilecekleri işsizlik, hastalık, yaşlılık ve ölüm gibi sosyal risklere karşı temel bir güvenlik ağı sunmaktır (Tanrıvermiş, 2009:55-72).

Özel sigortalar, bireylerin veya kurumların kendi inisiyatifleriyle dahil oldukları ve özel sigorta şirketleri tarafından sunulan isteğe bağlı sigorta hizmetlerini kapsar. Aydın'a (2005:66) göre, özel sigortalar ticari bir faaliyet niteliğinde olup piyasa mekanizmaları çerçevesinde işlem görür. Özel sigortalar ayrıca **hayat ve hayat dışı sigorta** olmak üzere iki alt başlık altında incelenmektedir

Hayat sigortaları, bireylerin yaşamlarıyla ilgili riskleri güvence altına almayı amaçlamaktadır. Ölüm, yaşlılık, hastalık gibi durumlar karşısında sigortalıya veya onun yakınlarına maddi güvence sağlar (Ertürk, 2004:48).

Hayat dışı sigortalar; yangın, deprem, trafik kazası, hırsızlık, tarım, nakliyat ve benzeri risklere karşı maddi varlıkların korunmasını amaçlar. Bu tür sigortalar, ölçülebilir ve belirli olasılıklarla sınıflandırılabilir risklere odaklanır (Genç, 2011:74).

Günümüzde toplumsal yaşamın temel yapı taşlarından biri haline gelen sigortacılık sektörü, ekonomik sistemin işleyişinde kritik bir rol oynamaktadır. Refah seviyesi yüksek ve ekonomik olarak gelişmiş ülkelerde sigortacılık faaliyetleri büyük ölçüde önem kazanmıştır. Buna karşın, gelişmekte olan ya da az gelişmiş ülkelerde karşılaşılan ekonomik sorunların temel nedenlerinden biri düşük tasarruf oranlarıdır. Bu tür ekonomilerde sürdürülebilir kalkınmanın sağlanabilmesi, mevcut tasarruf potansiyelinin ekonomiye kazandırılması ve üretken yatırımlara yönlendirilmesi ile mümkün olabilmektedir. Bu bağlamda sigorta sektörü, potansiyel tasarrufları reel tasarrufa dönüştürerek ekonomik büyümeye katkı sağlayan önemli bir araç olarak öne çıkmaktadır. Oluşturduğu fonlarla sigortacılık, özellikle gelişmekte olan ülkelerde kalkınmanın finansmanında stratejik bir kaynak niteliği taşımaktadır (Okunakul, 2005:94).

Sigorta sektörü, özellikle yüksek refah seviyesine sahip ve piyasa ekonomisinin hâkim olduğu ülkelerde, finansal sistemin en önemli iki unsurlarından biri olan bankalarla birlikte yer almaktadır. Türkiye'de genellikle yeterince tanınmasa da bazı Batı ülkelerinde sigorta şirketlerinin büyüklüğü o kadar fazladır ki, bu şirketler, gelirlerini değerlendirmek amacıyla

bünyelerinde bankalar kurabilmektedirler. Bu nedenle sigorta sektörü, her canlı ve büyüyen ekonominin vazgeçilmez sektörü haline gelmiştir. Başka bir deyişle, sigorta sektörü, gelişmiş ülkelerde ekonominin diğer faaliyet alanlarını etkileyen ve destekleyen önemli bir sektör olarak karşımıza çıkmaktadır.

Türkiye sigorta sektörü, ekonomik büyüme, finansal gelişim ve sosyal güvenlik sistemine katkı sağlama açısından önemli bir rol üstlenmektedir. Sektör, her geçen yıl büyüyerek ekonomik kalkınmaya hizmet etmekte ve toplumsal güvenliği sağlamaktadır. Yazıcıoğlu (2020:85), sigorta sektörünün Türkiye'nin finansal sisteminde her geçen yıl daha büyük bir yer tuttuğunu belirtirken, "Sigorta sektörü, finansal piyasalarda istikrar sağlayıcı ve sermaye birikimi yaratıcı işleviyle dikkat çekmektedir" ifadesine yer vermektedir.

Okunakul (2005:94), sektörü "Türkiye'deki sigorta sektörü, gelişen ekonomik yapı ile paralel olarak hizmet çeşitliliğini artırmış ve yerli sigorta ürünleriyle küresel piyasada rekabet edebilir hale gelmiştir" şeklinde tanımlamaktadır.

Türkiye sigorta sektörü, son yıllarda özellikle Bireysel Emeklilik Sistemi (BES) ile dikkat çekmektedir. 2017 yılında yürürlüğe giren otomatik katılım sistemi, Türkiye'deki tasarruf oranlarını artırmaya yönelik önemli bir adım olmuştur. Aydın ve Yılmaz (2019:78), bu düzenlemenin etkisini ele alırken "Otomatik katılım sistemi, bireylerin emeklilik dönemlerinde ek gelir sağlama fırsatı sunarken, aynı zamanda ülke ekonomisine de ciddi katkılar sağlamaktadır" şeklinde bir değerlendirmede bulunmaktadır.

LİTERATÜR ARAŞTIRMASI

Sigorta ve sigortacılık, ekonomik sistemin temel taşlarından biri olarak, bireylerin ve kurumların karşı karşıya kaldığı risklerin yönetilmesinde merkezi bir rol oynamaktadır. Bu alan, yalnızca finansal güvence sağlamakla kalmayıp aynı zamanda ekonomik kalkınmayı destekleyen önemli bir sektördür. Literatürde sigortacılıkla ilgili yapılan çalışmalar, sektörel gelişmeler, yapısal dönüşümler ve toplumsal etkiler açısından çeşitli bakış açıları sunmaktadır.

Son yıllarda yapılan araştırmalar, sigorta sektörünün ekonomik büyüme, tasarrufların artırılması ve finansal sistemin istikrarı üzerindeki etkilerini detaylı biçimde incelemiştir. Ayrıca, sektörde yaşanan dijital dönüşüm, müşteri odaklı hizmet anlayışı ve yeni ürün çeşitliliği de akademik çalışmaların odağında yer almaktadır.

Bu bölümde, sigorta ve sigortacılığa ilişkin literatürde yer alan bazı çalışmalara ve bulgularına yer verilmektedir.

Kamilçelebi (2012) Türkiye'de Sigorta Sektörünün SWOT Analizi çalışmasında, Türk sigorta sektörünün iç ve dış çevresinde karşılaşabileceği fırsatlar, üstünlükler, tehditler ve zayıflıkları ele almıştır. Sektörün güçlü yönleri arasında genç nüfus ve büyüme potansiyeli vurgulanırken, zayıf yönleri arasında sigorta bilincinin düşük olması ve yetersiz denetim mekanizmaları belirtilmiştir.

Kotan (2020) Sigortacılık Sektörünün Gelişimi ve Dijitalleşmesi Sürecinin SWOT Analizi çalışmasında, Türkiye'deki sigortacılık sektörünün dijitalleşme sürecinde karşılaşabileceği fırsatlar, üstünlükler, tehditler ve zayıflıkları analiz etmektedir. Dijitalleşmenin, sigorta şirketlerinin hizmet kalitesini artırma ve müşteri memnuniyetini sağlama açısından önemli fırsatlar sunduğu belirtilmiştir.

Yılmaz (2021) COVID-19'un Türk Sigorta Sektörüne Etkisi çalışmasında, COVID-19 pandemisinin Türk sigorta sektörü üzerindeki etkilerini incelemiştir. Pandemi sürecinde

sağlık sigortalarına olan talebin arttığı, ancak genel olarak sektörün büyüme hızında yavaşlama yaşandığı tespit edilmiştir.

Çelik & Yıldız (2021) Sigorta Sektöründe Regülasyonların Etkisi çalışmasında, Türkiye'deki sigorta sektöründe uygulanan regülasyonların sektörel gelişim üzerindeki etkilerini analiz etmektedir. Bulgular, düzenleyici çerçevenin sektörün büyümesi ve güvenilirliği açısından kritik olduğunu ortaya koymaktadır.

Pehlivan & Akpınar (2022) Türkiye'de Hayat Dışı Sigorta Şirketlerinin Performans Değerlendirmesi çalışmasında, Türkiye'de faaliyet gösteren hayat dışı sigorta şirketlerinin performansını TOPSIS ve Gri İlişkisel Analiz yöntemleriyle değerlendirmiştir. Analiz sonucunda, şirketlerin performanslarında önemli farklılıklar olduğu ve bazı şirketlerin sektörde öne çıktığı belirlenmiştir.

Kara & Özkan (2022) Sigorta Bilincinin Artırılmasında Eğitim Programlarının Rolü çalışmasında, Türkiye'de sigorta bilincinin artırılmasında eğitim programlarının etkisini değerlendirmektedir. Sonuçlar, eğitim programlarının sigorta farkındalığını ve katılımını artırmada etkili olduğunu göstermektedir.

Türkiye Sigortacılık Sektörü Ekonomik Etki Analizi (2022) çalışmasında, sigorta sektörünün Türkiye ekonomisine katkılarını analiz etmiştir. Sigorta sektörünün ekonomik büyümeye olumlu etkileri olduğu, ancak sigorta penetrasyonunun düşük seviyelerde kaldığı belirtilmiştir.

Türkeri (2023) Sigortacılık Sektöründe Başarı Kriteri Olarak Pozitif Psikolojik Sermaye çalışmasında, sigorta sektöründe çalışanların pozitif psikolojik sermaye düzeylerinin iş performansı üzerindeki etkisini incelemiştir. Sonuçlar, yüksek pozitif psikolojik sermayeye sahip çalışanların daha yüksek iş performansı sergilediğini göstermiştir.

Torusdağ, Tepeci & Metin (2023) İklim Değişikliğinin Sigorta Sektörü Üzerindeki Etkileri Türkiye Örneği çalışmasında, iklim değişikliğinin Türkiye'deki sigorta sektörü üzerindeki etkilerini analiz etmiştir. Artan doğal afetlerin, sigorta taleplerini ve risk yönetimi stratejilerini önemli ölçüde etkilediği belirtilmiştir

Yılmaz & Demir (2023) Sigorta Sektöründe Dijitalleşme ve Müşteri Deneyimi çalışmasında, Türkiye'deki sigorta sektöründe dijitalleşmenin müşteri deneyimi üzerindeki etkilerini incelemektedir. Araştırma, dijital platformların müşteri memnuniyeti ve sadakati üzerindeki olumlu etkilerini ortaya koymaktadır.

YÖNTEM

Bu çalışmanın amacı, yayımlanmış sigorta ve sigortacılık temalı akademik makalelerin bibliyometrik yöntemle analiz edilerek değerlendirilmesidir. Çalışmanın odağını ise "sigorta" ve "sigortacılık" temalı akademik yayınlar oluşturmaktadır. Çalışma kapsamında yalnızca son 15 yıllık dönemde yayımlanmış olan toplam 27 makale indirilmiş ve değerlendirmeye tabi tutulmuştur. İlgili makaleler; dergi adı, yayın yılı, yazar sayısı, yazarların kurumsal bağlılıkları, yazar ünvanı, çalışma dili, araştırma yöntemi, anahtar kelimeler ve sırası gibi çeşitli bibliyometrik kriterler doğrultusunda analiz edilmiştir.

Bibliyometrik analiz, bilimsel yayınların sayısal veriler aracılığıyla sistematik olarak incelenmesini amaçlayan bir araştırma yöntemidir. Bu yöntem, belirli bir alandaki akademik literatürün yapısını, eğilimlerini ve gelişimini değerlendirmek amacıyla kullanılır. Bibliyometrik analiz, genellikle makale sayısı, yazar sayısı, atıf sayısı, anahtar kelime sıklığı, yayımlandığı dergi, yayın dili ve yazarların kurumsal dağılımı gibi çeşitli parametreler

üzerinden gerçekleştirilerek, literatürün detaylıca incelenmesinde etkin bir yöntem olarak öne çıkmaktadır (Pritchard, 1969:348).

Bu yöntem, araştırma alanlarının zaman içindeki değişimini izleme, etkili yazarları, önemli dergileri ve iş birliklerini ortaya koyma açısından da oldukça işlevseldir. Böylece bilimsel üretimin haritası çıkarılarak, literatürdeki boşluklar ya da yoğunlaşan konular daha net bir şekilde analiz edilebilir.

Literatür incelendiğinde Bibliyometrik konulu çalışmaların ilk olarak 1917 yılında Cole ve Eales tarafından 1550 1860 yılları arasını konu alan karşılaştırmalı anatomi alanındaki çalışmaların istatistiki bir analizinin yapılmasıyla ortaya konulduğu görülmektedir. Türkiye' de ise Özinönü tarafından 1970 yılında yayınlanan ve biyoloji, astronomi, kimya, fizik, matematik ve yer bilimleri alanlarındaki bilimsel verimliliği ölçen çalışma, bibliyometrik anlamda yapılan ilk çalışma olarak kabul edilmektedir (Hotamışlı & Erem, 2014:3). Son yıllarda bibliyometrik analiz yöntemlerine duyulan ilginin artmasındaki başlıca etkenlerden biri, artan bilimsel üretimin sistematik olarak bibliyografik veri tabanlarında arşivlenmeye başlanmasıdır.

Günümüzde bibliyometrik analiz, bilimsel araştırmaların değerlendirilmesinde yaygın biçimde tercih edilen yöntemlerden biri haline gelmiş ve geniş veri tabanları aracılığıyla kaynakların kapsamlı biçimde incelenmesine olanak tanımıştır. Özellikle sosyal bilimler başta olmak üzere birçok disiplinde, bilimsel literatürün yapısını ve gelişim sürecini analiz etmek amacıyla bibliyometrik çalışmalara giderek daha fazla başvurulmaktadır.

BULGULAR

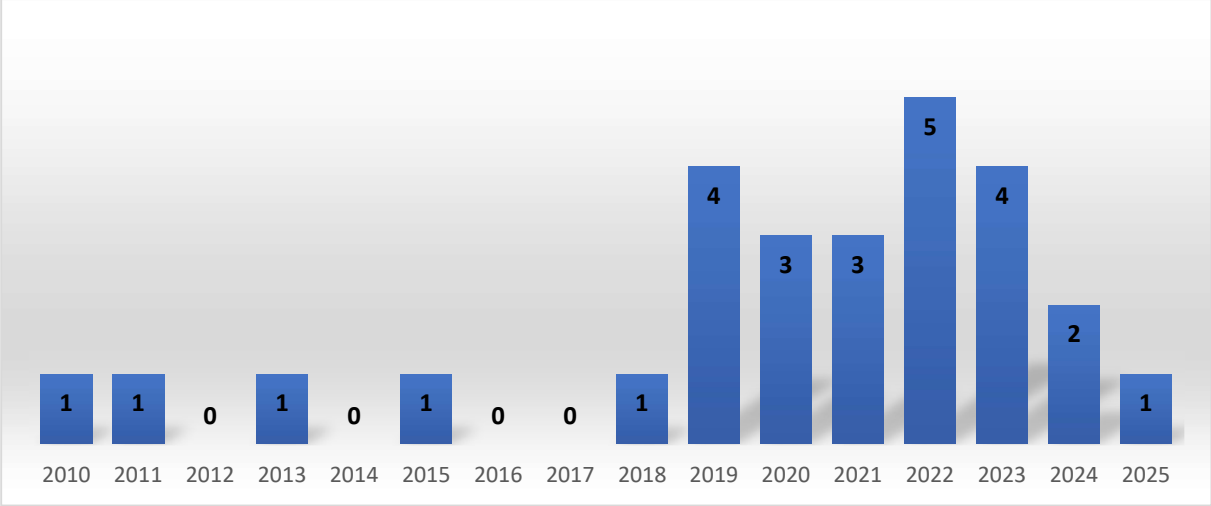
Çalışma kapsamında analiz edilen makalelerin yayımlandıkları dergilere ilişkin dağılım Tablo 1'de sunulmuştur. Tablo incelendiğinde, sigorta ve sigortacılık temalı çalışmaların kamu ve özel sektör tarafından yayımlanan, ulusal ve uluslararası ölçekteki farklı akademik dergilerde yer aldığı görülmektedir. Bu durum, konunun disiplinler arası bir ilgi gördüğünü ve farklı araştırma platformlarında ele alındığını ortaya koymaktadır.

Tablo 1. Makalelerin Yayınlandığı Dergiler

Dergi adı	Sayı
Anadolu Bil Meslek Yüksekokulu Dergisi	2
Marmara Üniversitesi İktisadi ve İdari Bilimler Dergisi	1
Finansal Araştırmalar ve Çalışmalar Dergisi	1
Afyon Kocatepe Üniversitesi Sosyal Bilimler Dergisi	1
Selçuk Üniversitesi Sosyal Bilimler Meslek Yüksekokulu Dergisi	1
Sosyal ve Beşerî Bilimler Dergisi	1
Yaşar Üniversitesi E-Dergisi	1
Düzce Üniversitesi Sosyal Bilimler Dergisi	1
Muhasebe ve Finansman Dergisi	1
JOEEP: Journal of Emerging Economies and Policy	1
Liberal Düşünce Dergisi	1
EKOIST Journal of Econometrics and Statistics	1
Uygulamalı Sosyal Bilimler ve Güzel Sanatlar Dergisi	1
Biruni Sağlık ve Eğitim Bilimleri Dergisi	1
Iğdır Üniversitesi Sosyal Bilimler Dergisi	1

Karatay Sosyal Araştırmalar Dergisi	1
İstanbul Kültür Üniversitesi	1
Kahramanmaraş Sütçü İmam Üniversitesi İİBF Dergisi	1
İşletme Araştırmaları Dergisi	1
Journal of Institute of Economic Development and Social Researches	1
Doğuş Üniversitesi Dergisi	1
Finans Ekonomi ve Sosyal Araştırmalar Dergisi	1
Manisa Celal Bayar Üniversitesi Sosyal Bilimler Dergisi	1
Bankacılık ve Sigortacılık Araştırmaları Dergisi	1
Türk Yönetim ve Ekonomi Araştırmaları Dergisi	1
MANAS Sosyal Araştırmalar Dergisi	1
Cumhuriyet Üniversitesi İktisadi ve İdari Bilimler Dergisi	1

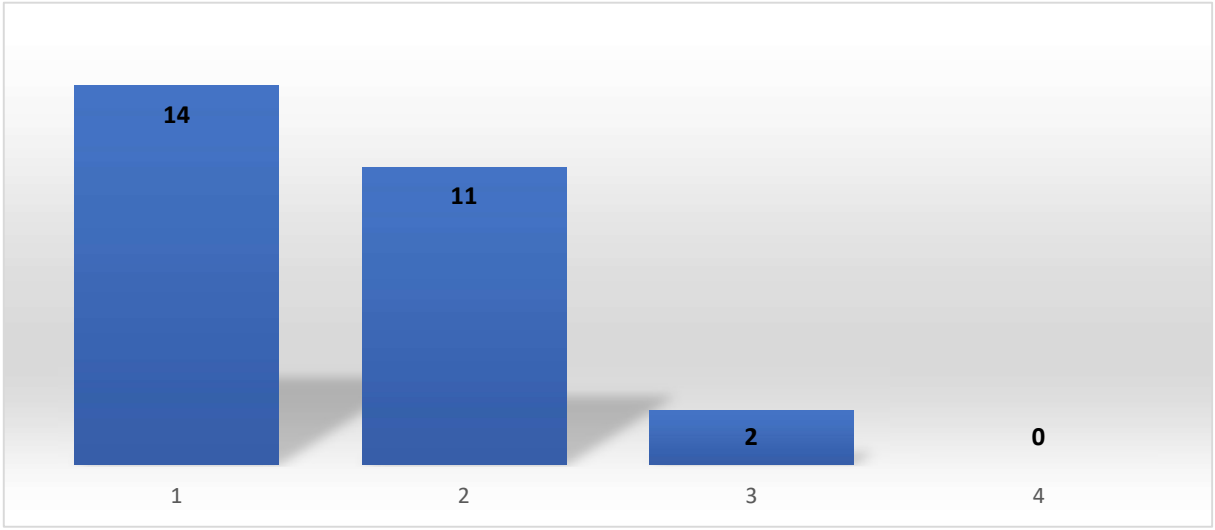
Grafik 1. Makalelerin Yıllara Göre Dağılımı



Yıllara göre yapılan inceleme sonucunda, sigorta ve sigortacılık temalı makalelerin en yoğun şekilde 2022 yılında yayımlandığı belirlenmiştir. Sigorta ve sigortacılık konulu çalışmalara odaklanıldığında ise, 2018 yılından itibaren bu alandaki yayın sayılarında dikkat çekici bir artış ve dalgalanma gözlemlenmektedir. Özellikle 2020 ve 2021 yıllarında bu artış eğrisinin yerini belirgin bir düşüşe bıraktığı görülmektedir. Grafik verileri incelendiğinde, 2022 yılı sonrasında ilgili alanda yayımlanan makale sayısında istikrarlı bir azalma eğilimi ortaya çıkmıştır. Bu gerileme, alandaki akademik dergi sayısının sınırlı olması ve mevcut yayın kapasitelerinin yetersizliğiyle açıklanabilir.

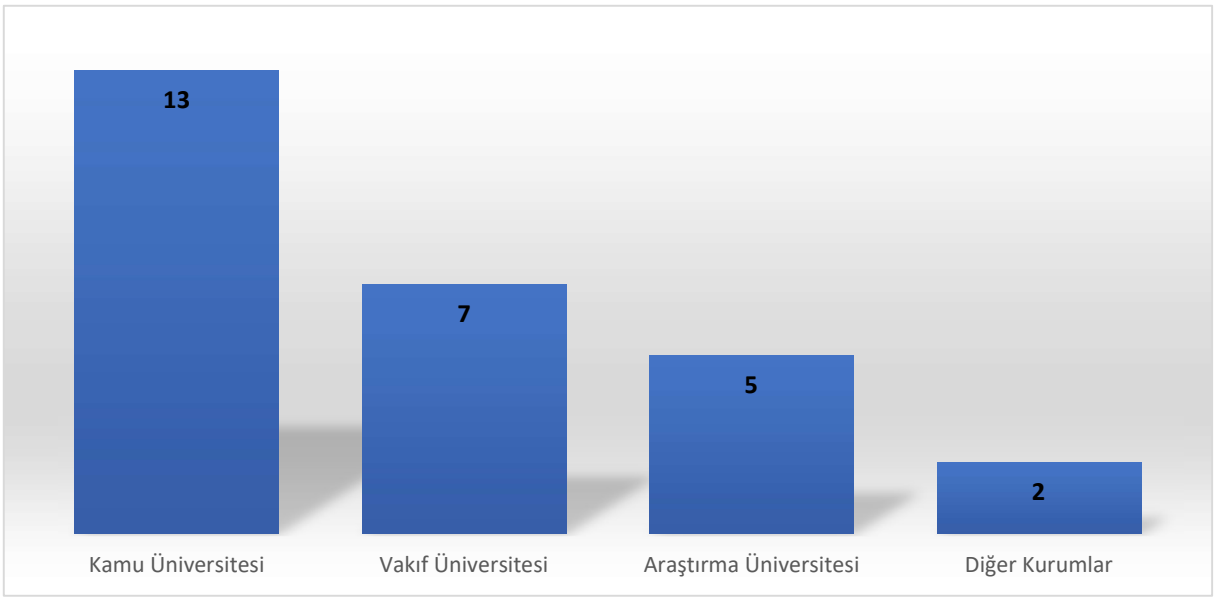
Özellikle 2019 yılı sonrasında ortaya çıkan COVID-19 pandemisi, yalnızca toplumsal yaşamı değil, aynı zamanda ekonomik yapıları ve risk yönetimi anlayışlarını da köklü şekilde etkilemiştir. Bu süreçte başta kamu sektörü olmak üzere birçok kurum ve kuruluş, sigorta sistemlerinin yeniden yapılandırılması, sağlık sigortalarının kapsamlarının genişletilmesi ve risk temelli poliçelerin yaygınlaştırılması yönünde adımlar atmıştır. Pandeminin yarattığı bu yeni ihtiyaçlar, akademik camiada da sigorta ve sigortacılık alanına yönelik araştırma ilgisinin artmasına zemin hazırlamış olabilir. Bu durum, literatürde söz konusu döneme ilişkin yapılan çalışmaların artış göstermesiyle desteklenmektedir.

Grafik 2. Yazarların Sayısına Göre Dağılımı



Makaleler yazar sayıları itibarı ile değerlendirildiğinde tek yazarlı ve çok yazarlı bir dağılım olduğu görülmektedir (Grafik 2). Bununla birlikte tek yazarlı makalelerin toplamı dikkate alındığında önemli bir oranı teşkil ettiği görülmektedir (14 adet). Aynı zamanda toplamda 13 adet yayın da bunların 11 adeti iki yazarlı, 2 adeti de çok yazarlı olarak ortaya konmuştur. Dikkat çeken durum iki yazar sonrası yayınlardaki düşüştür. Grafik 2'nin incelenmesinde araştırmacıların hem bireysel hem de ortak iş birliği alanlarında sigorta ve sigortacılık konulu çalışmaları yaptıkları sonucuna varılabilir.

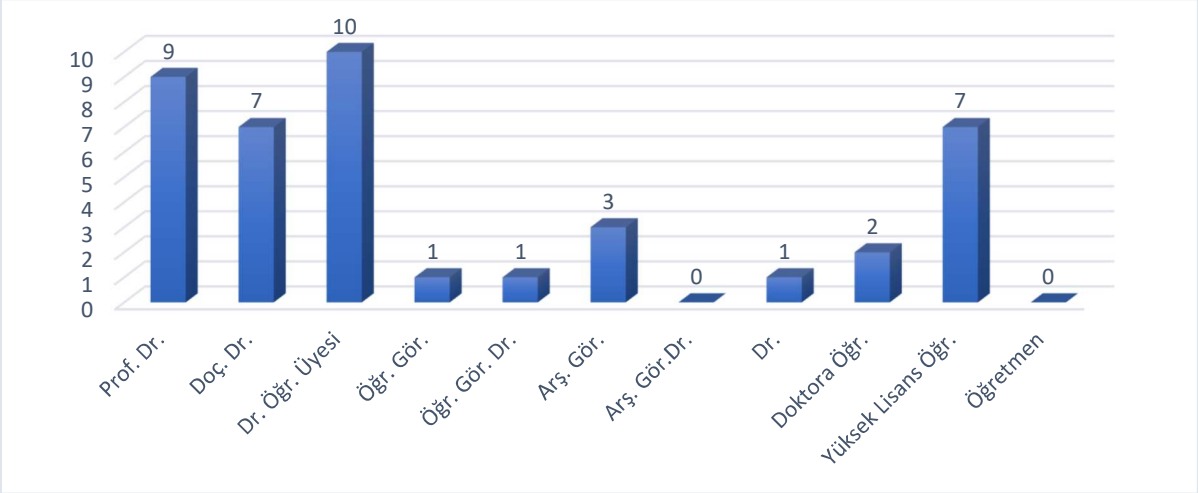
Grafik 3. Yazarların Kuruma Göre Dağılımı



Araştırmacıların kurumsal dağılımına bakıldığında, büyük çoğunluğunun kamu üniversitelerine bağlı kurumlarda görev yaptığı görülmektedir (Grafik 3). Bu kurumlar

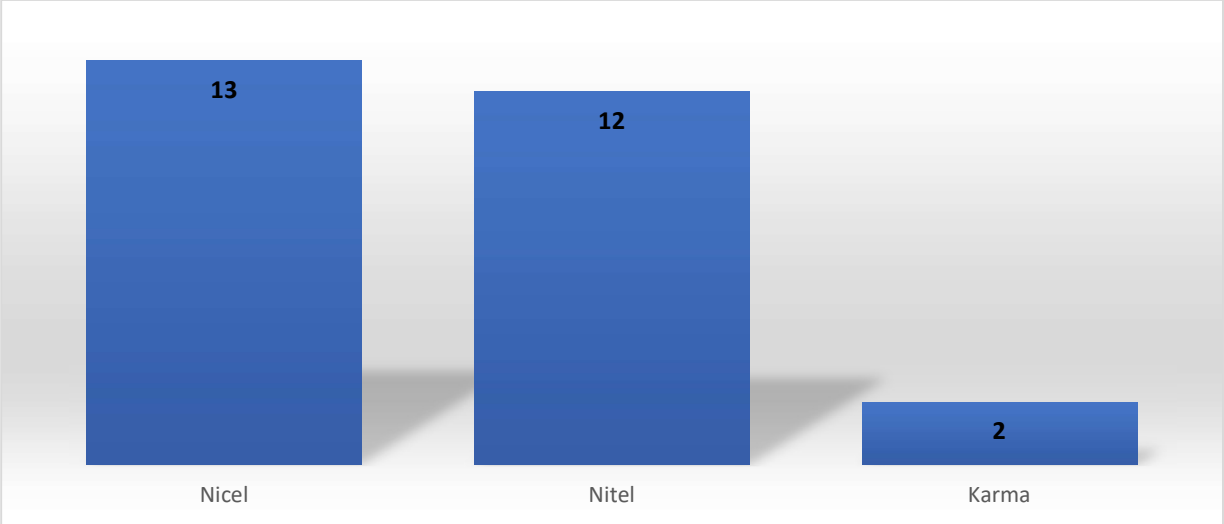
arasında yer alan 5 araştırma üniversitesi, sigorta ve sigortacılık alanındaki bilimsel üretimin önemli bir kısmını oluşturmaktadır. Ayrıca, 7 vakıf üniversitesinden ve 2 farklı kurumsal yapıdan gelen araştırmacıların da çalışmalara katkı sağladığı tespit edilmiştir. Bu durum, konunun akademik çevrelerde geniş bir ilgi alanı bulduğunu ve farklı kurumlardan araştırmacıların katkılarıyla disiplinler arası bir perspektif kazandığını göstermektedir.

Grafik 4. Yazarların Unvana Göre Dağılımı



Akademik unvanlar arasında, Prof. Dr. ve Dr. Öğr. Üyesi düzeyindeki akademisyenlerin sigorta ve sigortacılık alanındaki çalışmalarda belirgin bir yoğunluk sergilediği görülmektedir. Bu durum, alanın akademik derinliği ve uzmanlık gerektiren yapısıyla ilişkilendirilebilir. Ayrıca, öğretim üyeleri, öğretim elemanları ve diğer araştırmacıların hem bireysel hem de ortak çalışmalar yürüttükleri, bu iş birliklerinin disiplinler arası etkileşimi artırdığı ve araştırma kalitesini yükselttiği değerlendirilmektedir. Bu bağlamda, sigorta ve sigortacılık alanındaki akademik üretimin, farklı unvan düzeylerindeki araştırmacıların katkılarıyla zenginleştiği ve bu katkıların alanın gelişimine olumlu yansıdığı söylenebilir.

Grafik 5. Kullanılan Yönteme Göre Dağılım

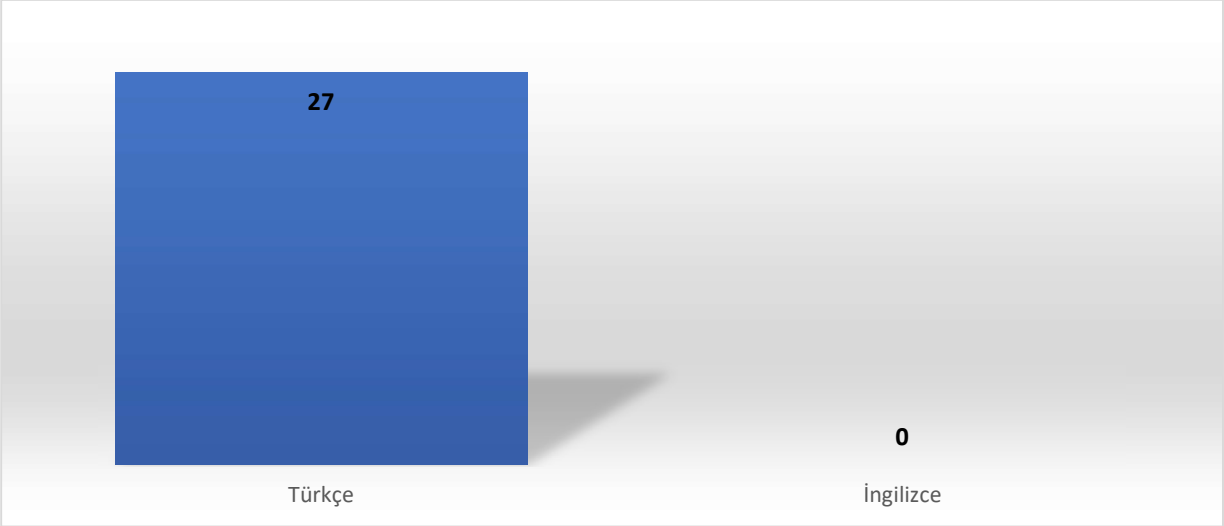


Yapılan araştırmalar incelendiğinde, sigorta ve sigortacılık alanında genellikle nicel, nitel ve karma yöntemler kullanılmaktadır. Çoğunlukla nicel yöntemlerin tercih edilmesi, bu alandaki araştırmaların sayısal verilerle kapsamlı analizler yapma imkânı sağlamasından kaynaklanmaktadır. Nicel yöntemler, sektörel performans analizi ve ekonomik etkilerin değerlendirilmesi gibi konularda objektif ve genellenebilir sonuçlar elde edilmesini mümkün kılar.

Öte yandan, nitel araştırmalar da önemli bir yer tutmaktadır. Sigorta sektörüne dair bazı çalışmalar, derinlemesine mülakatlar veya odak grup görüşmeleri gibi nitel veri toplama yöntemlerine başvurmuştur. Nitel yöntemler, sektördeki toplumsal ve psikolojik unsurları anlamak için kullanılır ve sayısal verilerin ötesine geçerek daha ayrıntılı analizler yapılmasına olanak tanır.

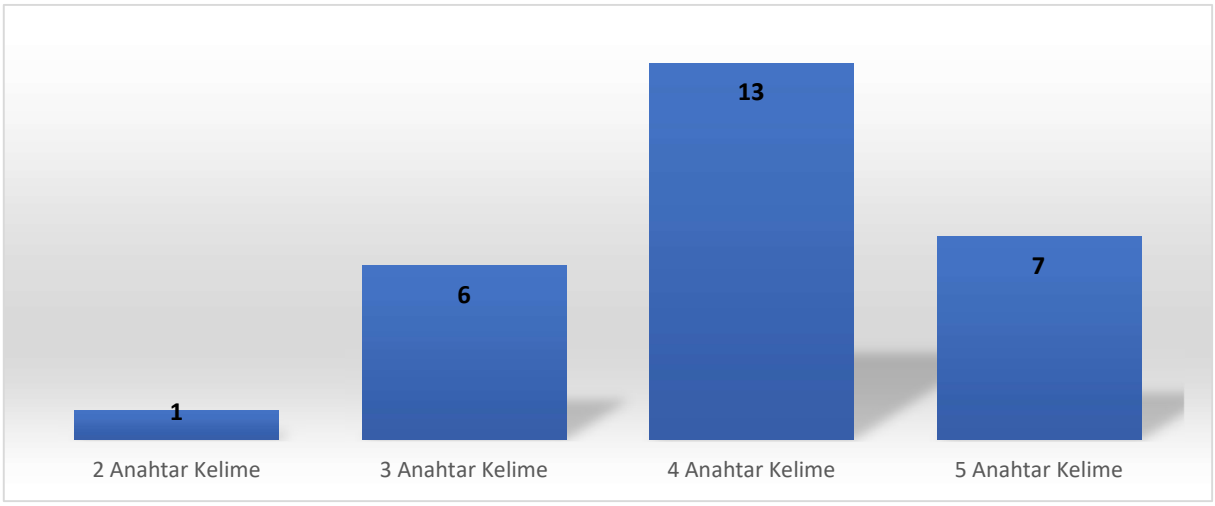
Bazı araştırmalarda ise karma yöntemler tercih edilmiştir. Karma yöntemler, nicel ve nitel verileri bir arada kullanarak daha kapsamlı bir değerlendirme yapmayı mümkün kılar. Böylece, araştırmalar her iki yöntemden de faydalanarak daha derinlemesine sonuçlar elde edebilir.

Grafik 6. Kullanılan Dile Göre Dağılım



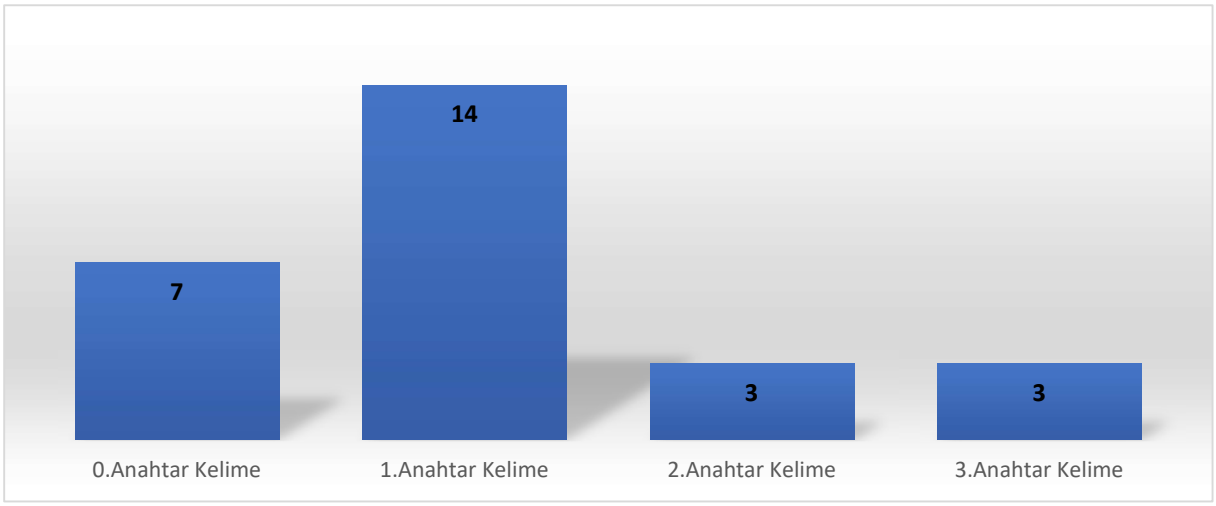
Sigorta ve sigortacılık alanında gerçekleştirilen akademik çalışmalarda, araştırmacıların hepsinin yayın dili olarak Türkçeyi tercih ettiği görülmektedir (Grafik 6). İncelenen 27 çalışmanın tamamının Türkçe olarak yayımlanmış olması, bu alandaki yayınların ağırlıklı olarak ulusal düzeyde yapıldığını göstermektedir. İngilizce dilinde herhangi bir yayına rastlanmaması, konunun uluslararası akademik literatürde yeterince temsil edilmediğine işaret etmektedir. Bu durum, hem Türkiye'deki sigortacılık araştırmalarının evrensel bilimsel tartışmalara entegrasyonu açısından bir sınırlılığı hem de yerel literatürün küresel görünürlüğünü artırmaya yönelik bir ihtiyaç olduğunu ortaya koymaktadır. Bu bağlamda, gelecek çalışmalarda İngilizce dilinde yayın yapma eğiliminin artması, alandaki bilimsel çeşitliliği ve etki alanını genişletebilir.

Grafik 7. Anahtar Kelime Sayısı



İncelenen çalışmalarda kullanılan anahtar kelime sayısına bakıldığında, genellikle 4 ila 5 anahtar kelimenin tercih edildiği görülmektedir. Anahtar kelime sayısının belirlenmesinde, çoğu zaman makalenin gönderildiği derginin yayın politikaları belirleyici olmakta; ancak bazı durumlarda araştırmacının tercihi de bu sayıya etki etmektedir. Anahtar kelime sayısı, aynı zamanda çalışmanın kapsamı ve içeriğiyle de doğrudan ilişkilidir. 5 ve üzeri anahtar kelimeye yer verilen makale sayısının sınırlı olması, bu durumun bir göstergesidir.

Grafik 8. Sigorta ve Sigortacılık Kelimesinin Anahtar Kelime Olarak Kullanılma Sayısı



Sigorta ve sigortacılık terimlerinin büyük oranda birinci sırada yer alması, bu kavramların araştırmaların odak noktasını oluşturduğunu ve yazarların bu konuya özellikle vurgu yapmak istediklerini ortaya koymaktadır. İkinci ve üçüncü anahtar kelimeden sonra bu tür terimlere daha az sıklıkla yer verilmesi, hatta bazı çalışmalarda hiç verilmemesi araştırmacıların sınırlı sayıda anahtar kelimeyle konunun özünü yansıtma eğiliminde olduklarını göstermektedir. Genel olarak anahtar kelimelerin seçimi ve sıralaması, araştırmacıların üzerinde çalıştıkları temaya bağlı olarak şekillenmektedir.

SONUÇ

Sigorta sektörü hem bireysel düzeyde hem de toplumsal ölçekte karşılaşılan çeşitli risklerin etkilerini azaltarak ekonomik güvenliğin sağlanmasına katkı sunan temel alanlardan biridir. Sigortacılık faaliyetleri, yalnızca bireylerin gelecekteki belirsizliklere karşı korunmasını sağlamakla kalmamakta, aynı zamanda ekonomik dalgalanma ve kriz dönemlerinde ekonominin istikrarını destekleyici bir rol üstlenmektedir. Öte yandan, artan çevresel tehditler karşısında, sigorta şirketlerinin sürdürülebilirlik esasına dayalı poliçeler geliştirerek yeni risk türlerine karşı koruma sağlamaları beklenmektedir. Önümüzdeki süreçte sigorta sektörü; teknolojiyi etkin kullanan, müşteri ihtiyaçlarına daha hızlı cevap verebilen ve esnek yapısıyla öne çıkan dinamik bir yapıya dönüşecektir. Bu dönüşüm hem sektördeki rekabeti yoğunlaştıracak hem de bireylerin daha kapsamlı ve yenilikçi güvence araçlarına erişimini mümkün kılacaktır. Dolayısıyla, sigortacılık yalnızca ekonomik sistemin bir unsuru olarak değil, aynı zamanda yaşam kalitesinin sürdürülebilirliğine katkı sağlayan stratejik bir yapı olarak önemini korumaya devam edecektir. Sigorta sektörü, ekonomik istikrar ve bireysel güvenlik açısından temel bir işlev üstlenmektedir. Bu sektörün gelişimi için öncelikle toplumsal sigorta bilincinin artırılması gerekmektedir. Dijitalleşme ve teknoloji kullanımı yaygınlaştırılarak hizmet kalitesi ve erişilebilirlik artırılmalıdır.

Etkin regülasyon ve denetim sistemleri, sektöre olan güveni güçlendirirken; ürün çeşitliliği, farklı risk gruplarına hitap ederek sigortanın kapsayıcılığını artırır. Rekabetin desteklenmesiyle hem fiyat dengesi sağlanabilir hem de hizmet kalitesi yükselir. Devlet destekli sigorta modelleri, özellikle afet, tarım ve sağlık gibi alanlarda sektörün yaygınlaşmasına katkı sağlar. Ayrıca, sözleşme şeffaflığı ve Ar-Ge faaliyetleri de sektörün uzun vadeli sürdürülebilirliği açısından önemlidir. Sonuç olarak, sigorta sektörünün gelişimi çok boyutlu stratejilerle desteklenmeli; dijital dönüşüm, yasal altyapı ve toplumsal farkındalık bir bütün olarak ele alınmalıdır.

Bu çalışma kapsamında, sigorta ve sigortacılık konularına odaklanan akademik yayınların literatürde kayda değer bir yer edindiği görülmektedir. Bibliyometrik analiz yöntemiyle gerçekleştirilen araştırma, elde edilen bulgularla bu alandaki bilimsel eğilimleri ortaya koymuştur. İncelenen makalelerin hem özel hem de kamuya ait kurumlarca yayımlanan, ulusal ve uluslararası düzeydeki çeşitli sektörel dergilerde yer aldığı tespit edilmiştir. Elde edilen sonuçlar, son yıllarda sigorta ve sigortacılık temalı akademik yayınlarda anlamlı bir azalış yaşandığını ortaya koymaktadır. Bu azalış, küresel ölçekte yaşanan ekonomik krizler, doğal afetler ve salgın hastalıkların etkisiyle ilişkilendirilebilir. Çalışmalarda görev alan araştırmacıların kurum türlerine göre dağılımı incelendiğinde, bunların 13'ünün kamu üniversitelerine, 7'sinin vakıf üniversitelerine ve 2'sinin diğer kurumlara mensup olduğu; ayrıca 5 araştırma üniversitesinin de bu çalışmalarda temsil edildiği görülmektedir. Bu durum, sigorta alanının hem devlet hem de özel sektör odaklı kurumlar tarafından ilgi gören bir araştırma konusu olduğunu göstermektedir. Farklı kariyer düzeyinde araştırmacıların konuya ilgi duydukları görülmekle birlikte araştırmaya katılanlar içerisinde Prof. Dr. ve Dr. Öğr. Üyesi unvanlarında belirgin bir yoğunluk yer almaktadır. Araştırmacıların genelde dil olarak Türkçe ve yöntem olarak da çoğunlukla nicel yöntemler tercih ettikleri ortaya çıkmıştır. Araştırmaların önemli bir kısmı bireysel çalışmalar şeklinde yürütülmüş olmakla birlikte, ortak yürütülen çalışmalara da sıkça rastlanmıştır. Yayınlarda kullanılan anahtar kelime sayısı genellikle 4 ila 5 arasında değişmekte; "sigorta" ve "sigortacılık" terimlerine ise çoğunlukla ilk sıralarda yer verilmektedir. Bu tercih, araştırmacıların konuyu öne çıkarmaya yönelik bilinçli bir eğilim sergilediklerine işaret etmektedir. Gelecekteki araştırmalar, farklı veri tabanları ve uzun süreli zaman dilimleriyle daha geniş kapsamlı analizler yapılarak, sektördeki eğilimler daha derinlemesine incelenebilir. Ayrıca, sigorta alanındaki araştırmalarda karma yöntemlerin kullanımının

artırılması, daha zengin sonuçlar elde edilmesine olanak tanıyabilir. Uluslararası perspektifin de daha fazla dikkate alınması, Türk sigortacılık sektörünün küresel eğilimlerle uyumunu daha iyi anlamamıza yardımcı olacaktır.

Bu çalışma, belirli bir zaman dilimi ve veri tabanı çerçevesinde sınırlı sayıda yayını incelemek suretiyle yürütülmüştür. Bu nedenle, inceleme kapsamına dahil edilemeyen çalışmaların bulunması muhtemeldir. Ayrıca, sigorta ve sigortacılık konularında gerçekleştirilen bibliyometrik analizlerin sayıca sınırlı olması, mevcut sonuçların başka çalışmalarla karşılaştırılmasını güçleştirmektedir. Ancak bu durum, gelecekte yapılacak bibliyometrik analizlerin bu çalışma ile kıyaslanabilmesine olanak sağlayacak bir zemin oluşturmaktadır. İlerleyen dönemlerde yapılacak araştırmaların, farklı veri tabanları, değişkenler ve daha uzun zaman dilimleri üzerinden tasarlanması, literatürdeki eğilimlerin daha kapsamlı biçimde analiz edilmesine katkı sağlayacaktır.

KAYNAKÇA

Akın, F., & Ece, N. (2010). Gelişmiş ve Gelişmekte Olan Ülkelerde Sigortacılık Sektörü: Türk Sigorta Sektörü Üzerine Bir Değerlendirme. Anadolu Bil Meslek Yüksekokulu Dergisi(18), 69-81.

Akın, F., & Ece, N. (2011). Gelişmiş ve Gelişmekte Olan Ülkelerde Sigortacılık Sektörü: Türk Sigorta Sektörü Üzerine Bir Değerlendirme. Anadolu Bil Meslek Yüksekokulu Dergisi(21), 85-97.

Attila, İ., & Gülay, A. (2022). Türkiye'de Sigorta Prim Üretimlerinin Dünya Sigortacılık Sektöründeki Yeri. Uygulamalı Sosyal Bilimler ve Güzel Sanatlar Dergisi, 4(8), 30-45.

Aydemir, C., & Turgut, İ. (2022). Konvansiyonel Sigorta Kullanıcılarının Katılım Sigortacılık Sistemine Yönelik Algı Düzeyleri. Düzce Üniversitesi Sosyal Bilimler Dergisi, 12(1), 551-566.

Aydın, N. (2005). *Sigortacılığın Temel İlkeleri*. Ankara: Seçkin Yayıncılık.

Aydın, M., & Yılmaz, T. (2019). "Türkiye'de Bireysel Emeklilik Sistemi ve Otomatik Katılımın Etkileri". *Finansal Araştırmalar Dergisi*, 45(2), 76-89.

Baysal, C. (2010). *Sigorta ve Risk Yönetimi*. İzmir: Detay Yayıncılık.

Birds, J. (2013). *Modern Insurance Law* (9th Ed.). London: Sweet & Maxwell.

Clark, G. (2003). *Betting On Lives: The Culture Of Life Insurance İn England, 1695–1775*. Manchester University Press.

Çağıl, G., & Tunç, C. (2022). Türk Sigortacılık Sektöründe Ufrs 17'ye Geçiş Süreci ve Sigorta Şirketlerine Olası Etkileri. Finansal Araştırmalar ve Çalışmalar Dergisi, 14(26), 55-101. Https://Doi.Org/10.14784/Marufacd.1055182

Çakıcı, A. C. & Yıldırım, O. & Karacaoğlu, S. (2013). Ulusal Turizm Kongreleri Bildirilerinin Bibliyometrik Profili, 14. Ulusal Turizm Kongresi Bildiriler Kitabı, 05-08 Aralık, Kayseri, 1429-1447.

Çalhan, H. & Çakıcı, C. (2019). Uluslararası İndekslerce Taranan Kış Turizmi Başlıklı Makalelerin Bibliyometrik Analizi, 1. Uluslararası Kış Turizmi Kongresi Bildiriler Kitabı, 19-21 Aralık 2019 – Erzurum/Türkiye, 2 12.

Çelik, H., & Yıldız, E. (2021). Sigorta Sektöründe Regülasyonların Sektörel Gelişim Üzerindeki Etkisi: Türkiye Örneği. *Ekonomi ve Finans Araştırmaları Dergisi*, 13(3), 112–130.

Çetin, M., & Kara, R. (2016). "Sigorta Sektöründe Düzenleyici Politikalar ve Ekonomiye Etkileri". *Sigorta ve Finansal Araştırmalar*, 20(1), 120-130.

Duramaz, S. (2021). Türkiye'de Sigortacılığın Son Yıllardaki Gelişim Eğiliminin Değerlendirilmesi: 2016-2019 Yılları Arası Dönem İçin Sigortacılık Sektörüne Yönelik Bir Etkinlik Analizi. *Manisa Celal Bayar Üniversitesi Sosyal Bilimler Dergisi*, 19(4), 275–292.

Engin, C., & Karakuş, B. (2020). Dünya, Avrupa Birliği ve Türkiye'de Sigorta Sektörü. *Kahramanmaraş Sütçü İmam Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, *10*(2), 173-189.

Erdem, M. (2015). "Türkiye'de Sigortacılık Sektörünün Gelişimi". *Sigorta Araştırmaları Dergisi*, 2(1), 65–82.

Erdoğan, B. (2023). Sigorta Şirketlerinin Performansının Crıtıc-Maırca Modeliyle Değerlendirilmesi: Türk Sigortacılık Sektörü Üzerine Bir Araştırma. Afyon Kocatepe Üniversitesi Sosyal Bilimler Dergisi, 25(4), 1438-1455.

Ertürk, M. (2004). *Sigorta İşletmeciliği*. İstanbul: Türkmen Kitabevi.

Ersoy, B. (2025). Sigorta Sahteciliği Araştırmalarının Bibliyometrik Analizi: Genel Görünüm ve Eğilimler. *Doğuş Üniversitesi Dergisi*, 26(1), 339–358.

Evren, S. & Kozak, N. (2014). Bibliometric Analysis Of Tourism And Hospitality Related Articles Published İn Turkey". Anatolia, 25 (1), 61-80.

Genç, E. (2011). *Risk Yönetimi ve Sigortacılık*. Ankara: Nobel Yayın Dağıtım.

Gülay, A., Attila, İ., & Kabataş, Y. (2024). Dijitalleşme ve Teknolojik Gelişmelerin Türkiye'de Sigortacılık Sektörüne Etkilerinin İncelenmesi: Swot Analizi ile Bir Uygulama. *Türk Yönetim ve Ekonomi Araştırmaları Dergisi*, 5(1), 1–20.

Gürbüzer, G. B., & Sönmez, S. S. (2022). İhracat Kredi Sigortalarının Bibliyometrik Analizi: Web Of Science Veri Tabanında Bir İnceleme. *Karatay Sosyal Araştırmalar Dergisi*, 8, 95–121. Https://Doi.Org/10.54557/Karataysad.1095792

Hotamışlı, M. & Erem, I. (2014). Muhasebe ve Finansman Dergisi'nde Yayınlanan Makalelerin Bibliyometrik Analizi, Muhasebe ve Finansman Dergisi, (63),1-19.

İşseveroğlu, G. (2021). Sürdürülebilir Sigortacılık İçin Sürdürülebilirlik Açıklamaları: Bist Sigorta Şirketleri Faaliyet Raporlarının İçerik Analizi. Muhasebe ve Finansman Dergisi(92), 47-60.

Kamilçelebi, H. (2012). Türkiye'de Sigorta Sektörünün Swot Analizi ve Bir Araştırma. *Ekonomi Bilimleri Dergisi*, 4(1), 1-15.

Kara, M., & Özkan, L. (2022). Sigorta Bilincinin Artırılmasında Eğitim Programlarının Rolü: Türkiye'de Bir Uygulama. *Sigortacılık ve Risk Yönetimi Dergisi*, 8(2), 78–95.

Keskin, I. U. (2023). Türkiye'de Sigortacılık, Sigortacılığın Gelişimi, Ekonomik İşlevleri ve Sorunları [Yüksek Lisans Tezi, İstanbul Kültür Üniversitesi].

Kırkbeşoğlu, E., Ünal, E., & Kahraman, E. D. (2021). Türkiye'de Sigorta Acentelerinin

Kocayusufpaşaoğlu, N. (1998). *Sigorta Hukuku*. İstanbul: Beta Yayınları.

Kotan, Y. (2020). Sigortacılık Sektörünün Gelişimi ve Dijitalleşmesi Sürecinin Swot Analizi: Erzurum İli Üzerine Bir Araştırma. *Ekonomi Bilimleri Dergisi*, 12(2), 179-192.

Külekçi, İ. (2019). Türk Sigortacılık Sektöründe Hayat Dışı Sigorta Şirketlerinin Etkinlik Analizi. Ekoıst Journal Of Econometrics And Statistics, 14(29), 225-246.

Meral, H. (2023). Türk Sigortacılığının Yüz Yılı: Makro Çevresel Faktörler Üzerine Kapsamlı Bir Analiz. *Manas Sosyal Araştırmalar Dergisi*, 12(4), 171–185.

Okunakul, Ö. (2005). "Hayat Sigortacılığı Deneyimi Işığında Türkiye'deki Bireysel Emeklilik Sisteminin ve Ekonomik Katkılarının Değerlendirilmesi", Yüksek Lisans Tezi, Hacettepe Üniversitesi Sosyal Bilimler Enstitüsü, Ankara.

Okunakul, B. (2005). *Sigorta Sektörünün Ekonomik Gelişmeye Katkıları*. İstanbul: İstanbul Üniversitesi Yayınları.

Özüdoğru, H. (2017). *Sigorta ve Risk Yönetimi*. İstanbul: Ekin Basım Yayın.

Palmer, S. (2008). *Insurance: History, Risks, And Regulation*. New York: Routledge.

Pehlivan, E., & Akpınar, Ö. (2022). Türkiye'de Hayat Dışı Sigorta Şirketlerinin Performans Değerlendirmesine Yönelik Ampirik Bir Uygulama. *Öneri Dergisi*, 17(58), 516-548.

Pehlivan, P. (2018). Türk Sigorta Sektörünün Gelişimi ve Etkinliği. *Journal Of Institute Of Economic Development And Social Researches*, 4(11), 486–497.

Polat, C.& Sağlam, M. & Sarı T. (2013). Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi' Nin Bibliyometrik Analizi", Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi, Cilt: 27, Sayı: 2, 273-288.

Pritchard, A. (1969). Statistical Bibliography Or Bibliometrics? *Journal Of Documentation*, 25(4), 348–349.

Rejda, G. E., & Mcnamara, M. J. (2014). *Principles Of Risk Management And Insurance* (12th Ed.). Pearson Education.

Şahin, İ. E., & Akkoyuncu, H. (2019). Türk Sigortacılık Sektöründe Faaliyet Gösteren Hayat Dışı Sigorta Şirketlerinin Etkinlik Analizi. Selçuk Üniversitesi Sosyal Bilimler Meslek Yüksekokulu Dergisi, 22(2), 840-852.

Tanrıvermiş, H. (2009). "Sigorta Sisteminin Ekonomik ve Sosyal Fonksiyonları". *Ankara Üniversitesi Sbf Dergisi*, 64(3), 55-72.

Ttk, 29.06.1956 Tarih ve 6762 Sayılı Kanun, Resmî Gazete-9353, 09.07.1956.

Tuna, R., & Özmerdivanlı, A. (2024). Türk Sigortacılık Sektöründe Kârlılığı Etkileyen Firmaya Özgü Faktörlerin Belirlenmesine Yönelik Ampirik Bir Çalışma. *İşletme Araştırmaları Dergisi*, 16(1), 1–15.

Tunay, N., & Tunay, K. B. (2015). Finansal Krizler ve Sigortacılık: Deneysel Bulguların Işığında Türk Sigorta Sektörüne Dair Değerlendirmeler. Marmara Üniversitesi İktisadi ve İdari Bilimler Dergisi, 35(2), 81-104.

Türkeri, G. (2023). Sigortacılık Sektöründe Başarı Kriteri Olarak Pozitif Psikolojik Sermaye. Yüksek Lisans Tezi, Pamukkale Üniversitesi.

Türkiye Sigorta ve Reasürans Şirketler Birliği (2007), "Avrupa Birliği Sigorta Müktesebat Rehberi", İstanbul.

Türkiye Sigorta Birliği. (2022). Türkiye Sigortacılık Sektörü Ekonomik Etki Analizi. Https://Tsb.Org.Tr/Publications/Turkıye_Sıgortacılık_Sektoru_Ekonomık_Etkı_Analızı.

Torusdağ, T., Tepeci, M., & Metin, İ. (2024). İklim Değişikliğinin Sigorta Sektörü Üzerindeki Etkileri: Türkiye Örneği. *Doğal Afetler ve Çevre Dergisi*, 10(2), 409–423.

Umut, M. (2020). The Center Of Digitalization İn Turkish Insurance Sector: Insurance Information And Monitoring Center- Covid-19. Iğdır Üniversitesi Sosyal Bilimler Dergisi(Ek Sayı (2020), 323-356.

Umut, M. (2022). Türk Sigortacılık Piyasasında Sigorta Havuz Uygulamaları ve Sürdürülebilirliğine İlişkin İnceleme. Joeep: Journal Of Emerging Economies And Policy, 7(2), 399-408.

Yayla, Ş. O. (2019). Sigortacılık ve Türkiye'de Sigorta Sektörünün Durumu. Liberal Düşünce Dergisi, 24(94), 107-125.V

Yazıcıoğlu, M. (2020). "Türkiye Sigorta Sektörünün Büyüme Dinamikleri". *Ekonomi ve Finans*, 42(3), 80-95.

Yenisu, E. (2019). Sigortacılık Sektörü ve Ekonomik Büyüme İlişkisi: Türkiye Örneği. *Finans Ekonomi ve Sosyal Araştırmalar Dergisi*, 4(2), 206–217.

Yıldırım, İ. (2013). Türk Sigortacılık Sektörünün Yumuşak Karnı: Sigorta Suistimalleri Sorunu. Sosyal ve Beşerî Bilimler Dergisi, 5(1), 331-340.

Yıldırım, F., Yetiz, F., & Gülmez, M. (2020). Risk ve Sigortacılık Alanında Gerçekleştirilen Bilimsel Araştırmaların Bibliyometrik Analizi. *Cumhuriyet Üniversitesi İktisadi ve İdari Bilimler Dergisi*, 21(1), 203–219.

Yılmaz, A. (2021). Covıd-19 Türk Sigorta Sektörünü Nasıl Etkiledi? *Sigorta Araştırmaları Dergisi*, 5(2), 45-60.

Yılmaz, G. (2017). Restoranlarda Bahşiş ile İlgili Yayınlanan Makalelerin Bibliyometrik Analizi, Seyahat ve Otel İşletmeciliği Dergisi, 14(2), 65-79.

Yılmaz, A., & Demir, S. (2023). Sigorta Sektöründe Dijitalleşmenin Müşteri Deneyimine Etkisi: Türkiye Örneği. *Finansal Araştırmalar ve Çalışmalar Dergisi*, 15(1), 45–62.

Yörübulut, S. (2023). Türkiye'de Sigorta Sektöründe Sigortacılık/Aktüerya Mezunlarının İstihdam Edilme Durumlarının İncelenmesi. Biruni Sağlık ve Eğitim Bilimleri Dergisi, 6(1), 28-38.

Teachers' Views on the Use of Artificial Intelligence in Education

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Abstract

The main purpose of this study is to examine how teachers use artificial intelligence tools in their educational processes and to reveal their perceptions, attitudes and opinions towards these tools in depth. With the rapid development of technology, the integration of artificial intelligence tools into the field of education has also accelerated. This situation directly affects teachers' professional practices and pedagogical approaches. In this context, this study was conducted with a mixed design research method to address teachers' attitudes towards artificial intelligence technologies with both quantitative and qualitative dimensions. The methodological framework of the study was constructed in a structure where qualitative and quantitative data were collected and analyzed together. Three different tools were used in the data collection process: a demographic information form, a questionnaire to measure the use of artificial intelligence, and a semi-structured interview form to analyze teachers' views in depth. Quantitative data were analyzed using frequency and percentage analysis, while qualitative data were analyzed using content analysis. Fifteen teachers participated in the study and the data obtained from these participants were carefully analyzed and presented in detail under the title of findings. According to the findings, it shows that most teachers are willing to use artificial intelligence tools, but they adopt a cautious approach towards these tools. Especially the ethical dimension of artificial intelligence in education was the most frequently mentioned and emphasized theme by the teachers. A significant number of participants stated that they get information from artificial intelligence before using search engines and use these tools as consultants in the process of generating ideas. In addition, teachers stated that AI is a useful tool, especially in providing quick feedback and generating alternative ideas. However, they emphasized that it is not possible for this technology to replace the teacher in the long run and that the teacher's guidance and human touch are indispensable for the educational process. These results show that although artificial intelligence is seen as a supportive element in teaching processes, the human factor remains important.

Keywords: Artificial intelligence, ethics, education, technology integration

Introduction

Interest in the use of artificial intelligence (AI) in education has increased rapidly in recent years. Especially with the proliferation of generative AI tools, AI integration in schools and classrooms has gained momentum (Cardona et al., 2023). These technologies have started to transform teachers' professional practices and classroom roles. In Aljemely's (2024) study, AI-based tools change teachers' functions and offer them new

possibilities in teaching and assessment processes. In literature, there are many studies on how teachers adopt these tools and their effects on teaching and learning processes. It is stated that AI technologies have various enhancing effects on classroom teaching-learning processes. In particular, personalized learning and instant feedback opportunities draw attention to the potential of AI-supported systems to increase student achievement (Özer et al, 2023). AI-based intelligent tutoring systems and chatbots customize learning experiences by providing homework and study support to students and contribute to their development of different skills (Labadze et al., 2023). Teachers state that thanks to AI, they can plan their lessons more efficiently and implement various teaching strategies more easily. For example, AI tools can suggest new examples, simulations or visuals to enrich the course content, thus helping to improve the quality of teaching materials (Chen et al., 2020). On the other hand, the impact of AI on educational processes is not always positive; some limitations and concerns have also been raised. There are also concerns among teachers that AI tools may increase their workload instead of reducing it.

With the rapid development of technology, the integration of artificial intelligence tools into the field of education has also accelerated. This situation directly affects teachers' professional practices and pedagogical approaches. The aim of this study is to examine how teachers use artificial intelligence tools in educational processes and to reveal their perceptions, attitudes and opinions towards these tools.

Methodology

The study was conducted based on a mixed method design to comprehensively examine teachers' attitudes towards artificial intelligence technologies. In the research process, both quantitative and qualitative data were collected and analyzed together. This approach increased the depth and reliability of the findings by providing the opportunity to evaluate the research topic from multiple perspectives (Creswell & Plano Clark, 2018).

Three basic tools were used in the data collection process:

- Demographic information form to determine the demographic information of the participants,
- A structured questionnaire to measure the frequency and purposes of using artificial intelligence tools,
- Semi-structured interview form for in-depth understanding of teachers' views and experiences.

Quantitative data were analyzed using frequency and percentage distribution analyses, while qualitative data were evaluated using content analysis. The data obtained from 15 teachers who voluntarily participated in the study were analyzed with a holistic approach and presented in detail in the findings section.

Findings

Demographic Information

Table 1. *Demographic Information*

Branch	**Frequency**	%
Math	4	26,67%
Foreign Languages	3	20,00%
Social Sciences	2	13,33%
Computer Science Education	2	13,33%
Science and Technology	1	6,67%
Elementary Education	1	6,67%
Psychological Counseling and Guidance	1	6,67%
Biology	1	6,67%
Level	**f**	%
Primary School	2	13,33%
Secondary School	10	66,67%
High School	3	20,00%
Graduation status	**f**	%
Undergraduate	11	73,33%
Graduate	1	6,67%
Doctorate	3	20,00%
Experience	**f**	%
1-3 years	3	20,00%
4-5 years	2	13,33%
6-10 years	8	53,33%
11+ years	2	13,33%
Total	15	100%

When the branch distribution of the participants is examined, it is seen that 26.67% of the teachers work in Mathematics, 20% in Foreign Language, 13.33% in Social Sciences and Computer Science Education branches; Science and Technology, Elementary Education, Psychological Counseling and Guidance, and Biology branches are represented by 6.67%. According to the distribution of the teachers according to the levels they work in, 66.67% of them work in secondary school, 20% in high school and 13.33% in primary school. In terms of graduation status, 73.33% of the participants had a bachelor's degree, 6.67% had a master's degree and 20% had a doctorate degree. In

terms of teaching experience, 53.33% of the participants had 6-10 years of teaching experience, 20% had 1-3 years of teaching experience, 13.33% had 4-5 years of teaching experience and 13.33% had 11 years or more of teaching experience.

Quantitative Findings

Table 2. *Quantitative Findings*

Items	Total	
1) I use artificial intelligence tools frequently in my classes.	44	2,75
2) AI tools facilitate students' learning process.	58	3,63
3) The integration of artificial intelligence tools into education is essential.	65	4,06
4) Using these tools saves me time.	60	3,75
5) I am concerned about the reliability of AI tools.	59	3,69
6) AI tools cannot replace teachers.	67	4,19
7) I have received sufficient training to use artificial intelligence tools	31	1,94
8) I use search engines before I use AI tools.	53	3,31

When the findings regarding the attitudes of the participant teachers towards artificial intelligence tools are analyzed, it is seen that the mean of the answers given to the statement "Artificial intelligence tools cannot replace teachers" ($\bar{X}$ = 4.19) is the highest. This shows that the majority of teachers have a strong belief that artificial intelligence cannot replace the teaching profession. This is followed by the items "Integration of artificial intelligence tools into education is important" ($\bar{X}$ = 4,06) and "Using these tools saves me time" ($\bar{X}$ = 3,75). Teachers also showed a very high level of agreement that artificial intelligence tools facilitate students' learning process ($\bar{X}$ = 3.63).

On the other hand, the mean ($\bar{X}$ = 2,75) given to the statement "I use artificial intelligence tools frequently in my lessons" reveals that the frequency of use remains at a moderate level. In addition, the responses to the statement "I use search engines before I use AI tools" ($\bar{X}$ = 3,31) indicate that teachers still prefer traditional sources in the process of accessing information. The mean value ($\bar{X}$ = 3,69) given to the item "I am concerned about the reliability of artificial intelligence tools" indicates that teachers have a certain level of distrust towards these technologies. The lowest mean was observed in the statement "I have received sufficient training to use artificial intelligence tools effectively" ($\bar{X}$ = 1.94). This finding reveals that most of the teachers do not feel sufficiently equipped to use artificial intelligence tools.

Qualitative Findings

Findings related to the question "*Have you ever used artificial intelligence tools in education? If yes, which tools do you use?*"

Table 3. *Have you ever used artificial intelligence tools in education? If yes, which tools do you use?*

Category	**f**	**%**
Yes	9	60%
• Seldom	5	33%
• Frequently	4	27%
No	6	40%

When the answers to the question "Have you ever used artificial intelligence tools in education?" are analyzed, it is seen that 60% of the teachers stated that they used these tools at least once. Among these participants, 33% stated that they rarely used artificial intelligence tools and 27% stated that they used them frequently. On the other hand, 40% stated that they never use artificial intelligence tools. These findings reveal that a significant number of teachers have gained some experience with artificial intelligence tools; however, the frequency of use varies from teacher to teacher. On the other hand, the fact that the proportion of teachers who do not use these technologies at all is remarkable suggests that some teachers have not yet adapted to these technologies or lack access and awareness. It is seen that teachers use Chatgpt (n=6), Teachy app (n=1), Gemini (n=1), Grok (n=1).

Findings related to the question "*What do you think are the benefits of using these tools?*"

Table 4. *What do you think are the benefits of using these tools?*

Category	**f**	**%**
Saving time	9	60,0%
Support for the learning process	2	13,3%
Retention of knowledge	1	6,7%
Continuous learning and professional development	1	6,7%
Facilitating learning	1	6,7%
Fun	1	6,7%
Total	15	100,0%

Participants were asked what kind of benefits the artificial intelligence tools they use in education provide. According to the data obtained, the majority of teachers (60.0%) stated that the most important contribution of these tools was saving time. This finding shows that teachers see AI technologies as a means of facilitating routine tasks and reducing workload.

Other benefits include supporting the learning process (13.3%), increasing the retention of knowledge (6.7%), supporting continuous learning and professional development (6.7%), facilitating learning (6.7%) and providing a fun learning environment (6.7%). These findings reveal that teachers find AI tools valuable not only for saving time but also for their pedagogical contributions. However, the emphasis on benefits other than time saving was relatively low, suggesting that teachers may not yet have fully explored the instructional potential of these technologies.

Findings related to the question *"Do you think artificial intelligence tools contribute to the education process? Could you please explain?"*

Table 5. *Do you think artificial intelligence tools contribute to the education process? Could you please explain?*

Category	**f**	**%**
Saving time	6	30,0%
Content creation	5	25,0%
Feedback	4	20,0%
Individual learning	2	10,0%
Knowledge repository	1	5,0%
Equality	1	5,0%
Fun and engaging	1	5,0%
Total	20	100,0%

When the opinions of the teachers regarding the contributions of artificial intelligence tools to the educational process are analyzed, 30% of the participants stated that the most important contribution of these tools is saving time. This is followed by creating content (25.0%) and providing quick feedback to students (20.0%). These findings show that teachers find artificial intelligence technologies especially useful in preparing teaching materials and increasing the efficiency of the teaching process.

Some of the participants stated that AI tools support individualized learning (10.0%), provide quick access to information (5.0%), provide equal opportunities among students (5.0%), and make the learning process more fun and interesting (5.0%). This diversity reveals that teachers evaluate AI tools from different pedagogical perspectives and think that they contribute in various areas. However, the fact that direct teacher-centered functions such as time and content generation are more prominent indicates that awareness of the student-oriented use of these tools may still be limited.

Findings related to the question "*What are your thoughts about the negative aspects of using these tools in education?*"

Table 6. *What are your thoughts about the negative aspects of using these tools in education?*

Category	f	%
Ethics	12	80%
Reliability	3	20%
Total	15	100%

When the participants' views on the negative aspects of the use of artificial intelligence tools in education are analyzed, it is seen that ethical problems are the most frequently expressed concern with a rate of 80%. This shows that teachers are especially concerned about issues such as academic honesty, student responsibility and moral decision-making processes in the use of artificial intelligence.

In addition, 20% of the teachers expressed negative opinions about the reliability of artificial intelligence tools. These views draw attention to the technical limitations of AI systems such as accuracy, data security and errors in knowledge generation. When the findings are evaluated in general, it is understood that although teachers have positive attitudes towards artificial intelligence technologies, they have serious ethical and technical concerns about the responsible and conscious use of these technologies in the educational environment.

Findings related to the question "*How do you think these technologies can affect the teaching profession?*"

Table 7. *How do you think these technologies can affect the teaching profession?*

Category	f	%
No	13	86,7%
• Reducing workload	7	46,7%
• Support for teachers	3	20,0%
• Positive effect on pedagogy	2	13,3%
• Positive effect on content	1	6,7%
Not sure	2	13,3%
Total	15	100,0%

When the participants were asked how artificial intelligence technologies might affect the teaching profession, a majority of 86.7% stated that they thought that these technologies would not directly affect the teaching profession. This shows that teachers

have a strong belief that it is unlikely that their professional roles will be replaced by artificial intelligence systems.

However, 46.7% of the teachers stated that AI tools can reduce their workload and 20% of the teachers stated that these technologies can play a supportive role for the teacher. In addition, 13.3% stated that artificial intelligence can contribute positively to the pedagogical process, while 6.7% stated that these technologies contribute to content knowledge. On the other hand, 13.3% were undecided and drew attention to the uncertainty on this issue.

These findings show that teachers generally do not see artificial intelligence as an occupational threat but draw attention to its potential to support teaching processes. Most teachers position AI as a tool to help them rather than transform their professional roles.

Findings related to the question "*What kind of support should be provided for each teacher to use artificial intelligence tools?*"

Table 8. *What kind of support should be provided for each teacher to use artificial intelligence tools?*

Category	**f**	%
Tool based trainings	10	66,7%
In-service trainings	3	20,0%
Courses and seminars	1	6,7%
Technology integration	1	6,7%
Total	15	100,0%

When the participants were asked what kind of support they needed to use artificial intelligence tools effectively, the most emphasized need was tool-oriented training with a rate of 66.7%. This finding reveals that teachers especially need practical programs that directly teach the functions and usage of the tools to use the technology.

While 20% of the teachers stated that in-service training programs should be provided, 6.7% stated that courses and seminars would be useful, and another 6.7% stated that technology integration should be provided first. This diversity reflects that teachers' individual needs and expectations vary in professional development processes. However, the tendency is that teachers use artificial intelligence tools effectively in a pedagogical context, they primarily need practical and systematic training directly related to the use of the tools.

Results

According to the findings, it is seen that most teachers are willing to use artificial intelligence tools, but they adopt a cautious approach towards these tools. Especially the ethical dimension of artificial intelligence in education was

the most frequently mentioned and emphasized theme by teachers. Although teachers generally find AI useful and easy to use, they are concerned about ethics, security and the future of the teaching profession. Therefore, they see AI as a supportive tool but emphasize the importance of the human touch (Shao et al., 2025). A significant number of participants stated that they get information from AI before using search engines and use these tools as consultants in the process of generating ideas. However, teachers indicated that AI was a useful tool, especially in providing quick feedback and generating alternative ideas. Similarly, teachers often use AI as an advisor, idea generator or feedback provider, but emphasize that the final decisions should remain under human control (Merzifonluoglu & Gunes, 2025).

Although it is stated that artificial intelligence is an important tool, they emphasized that it is not possible for this technology to replace the teacher in the long run, and that the guidance and human touch of the teacher is indispensable for the educational process. These results show that although artificial intelligence is seen as a supportive element in teaching processes, the human factor remains important. In Yang's (2024) study, it is clearly stated that AI contributes to education, but it cannot replace teachers' roles such as emotional support, guidance and encouraging critical thinking. While the research emphasizes that it is necessary to train teachers to use AI effectively, it also argues that these technologies should enhance the roles of teachers, not replace them.

Recommendations

- Training programs for teachers on the ethical use of artificial intelligence should be created. This is important in terms of reducing concerns and encouraging conscious use.
- Workshops and guidance services should be offered to teachers to increase their digital competencies and enable them to use AI more effectively.
- It should be emphasized that artificial intelligence should be seen as a supportive element to the role of the teacher, not a substitute, and this perspective should be included in education policies.

References

Cardona, M. A., Rodríguez, R. J., & Ishmael, K. (2023). *Artificial intelligence and the future of teaching and learning: Insights and recommendations.* Office of Educational Technology.

Retrieved from https://www.ed.gov/sites/ed/files/documents/ai-report/ai-report.pdf

Aljemely, Y. (2024). Challenges and best practices in training teachers to utilize artificial intelligence: a systematic review. *Frontiers in Education, 9*, 1470853.

Labadze, L., Grigolia, M., & Machaidze, L. (2023). Role of AI chatbots in education: systematic literature review. *International Journal of Educational Technology in Higher Education, 20*(1), 56.

Özer, S., Akgül, S., & Yıldırım, A. (2023). Okullarda Yapay zekâ kullanımına ilişkin öğretmen görüşleri. *Ulusal Eğitim Dergisi, 3*(10), 1776-1794.

Chen, L., Chen, P., & Lin, Z. (2020). Artificial intelligence in education: A review. *IEEE Access, 8*, 75264-75278.

Creswell J. W., Plano Clark V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). Sage

Shao, A., Lu, Z., Zhong, B., Liu, S. Q., & Lu, W. (2025). Human touch vs. AI tech: Understanding user preferences in the future of education. *Computers in Human Behavior, 164,* 108492.

Merzifonluoglu, A., & Gunes, H. (2025). Shifting dynamics: Who holds the reins in decision-making with artificial intelligence tools? Perspectives of Gen Z pre-service teachers. *European Journal of Education, 60*(1), e70053.

Yang, Z. (2024). Empowering teaching and learning with artificial intelligence. *Frontiers of Digital Education, 1*(1), 1-3.

The Importance of Defining Actors' Income Models and Its Impact on the Professional Definition of Acting

Oyuncuların Gelir Elde Etme Biçimlerinin Belirlenmesinin Önemi ve Mesleki Tanıma Olan Etkisi

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Abstract

This paper examines the legal and economic status of the acting profession in Turkey, focusing on how actors' income models influence the professional definition of acting. The acting profession differs from traditional forms of employment due to its diverse working conditions and income structures. The absence of a well-defined framework for actors' income models creates significant uncertainties regarding professional identity and status. In Turkey, the acting profession is not directly regulated by law but is instead addressed indirectly through certain regulations and professional associations. This situation complicates the protection of actors' economic rights and results in legal gaps in areas such as taxation, social security, and contract types. This study highlights the importance of defining actors' income models within an economic and political context and categorizes these income structures into three main types. This classification is based on the structural differences between actors' professional activities and their means of generating income. The research explores how these income models are shaped within the economic-political framework and examines their impact on the professional definition of acting. Establishing a systematic framework for actors' income models is crucial for defining the profession and ensuring legal protections. Clarifying the professional status of actors will not only strengthen their economic rights but also foster greater professionalization within the industry. In this context, determining the legal and economic status of the acting profession will enhance the effectiveness of professional organizations and unions while also improving the credibility of acting education institutions.

Keywords: Acting, Income Models, Theatre, Cinema

Özet

Bu çalışma, Türkiye'de oyunculuk mesleğinin hukuki ve ekonomik statüsünü inceleyerek oyuncuların gelir elde etme biçimlerinin meslek tanımı üzerindeki etkilerini

ele almaktadır. Oyunculuk mesleği farklı çalışma biçimlerine ve gelir modellerine sahip olması nedeniyle geleneksel istihdam türlerinden ayrılmaktadır. Oyuncuların gelir elde etme biçimlerinin net bir çerçevede tanımlanmamış olması mesleki kimlik ve statü açısından ciddi belirsizliklere yol açmaktadır. Türkiye'de oyunculuk mesleği doğrudan bir yasa ile düzenlenmemekte yalnızca bazı mevzuatlar ve meslek birlikleri aracılığıyla dolaylı bir şekilde ele alınmaktadır. Bu durum, oyuncuların ekonomik haklarının korunmasını zorlaştırarak vergi, sosyal güvence, sözleşme türleri gibi alanlarda hukuki boşlukların oluşmasına yol açmaktadır. Çalışmada, oyuncuların ekonomi politik bağlamda gelir modellerinin tanımlanmasının önemine değinilerek oyuncuların gelir elde etme biçimleri üç ana kategori altında sınıflandırılmıştır. Bu gelir modeli sınıflandırması, oyuncuların mesleki faaliyetleri ile gelir elde etme biçimleri arasındaki yapısal farklar temel alınarak oluşturulmuştur. Çalışmada, gelir modellerinin ekonomi politik bağlamda nasıl şekillendiği ve meslek tanımına nasıl etki ettiği tartışılmıştır. Oyuncuların gelir elde etme biçimlerinin sistematik bir çerçeveye oturtulması, meslek tanımının yapılabilmesi ve hukuki güvencelerin sağlanabilmesi için kritik bir önem arz etmektedir. Oyuncuların mesleki statüsünün netleştirilmesi ilgili meslek kolunun hem ekonomik haklarını güçlendirecek hem de sektördeki profesyonelleşmeyi teşvik edecektir. Bu doğrultuda oyunculuk mesleğinin hukuki ve ekonomik statüsünün belirlenmesi, yalnızca meslek örgütlerinin ve sendikaların etkinliğini artırmakla kalmayacak aynı zamanda oyunculuk eğitimi veren kurumların itibarını da güçlendirecektir.

Anahtar Kelimeler: Oyunculuk, Gelir Modelleri, Tiyatro, Sinema

Giriş

Oyuncuların toplum içerisindeki ekonomik ve hukuki açıdan statüleri, tarih boyunca neredeyse her dönem sanatsal ve toplumsal açıdan tartışmalara konu olmaktadır. Günümüzde sinema, tiyatro ve dijital platformlar gibi farklı mecralarda icra edilen bu meslek, geniş bir gelir modeli biçimine sahiptir. Türkiye'de oyuncuların gelir elde etme biçimlerinin belirli bir sistematik çerçevede tanımlanmamış olması, mesleğin hukuki statüsünü belirsiz kılarak oyuncuların çalışma koşullarını açıklamada ciddi sorunların ortaya çıkmasına yol açmaktadır. Türkiye'de oyunculuk mesleği, doğrudan bir yasa ile tanımlanmamakta birlikte sadece bazı mevzuatlar ve meslek birlikleri aracılığıyla dolaylı olarak ele alınmaktadır. Oyuncular, büyük oranda serbest meslek erbabı olarak değerlendirilmekte elde ettikleri gelirler ise proje bazlı veya parça başı belirlenen ücretler üzerinden şekillenmektedir. Ayrıca, kamu kurumlarında tam zamanlı olarak çalışan veya özel sektör bünyesinde istihdam edilen oyuncular da bulunmaktadır. Gelir elde etme biçimlerindeki bu çeşitlilik, oyuncuların meslek tanımının yapılmasını zorlaştırmakta vergi yükümlülükleri, sosyal güvence ve sözleşme türleri gibi konularda ekonomik statülerinin belirsizleşmesine yol açarak önemli problemlerin ortaya çıkmasına neden olmaktadır.

Bu çalışma, oyuncuların gelir elde etme biçimlerine odaklanarak mesleğin ekonomi politik bağlamda nasıl bir çerçeveye oturtulması gerektiğini tartışmaya

açacaktır. Oyuncuların gelir elde etme modellerini belirlemek yalnızca gelir düzeylerini değil aynı zamanda mesleki hakları ile hukuki güvencelerini de doğrudan etkilemektedir. Bu nedenle, oyunculuk mesleğinin doğru bir tanımını yapabilmek adına öncelikle oyuncuların gelir elde etme biçimlerinin neler olduğunun net bir şekilde tanımlanması gerekmektedir. Bu doğrultuda çalışmada oyuncuların gelir elde etme biçimleri üç temel kategori altında sınıflandırılacak ve bu sınıflamanın meslek tanımı açısından önemi ve nasıl bir katkı sunabileceği değerlendirilecektir.

1. Problem Tanımı

Oyuncuların gelir elde etme biçimlerinin tanımlanmaması, birincil olarak oyunculuk mesleğinin genel tanımını doğrudan etkilemektedir. Gelir modellerinin net olarak belirlenmemesi, oyuncuların hangi ekonomik statüde değerlendirileceği konusunda sürekli bir belirsizlik yaratmakta, bu durum ise oyuncuların mesleki haklarının korunmasını zorlaştırmaktadır. Bu doğrultuda bazı temel sorunlar ortaya çıkmaktadır. Bunlardan başlıcası oyuncuların mesleki kimlik ve statü eksikliği yaşamalarıdır. Oyuncuların gelir elde etme biçimleri meslek tanımıyla doğrudan bağlantılıdır. Fakat oyuncuların gelir modellerinin netleştirilmemesi, oyunculuk mesleğinin açık bir tanımının yapılmasını zorlaştırmakta dolayısıyla mesleğin ekonomik faaliyetinin ne olduğu anlaşılamamaktadır. Bir iş kolunda meslek tanımının yapılabilmesi için öncelikle o iş kolundaki ekonomik faaliyet biçimi ile temel standartların belirlenmesi gereklidir. Oyuncuların gelir modelleri tanımlanmadığı müddetçe oyunculuk; profesyonel, standartları belirlenmiş bir meslek olarak değil, geçici veya amatör bir faaliyet olarak değerlendirilmek zorunda kalacaktır. Bu durum özellikle oyuncuların vergilendirilmesi sürecinde de ciddi sorunlara yol açmaktadır. Türkiye'de oyuncular, 90.01.18 Bağımsız Aktör, Aktris ve Dublörlerin Faaliyetleri başlığı altında vergilendirilmekte ancak oyunculuk mesleği hukuki ve yasal çerçevede açıkça tanımlanmamaktadır. Sadece bazı yasal düzenlemeler ile meslek birlikleri çerçevesinde değerlendirilen dolaylı tanımları mevcuttur(*5441 Sayılı Devlet Tiyatroları Personeli Hakkında Kanun*, 1949; *İstanbul Büyükşehir Belediyesi, Şehir Tiyatroları Şube Müdürlüğü, Görev ve Çalışma Yönetmeliği*, 2022). Mesleki Yeterlilik Kurumu (MYK) tarafından belirlenen meslek standartları içinde oyunculuk mesleğinin tanımı dolaylı olarak yer almaktadır. Oyunculuk mesleğinin tanımı ile mesleki standartları, sahne sanatları alanıyla ilgili bölümler tarafından belirlenmiş olmakla birlikte özel bir yasa çerçevesiyle belirlenmemiştir(*Oyuncu*, 2025). Oyuncuların bu kategori altında değerlendirilmesi, mesleğin kıstaslarının neler olduğunun belirlenmeden salt gelir elde etme biçimi üzerinden vergilendirilmesine neden olmaktadır. Ayrıca, oyuncuların gelir elde etme biçimleri net olarak tanımlanmadığından -ve aynı zamanda oyunculuk mesleğinin tanımı ve standartları belirlenmediğinden- mesleğin vergilendirilmesi bir serbest meslek faaliyeti olarak değerlendirilmektedir. Yapılan serbest meslek faaliyeti tanımı çerçevesinde değerlendirildiğinde, ilgili iş kolunda genel geçer bir algının oluşmasına zemin hazırlamaktadır. Bu bağlamda oyunculuk mesleği herhangi bir formel eğitim sürecine tabi tutulmadan da icra edilebileceği yönünde bir kanaatin ortaya çıktığı görülmektedir. Bu durum aynı zamanda mesleğin yeterliliklerinin belirlenmesinin göz ardı edilerek oyuncuların faaliyet gösterdikleri endüstri içerisinde ekonomik haklarını savunmalarını zorlaştırmaktadır.

Oyuncuların çalışma biçimlerinin farklılık göstermesi aynı zamanda hangi gelir modeline göre vergilendirileceği, hangi sigorta sistemine tabi olacağı veya sözleşme

türlerinin nasıl şekilleneceği gibi hukuki düzenlemeler konusunda eksiklikler ile tutarsızlıklar yaratmaktadır. Özellikle serbest meslek erbabı olarak çalışan oyuncuların sosyal güvencelerinin kendilerinin mi yoksa işverenlerinin mi yapacağı konusu sürekli tartışmaya yol açmaktadır. Bu noktada oyuncu eğer bağımsız bir serbest meslek erbabı olarak ilgili iş kolunda rol alacaksa, elde edeceği asgari gelir miktarı belirlenerek bağımsız olarak mı yoksa bir işverene tabi olarak mı çalışacağı netleştirilmelidir. Oyucuların asgari gelir miktarının belirlenmemesi düşük ücret alan oyuncuların gereksiz yere defter açmalarına ve fazladan vergilendirilmeleri gibi sonuçlara yol açmaktadır. Oyuncuların büyük bir kısmı proje bazlı çalıştığı için, sürekliliği olmayan gelirleri sosyal güvence açısından büyük risk oluşturmaktadır. Oyuncular için belirli bir hukuki statü tanımlanmadığı sürece, işverenler karşısında zayıf bir konumda kalarak ücret ile hukuki haklar konusunda pazarlık güçlerini yitirmekte böylece hak kaybına uğramaları kaçınılmaz olmaktadır. Özellikle, serbest meslek erbabı olarak vergilendirilen oyuncuların, meslek tanımları yapılmadığı için telif hakları, iş güvencesi ve sigorta gibi sosyal haklar konusunda belirsizlik yaşamaları kaçınılmazdır. Vergilendirme sürecinde 90.01.18 Bağımsız Aktör, Aktris ve Dublörlerin Faaliyetleri başlığı altında toplanmaları(*193 Sayılı Gelir Vergisi Kanunu*, 1960), onların iş güvencesinden muaf, düzensiz bir ekonomik çerçevede çalışmasına neden olmaktadır. Bu durum, oyuncuların meslek tanımı yapılmadan yalnızca ekonomik bir kategoriye yerleştirilerek vergilendirilmesini ve yasal güvencelerden yoksun bırakılmasını beraberinde getirmektedir.

Oyunculuk mesleği günümüzde sadece tiyatro ile sınırlı değildir. Sinema, dizi sektörü, reklamcılık, seslendirme ve dijital platformlar gibi farklı alanlarda faaliyet gösteren oyuncuların gelir modelleri de farklılık göstermektedir. Ancak, bu iş alanlarındaki gelir kaynakları arasında net bir ayrım yapılmadığı için oyuncuların hangi çalışma biçiminde hangi haklara sahip olduğu belirsiz kalmaktadır. Örneğin, bir oyuncu hem kamuda devlet tiyatrosunda çalışıp hem de reklam filmlerinde oynayabilir veya seslendirme yapabilir. Ancak bu ve benzer gelir modelindeki oyuncuların devlet tiyatrosundan (kamudan) sabit maaş alırken, reklam sektöründe proje bazlı ücretlendirilmesi durumu aynı meslek içinde bile farklı ekonomik statülerin ortaya çıkmasına yol açmaktadır(Akdede, 2011, s. 69)[1]. Özellikle oyuncunun hem kamuda hem de özel sektörde faaliyet göstermesi oyuncunun mesleki önceliklerinin ve bağımlılıklarının kamuya mı yoksa özel sektöre mi ait olduğu sorununu ortaya çıkarmaktadır. Oyunculuk mesleğinin statüsü net olarak tanımlanmadığından, sendikal örgütlenme ve meslek birliklerinin etkisi sınırlı kalmaktadır. Oyuncular, serbest meslek erbabı olarak kabul edildiğinde farklı sendikalara üye olabilmekte, ancak belirli bir işverene bağlı olduklarında işçi statüsüne geçerek farklı bir hukuki çerçevede değerlendirilme zorunluluğuyla karşı karşıya kalmaktadırlar. Bu nedenle, oyuncular için ortak bir hukuki çerçeve oluşturulmadığından, sendikalar ve meslek birlikleri oyuncuların haklarını tam anlamıyla savunamamaktadır. Oyuncuların gelir elde etme biçimlerinin belirlenmemesi, oyuncuların sendikal örgütlenme haklarını zayıflatarak çalışma koşullarını iyileştirme süreçlerini sekteye uğratmaktadır.

Türkiye'de oyunculuk mesleğinin hukuki çerçevede doğrudan tanımlanmamış olması, mesleğin kurumsal yapısını zayıflatmakta böylece mesleki eğitimin gerekliliğini

[1] Konu ile ilgili ayrıntılı araştırma ve ekonomi politik bağlamdaki değerlendirmeler için bkz. (Akdede, 2014a, 2014b)

de tartışmaya açmaktadır. Oyunculuk, sahne sanatları ve görsel-işitsel medya alanlarında profesyonel bir uzmanlık gerektiren bir meslek olmasına rağmen, meslek tanımının yasal olarak netleştirilmemesi -ve oyunculuk alanına dair standartların belirlenmemesi- bu alanda eğitim veren kurumların itibarını olumsuz etkilemekte; özellikle alana yönelik herhangi bir eğitim almamış bireylerin sektöre girişini kolaylaştıran koşul ve şartların yaratılmasına neden olmaktadır. Bu durum oyunculuk mesleğine yönelik eğitim veren kurumlarda prestij kaybına yol açarak hem sektördeki nitelikli iş gücünün değerini azaltmakta hem de liyakate dayalı işleyişin önünde büyük bir engel oluşturmaktadır. Oyunculuk mesleğinin yasal statüsünün belirlenmesi adına oyuncuların gelir modellerinin tanımlanması, mesleki eğitimin önemini vurgulamak ve sektördeki profesyonelleşmeyi teşvik etmek adına kritik bir gereklilik olarak karşımıza çıkmaktadır.

2. Ekonomi Politik Bağlamda Oyuncuların Gelir Modellerinin Tanımlanmasının Önemi

Oyunculuk mesleğinin tanımının yapılabilmesi için öncelikle oyuncuların hangi ekonomik koşullarda faaliyet gösterdiğinin belirlenmesi gerekmektedir. Oyuncular; serbest çalışma, proje bazlı istihdam ve kamusal maaşlı istihdam gibi farklı gelir modellerine sahiptir ve genellikle birden fazla işte çalışırlar (Akdede, 2022, s. 32). Bu nedenle oyuncuların gelir modelleri netleşmeden meslek tanımı yapılmaya çalışılırsa eksik ve yetersiz bir çerçeve oluşturulacaktır. Ekonomi politik açıdan oyuncuların gelir elde etme biçimlerinin tanımlanması, onların iş güvencelerinin ve haklarının korunmasına doğrudan katkı sağlayacaktır. Gelir modellerinin net bir şekilde belirlenmesi, oyuncuların hangi sektörde nasıl çalıştığını anlamaya yardımcı olurken mesleğin toplumsal ve ekonomik statüsünün belirlenmesine de zemin hazırlayacaktır. Bu nedenle, oyunculuk mesleğinin doğru bir şekilde tanımlanması için önce gelir elde etme biçimlerinin ekonomi politik bağlamda ele alınması ve hukuki, ekonomik ve mesleki statünün netleştirilmesi gerekmektedir.

Oyuncuların gelir elde etme biçimleri üç başlık altında sınıflandırılabilir:

a. Geçici veya Yarı Zamanlı Faaliyetlerden Elde Edilen Gelirler

Tiyatro, sinema, dizi, reklam, seslendirme gibi alanlarda proje bazlı ya da parça başı ücretlerle bir serbest meslek erbabı gibi faaliyet göstererek çalışmak. Dijital platformlarda (Netflix, YouTube, TikTok vb.) içerik üretimi yaparak gelir elde etmek. Sponsorluklar ve marka iş birliklerinden gelir kazanmak.

b. Tam Zamanlı Olarak İstihdam Edilen Oyuncuların Gelirleri

Devlet Tiyatrosu, Şehir Tiyatrosu gibi kamu kurumlarında kadrolu olarak çalışarak düzenli maaş almak. Bazı büyük özel tiyatrolarda veya tiyatro prodüksiyon şirketlerinde sürekli çalışan olarak görev alarak maaş ya da sözleşmeli ücret almak. Üniversitelerde oyunculuk alanında öğretim üyeliği akademisyenlik vb. görevler yaparak düzenli bir maaş karşılığı gelir elde etmek.

c. Oyunculuk Mesleği Dışında Başka Gelir Kaynaklarıyla Gelir Elde Eden Oyuncular

Oyunculuk dışında başka bir sektörde veya faaliyet kolunda (örneğin işletmecilik, medya ve içerik üretimi gibi alanlarda) çalışarak gelir elde etmek. Aileden gelen servet veya önceden birikmiş mal varlığıyla geçimini sağlamak. Oyunculuk alanı dışında eğitim ve danışmanlık hizmeti vererek ek gelir sağlamak.

Bu sınıflandırma, oyuncuların mesleki faaliyetleri ile gelir elde etme biçimleri arasındaki yapısal farkları temel alarak oluşturulmuştur. Oyunculuk mesleği, diğer geleneksel istihdam biçimlerinden farklı olarak sürekliliği ve güvencesi değişkenlik gösteren çeşitli çalışma modellerini içinde barındırmaktadır. Bu bağlamda oyuncuların gelir kaynakları, çalışma şekillerine ve sektördeki yerleşiklik düzeylerine göre üç ana başlık altında ele alınmıştır. Geçici veya yarı zamanlı faaliyetlerden elde edilen gelirler, özellikle serbest meslek statüsünde çalışan ve proje bazlı iş ilişkileri kuran oyuncular için temel bir model teşkil etmektedir. Buna karşın, tam zamanlı olarak istihdam edilen oyuncuların gelirleri, kamu ve özel sektörde kurumsal bir yapıya bağlı olarak düzenli maaş ve sözleşmeli çalışma düzeni ile şekillenmektedir. Son olarak, oyunculuk mesleğinden doğrudan gelir elde edemeyen veya ek gelir ihtiyacı duyan bireylerin başka sektörlerde çalışarak ya da mevcut birikimleriyle geçimlerini sağlamaları, sektörün ekonomik yapısı içinde sıkça rastlanan bir diğer durumdur. Bu sınıflama, oyuncuların çalışma koşullarının esnekliği, sektörel güvenceleri ve gelir istikrarı gibi faktörleri göz önünde bulundurarak, mesleğin ekonomik gerçekliğini açıklamaya yönelik sistematik bir çerçeve sunmaktadır. Ancak, bu sınıflandırma kesin ve mutlak bir ayrım olarak değerlendirilmemelidir; zira oyuncuların gelir elde etme biçimleri sektörel dinamiklere, bireysel kariyer tercihlerine ve piyasa koşullarına bağlı olarak sürekli değişkenlik göstermektedir. Bununla birlikte alan yazına dair yapılan okumalar ile gözlemler ışığında oyuncuların ekonomik durumunu en iyi yansıtan ve açıklamaya çalışan en yakın model olduğu kanaatindeyim.

3. Sonuç

Oyunculuk mesleği, günümüz kültür endüstrisinin önemli bir parçası olmasına rağmen, hukuki ve ekonomik çerçevesinin belirsizliği nedeniyle mesleki statü açısından ciddi sorunlarla karşı karşıyadır. Oyuncuların gelir elde etme biçimlerinin net bir şekilde tanımlanmaması, meslek standartlarının oluşturulmasını zorlaştırmakta ve bu durum, mesleki hakların korunmasını engelleyerek oyuncuların hukuki, ekonomik ve sosyal güvencelerini tehdit etmektedir. Oyuncuların çalışma koşullarındaki çeşitlilik, farklı gelir modellerine tabi olmalarına yol açarken vergilendirme, sosyal güvence ve mesleki örgütlenme süreçlerinde önemli eşitsizlikler ile belirsizliklere neden olmaktadır.

Bu çalışmada, oyuncuların gelir elde etme biçimleri üç ana kategoriye ayrılarak değerlendirilmiş ve bu sınıflamanın mesleki statünün belirlenmesinde nasıl bir temel teşkil edebileceği tartışılmıştır. Oyunculuk mesleğinin profesyonel bir kimlik kazanabilmesi için öncelikle ekonomi politik bir bağlamda gelir modellerinin neler olduğunun belirlenmesi büyük önem arz etmektedir. Sektördeki belirsizliklerin giderilmesi adına, oyuncuların çalışma biçimlerine göre hukuki statülerinin açıkça tanımlanması, gelir modellerinin sistematik bir çerçeveye oturtulması ve sosyal güvence mekanizmalarının güçlendirilmesi kritik bir gereklilik olarak ortaya çıkmaktadır.

Özetle, oyunculuk mesleğinin hukuki ve ekonomik açıdan net bir çerçeveye oturtulması, yalnızca oyuncuların haklarının korunmasını sağlamakla kalmayacak, aynı zamanda sektördeki profesyonelleşmeyi de teşvik edecektir. Bu bağlamda, gelir elde etme biçimleri ile meslek tanımının sistematik bir şekilde belirlenmesi, oyuncuların sektörde daha güvenceli ve sürdürülebilir bir kariyer inşa etmelerine katkıda bulunacaktır. Yapılacak düzenlemeler hem meslek örgütlerinin etkinliğini artıracak hem de oyunculuk eğitimi veren kurumların itibarını güçlendirerek nitelikli iş gücünün korunmasına katkı sağlayacaktır.

Kaynakça

193 Sayılı Gelir Vergisi Kanunu. (1960). mevzuat.gov.tr. https://www.mevzuat.gov.tr/mevzuatmetin/1.4.193.pdf

5441 Sayılı Devlet Tiyatroları Personeli Hakkında Kanun. (1949). mevzuat.gov.tr. https://www.mevzuat.gov.tr/MevzuatMetin/1.3.5441.pdf

Akdede, S. H. (2011). Tiyatrocuların Ekonomisi ve Devlet Tiyatroları. *İktisat ve Toplum Dergisi*, *12*, 68-74.

Akdede, S. H. (2014a). *Devlet Sanat İlişkisi Sanatın Politik Ekonomisi*. Efil Yayınevi.

Akdede, S. H. (2014b). *Kültür ve Sanatın Politik Ekonomisi: Devlet Tiyatroları Örneği*. Efil Yayınevi.

Akdede, S. H. (2022). Sanatın Politik Ekonomisi-II: Türkiye'de Oyunculuğun Politik Ekonomisi. *İktisat ve Toplum Dergisi*, *12*(142), 31-35.

İstanbul Büyükşehir Belediyesi, Şehir Tiyatroları Şube Müdürlüğü, Görev ve Çalışma Yönetmeliği. (2022). Şehir Tiyatroları Şube Müdürlüğü, Görev ve Çalışma Yönetmeliği. https://stcdn.ibb.istanbul/Uploads/2022/9/sehir-Tiyatrolari-sube-Mudurlugu-Gorev-ve-calisma-Yonetmeligi.doc

Oyuncu. (2025). [Portal.myk.gov.tr]. MYK Ulusal Meslek Standardı Oyuncu (Seviye 6). https://portal.myk.gov.tr/index.php?fileName=13UMS0371-6%20Rev%2000%20Oyuncu&dl=Meslek_Standartlari/3371/SON_TASLAK_PDF_20180925_155820.pdf

Assessment of the Transition from Traditional to Innovative Management in the Tourism Sector: The Case of Turkey

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Abstract

This study investigates: a) The development of innovative management practices inTurkey's tourism sector b) The dynamic drivers of change (opportunities and challenges focused on Kingdom's tourism)c) Enabling this transformation, what benefit can we obtain from digital innovation? Employing a mixed method approach including case analysis and performance indicators, it provides new insights into the potential benefits of data-driven decision-making, the impact of smart tourism technologies and customer-centricity centred tourists experience. The results show considerable progress in terms of operational efficiency, customer satisfaction, and long-term sustainability. But challenges like these and others remain, including resistances to change, regulatory restrictions and skills shortages. Through this, the current study enhances the IT tourism management literature by providing practitioners and policymakers with rich detail on how to innovate and maintain global competitiveness for the long term.

In conclusion, all of the results suggest that though digitization and innovation have immensely enhanced the efficiency of service delivery and responsiveness to self-improvement, these opportunities are marred by obstacles such as resistance to change, legislation challenges and lack of skilled human resources, among others. Finally, enhancing a culture of ongoing innovation and advanced technological integration is deemed essential for the future resilience and global competitiveness of Turkey's tourism sector amid an accelerating market evolution.

Keywords: Touristic management, Innovation, Digital transformation, Smart tourism, Turkey

I. INTRODUCTION

The tourism industry had emerged as one of the most innovative and rapidly changing sectors of the global economy, fuelled by technological progress, changing consumer trends, and growing rivalry among destinations. The way tourism businesses function has been greatly affected by the digital revolution in recent years, leading them to embrace management practices spanning from innovation to service quality in order to remain competitive. Tourism-dependent countries, like Turkey, have come to realize the importance of focusing on digital solutions to incorporate data-driven decision-making and customer-oriented methods into their operations, to support development and guarantee sustainability on a longer-term basis. However, while these technological innovations present tremendous opportunities, they also pose risks that must be solved on both operational and strategic levels. Smart tourism technologies have been one of the main facilitators of change in Turkey's tourism sector (Mirzohmedov, 2023).

These new technologies consist of artificial intelligence (AI) driven customer service tools, real-time data analysis solutions, Internet of Things (IoT) compatible hospitality channels, and automated booking mechanisms delivering tailored experience. In addition, the increasing prevalence of digital marketing and social media strategies has completely revolutionized how tourism businesses engage their potential customers, impacting their decision-making through targeted advertisements, online reviews, and influencer partnerships (Okuyucu, 2023).

Simultaneously, the industry has been incentivized to adopting smart energy solutions; digitalized supply chain management; and eco-friendly tourism practices by sustainability concerns. Even with these advances, major impediments stand in the way of seamless digital transformation. Among the most stubborn barriers is resistance, rooted in traditional business models, a dearth of technological expertise in the workforce and fears of the financial implications of digital transformation. Training and upgrading the systems in SMEs is unaffordable for many, and they are not always able to use the new digital strategies. In addition, regulatory restraints can impede the take-up of new technologies because governments often require extensive approval processes before deploying new digital infrastructure, while data privacy regulations add an additional level of complexity for organizations with respect to how they manage customer data. The second critical problem is the lack of skilled human capital (Mirzohmedov, 2023).

Digitalization has ushered in new avenues for growth and efficiency, and there is a growing need for employees trained in big data analytics, artificial intelligence, cybersecurity, and digital marketing. Many tourism businesses struggle to hire and retain the professionals with the digital skills needed to close the gap between available technology and effective use of that technology. All tackling this challenge requires strategic workforce planning, supported training initiatives by government, and partnerships between academia and tourism industry to create specialized degree programmes to educate the workforce. The aim of this research is to find out developmental positioning of innovative management practices in Turkey's tourism sector, denominator of digital transformation causatives, and advantages and barriers as a result of these changes (Okuyucu, 2023).

Adopting a mixed-methods methodology, the study integrates qualitative case analysis to derive contextual insights and utilizes quantitative performance indicators to

measure the tangible benefits of digital transformation in areas of operational efficiency, customer engagement, and market position. Through investigating how business leaders may act as catalysts for innovation and how leadership styles affect the utilization of technology by tourism enterprises, this article provides valuable contributions to better understand the decision-making practices of tourism businesses. It also examines whether external pressures globalization, changing consumer expectations, financial crises speed up or slow down the digital transition (Republic of Turkey Ministry of Culture and Tourism, 2023).

To the best of our knowledge, the above research follows the qualitative approach and thus adds to the extant body of knowledge by incorporating practical implications for regulators, businessmen and industry leaders on how to endorse digital transformation in the present era. Enhancing a competitive environment of progressive development, advancing efficiency of tourism specialists in utilizing digital tools, and collaboration between public and private sectors alike are critical to making sure Turkey's tourism market stays in the dogfight for the global game. In the age of fast-paced technological changes itself, comprehending the essence of digital transformation is a business proposition and a game changer for the backdrop of tourism development.

2. METHODOLOGY

In this study a using the mixed-methods analysis conducted in Turkey tourism sector, innovative management practices and digital transformation success between organizations were investigated. The combination of qualitative and quantitative research methods creates a rounded understanding of the underlying factors that spur innovation and what challenges are experienced by industry players, as well as how effective are the strategies employed.

The literature review means searching for, analysing and discussing academic studies, industry reports, policy documents dealing with issues related to digital transformation, smart tourism technologies and innovation in tourism management to develop theoretical concepts and identify areas for proceeding research.

3. FINDINGS AND ANALYSIS

This study identifies the drivers, obstacles, and outcomes of digital transformation in tourism and innovative management practices in Turkey tourism sector.

3.1. Top Engines of Digital Transformation in Tourism Sector

This study identified certain key factors that have synergized the speed of adoption for digital transformation in the tourism industry. Some guides use data for making decisions, enabling businesses to tailor services to buy based on customer behaviour patterns and market trends; while this can be among the most influential drivers. Smart tourism technologies, including AI-enabled customer service systems, automated booking engines, and digital marketing solutions have also driven customer experience improvement through greater engagement and service efficiency. Additionally, the rise of personalized travel experiences has compelled businesses to adopt digital solutions,

including mobile apps, virtual reality (VR) tourism experiences, and blockchain-based reservation systems.

Another important driver is the competitive pressure in the worldwide tourist market. Digital transformation has been emphasized by Turkish tourism businesses as a necessary move towards retaining international competitiveness in the face of the ever-shifting requirements of tech-familiar travellers. Moreover, the development of digital infrastructure through prospective regulatory policies, along with the push for e-governance have also helped bring technology into the domain.

3.2. Obstacles and Hurdles to Digital Transformation

While the digital transformation of the tourism industry has its benefits, a number of challenges are coming in the way of it. A major obstacle to adopting IoT is the resistance to change from businesses, especially from small and medium-sized enterprises (SMEs). For most organizations, the digital transformation has been weighed down by fears of economic costs, higher technological complexities, and loss of jobs (Mirzohmedov, 2023).

Another bottleneck is the shortage of skilled human capital tourism businesses need professionals with expertise in digital marketing, data analytics, and AI-based solutions. Organizations across verticals are experiencing a slowdown of innovation because of the technology lagging the workforce capabilities. Other challenges that impact the smooth implementation of digital tools include regulatory restrictions like data privacy laws and cybersecurity threats.

Financial constraints further emerge as a significant challenge, especially for SMEs, who may not have the capital to invest in sophisticated digital systems. This is a challenge many businesses have, struggling with how they will fund technology commitment, systems upgrade, and employee training. In addition, the process of technological integration is complex, and businesses need to guarantee that they can achieve the interoperability of existing legacy systems with the latest digital platforms (Turkish Statistical Institute, 2024).

3.3. How Digital Transformation Affects Business Performance

From a financial perspective, digitized enterprises write-up incomes development as good as they are some-more cost-efficient. According to a report, businesses utilizing digital marketing methods and tailor-made customer interaction techniques witness 15–25% growth in direct bookings on average, thereby not relying on any third-party platforms. Indeed, companies leveraging AI-powered predictive analytics for demand forecasting have been able to optimize their resource allocation and inventory management, leading to lower operational expenses.

Despite these benefits, businesses that struggle with implementation report delays in digital adoption, waste in system integration and workforce adaptation. Organizations that fail to overcome these barriers tend to be slower to grow and leave customers unsatisfied because their service models are outdated.

3.4. Industry Leading Practices and Strategic Recommendations

The recommendations for best practices and strategic approaches to advance digital transformation in the tourism sector follow from the study findings. Adopting a digital-first mindset organization-wide is where companies need to start leadership must support it and invest in technology-centric business models. To ensure smooth technology adoption business should focus on continuous employee training programs to help in closing the digital gap (Özcan, 2020).

A further important recommendation is to improve collaboration between the public and private sectors. Government support through investments in digital infrastructure, incentives for technology adoption, and regulatory frameworks that encourage innovation will further speed up digital transformation. In addition to this, cross-industry partnerships between technology providers and tourism businesses can accelerate the deployment of AI, big data and automation solutions (Acetes Travel, 2025).

Change is difficult; digital transformation must happen in stages better yet; incremental digital transformational strategies often win out when it comes to overcoming change resistance. The next step will be to develop a digital strategy that is customer-centric and emphasizes creating personalized experiences, delivering efficient service, and engaging in real time that further assets on business competitiveness (Mirzohmedov, 2023).

Table 1. Tourism Income and Average Expenditure Per Capita, 2012 - 2024

Year	Annual Quarter	Tourism income(r) (Bin $-Thousand $)	Tourism income from transfer passengers(2) (Bin $-Thousand $)	Tourism income from visitors (Bin $-Thousand $)	Average expenditure per capita from visitors ($)	Average expenditure per night from visitors ($)
2019	Annual	**42 851 778**	**-**	**42 851 778**	**826**	**79**
	I	4 844 420	**-**	4 844 420	729	81
	II	9 163 454	**-**	9 163 454	718	82
	III	19 831 482	**-**	19 831 482	918	80
	IV	9 012 421	**-**	9 012 421	831	72
2020	Annual	**15 287 810**	**118 439**	**15 169 371**	**958**	**69**
	I	4 842 626	66 779	4 775 847	847	90
	II	651 396	130	651 266	-	-
	III	5 531 919	12 645	5 519 274	985	67
	IV	4 261 869	38 886	4 222 983	922	56

2021	Annual	**30 528 342**	**218 620**	**30 309 722**	**1 032**	**74**
	I	2 669 614	43 187	2 626 427	1 010	61
	II	3 492 260	48 058	3 444 202	847	67
	III	15 596 408	60 346	15 536 063	1 139	82
	IV	8 770 059	67 029	8 703 030	962	70
2022	Annual	**50 248 936**	**391 907**	**49 857 030**	**971**	**85**
	I	6 368 559	64 286	6 304 272	977	77
	II	10 624 004	87 578	10 536 425	883	89
	III	21 508 293	129 493	21 378 800	1 018	87
	IV	11 748 081	110 549	11 637 532	972	84
2023	Annual	**56 439 612**	**565 436**	**55 874 176**	**979**	**92**
	I	8 450 781	116 613	8 334 167	1 019	84
	II	13 440 175	132 677	13 307 498	951	101
	III	22 502 131	163 974	22 338 157	996	91
	IV	12 046 525	152 172	11 894 353	954	89
2024	Annual	**61 103 419**	**606 401**	**60 497 018**	**972**	**97**
	I	8 947 889	163 089	8 784 800	975	93
	II	15 018 943	143 425	14 875 518	924	101
	III	23 348 551	162 118	23 186 433	999	95
	IV	13 788 036	137 769	13 650 267	981	97

Source: Turkish Statistical Institute, 2024

As the tourism income of turkey and the visitor expenditure are two vital subjects to monitor, the analysis comparing these elements from the year 2019 up until 2024, presents drastic changes in regards to foreign countries, where the eventual impact of the COVID-19 pandemic and the recovery are better off by year 2024.

Tourism income from 42.85 billion dollars dropped to 15.28 billion dollars between the years of 2019 and 2020, largely because of the travel bans and low international mobility. More, even though the total number of tourists is lower than before, it indicates that a tourist spends more per visit (the average expenditure per

capita increased from $826 in 2019 to $958 in 2020) that may come from longer stay at the countries visited or higher costs from pandemic restriction travellers.

The subsequent recovery stage from 2021 onwards sees a 69.96% increase to tourism revenue whereby they achieve a value of $50.25 billion in 2022 which the following value $61.10 billion in 2024 (Investment Office of the Presidency of the Republic of Turkey, 2025).

This expansion is largely due to the lifting of restrictions, an increase in international demand, and Turkey's strategic investments in digitalization and smart tourism technologies. The per capita expenditure settled within the $950–$1,032 range, with marked spikes in 2021 ($1,032) and 2023 ($979), reflecting the changing spending habits of visitors as the industry adjusted to post-covid travel behaviour (Investment Office of the Presidency of the Republic of Turkey, 2025).

Quarterly data is subject to seasonality, with Q3 ever forming the most significant tourism income in all years, reflecting peak summer travel. The Q3 income peaked in 2024 when it reached $23,34 billion, beating the years prior to the pandemic, reflecting the resilience of the tourism rebound in Turkey (Investment Office of the Presidency of the Republic of Turkey, 2025).

This growth is an indication of changing consumer behaviour and a testament to the possibilities Youtan Yi can create. Visitor spend per night varies greatly from quarter to quarter ($56 (Q4 2020) versus $101 (Q2 2023; Q2 2024) highlighting the impact of cost structures, elasticity of demand to inflation, and changing market dynamics on spending behaviour. They should ensure an equilibrium between affordability and profit that will keep Turkey competitive in the global tourism marketplace.

To sum up, the tourism sector of Turkey has shown high resilience capacity and a robust growth trend in the post-COVID world. While the growing income from tourism paired with a constant per-capita outlay for travellers indicate a good trend. Key findings include an emphasis on improved customer experience, digital transformation, as well as the need to manage economic challenges, including inflation and labour shortages, to ensure sustainable long-term growth in the industry.

Table 2. Arriving foreigners and citizens

Nationality	2019	2020	2021	2022	2023	2024
Foreigner total	**45 058 286**	**12 734 213**	**24 712 266**	**44 564 395**	**49 209 180**	**52 629 283**
OECD Countries (Europe)	**15 162 487**	**3 571 777**	**7 221 277**	**17 106 276**	**19 016 304**	**21 058 595**
Germany	5 027 472	1 118 932	3 085 215	5 679 194	6 193 259	6 620 612
Austria	401 475	112 126	284 095	454 638	496 482	548 794
Belgium	557 435	138 729	339 529	596 173	596 355	625 263
Czech Republic	311 359	15 642	89 734	295 454	384 158	410 280
Denmark	335 877	44 694	111 499	356 127	319 835	345 198
Finland	135 192	15 003	32 809	117 281	117 123	123 414
France	875 957	311 708	621 493	986 090	1 031 824	1 088 386
Netherlands	1 117 290	271 526	645 601	1 244 756	1 232 220	1 303 262
United Kingdom	2 562 064	820 709	392 746	3 370 739	3 800 922	4 433 782
Ireland	96 886	26 176	36 947	136 608	163 165	195 899
Spain	257 342	54 381	104 848	298 165	324 690	382 896
Sweden	444 285	93 703	192 872	415 696	364 984	397 201
Switzerland	311 107	127 643	219 591	382 835	390 044	406 357
Italy	377 011	72 619	116 806	420 661	602 176	719 668
Iceland	3 966	541	962	4 070	3 975	4 758
Luxembourg	10 957	2 228	8 499	13 186	15 633	17 228
Hungary	149 523	16 563	76 257	165 842	222 327	252 066
Norway	208 330	25 100	54 633	191 789	203 325	222 994
Poland	880 839	145 908	585 076	1 135 903	1 539 123	1 866 986
Portugal	54 130	12 893	26 379	74 812	92 901	112 371
Slovakia	207 108	8 648	37 963	196 462	235 303	274 047
Greece	836 882	136 305	157 723	569 795	686 480	707 133
OECD Countries (other)	**1 241 834**	**269 668**	**519 277**	**1 589 935**	**2 199 958**	**2 471 015**
U.S.A.	578 074	148 937	371 759	1 013 478	1 334 337	1 442 191
Australia	120 837	15 109	15 674	118 847	192 770	205 874
South Korea	212 970	36 636	15 206	99 869	159 039	206 931
Japan	103 320	19 122	7 153	30 610	78 782	134 697
Canada	139 164	34 210	72 034	197 416	248 868	302 728
Mexico	66 557	12 775	34 705	114 267	155 155	142 963
New Zealand	20 912	2 879	2 746	15 448	31 007	35 631
Other European countries	**4 964 914**	**2 009 596**	**2 973 702**	**5 544 613**	**5 615 126**	**5 966 990**
Albania	134 869	49 667	89 748	145 032	142 482	159 828
Bosnia Herzegovina	144 445	61 651	131 347	200 698	177 893	197 388

Bulgaria	2 713 464	1 242 961	1 402 795	2 882 512	2 893 092	2 918 581
Estonia	77 041	5 113	47 597	93 209	96 227	103 956
Croatia	56 465	16 566	29 464	61 327	66 948	77 003
Latvia	86 051	9 392	44 760	97 240	117 936	124 732
Lithuania	229 704	14 194	114 227	251 619	277 810	285 026
North Macedonia	222 862	115 483	182 045	266 184	251 066	246 626
Romania	763 320	269 076	496 178	886 555	990 005	1 173 358
Slovenia	50 414	8 108	18 580	48 622	53 600	58 884
Serbia	282 347	129 284	238 852	357 787	311 738	342 002
Other European countries	203 932	88 101	178 109	253 828	236 329	279 606
Com.of independent states	**13 157 885**	**4 350 741**	**8 742 390**	**10 056 039**	**11 938 351**	**12 574 364**
Azerbaijan	901 723	236 797	470 618	683 834	855 445	956 178
Belarus	258 419	106 426	220 932	239 966	309 216	334 796
Armenia	66 882	9 309	10 178	36 445	31 950	31 587
Georgia	1 995 254	410 501	291 852	1 514 813	1 633 977	1 466 188
Kazakhstan	455 724	137 213	366 076	712 136	826 319	863 542
Kyrgyzstan	121 364	52 142	102 840	147 487	169 906	184 174
Moldova	198 867	109 137	192 441	274 257	288 377	329 796
Uzbekistan	252 138	102 598	272 604	419 673	470 644	569 818
Russian Federation	7 017 657	2 128 758	4 694 422	5 232 611	6 313 675	6 710 198
Tajikistan	44 155	16 972	41 440	74 101	78 185	32 785
Turkmenistan	297 706	43 236	18 979	45 249	120 928	153 688
Ukraine	1 547 996	997 652	2 060 008	675 467	839 729	941 614
East Asian Countries	**591 504**	**65 554**	**52 166**	**157 335**	**362 086**	**558 801**
China	426 344	40 264	33 641	89 515	248 119	409 733

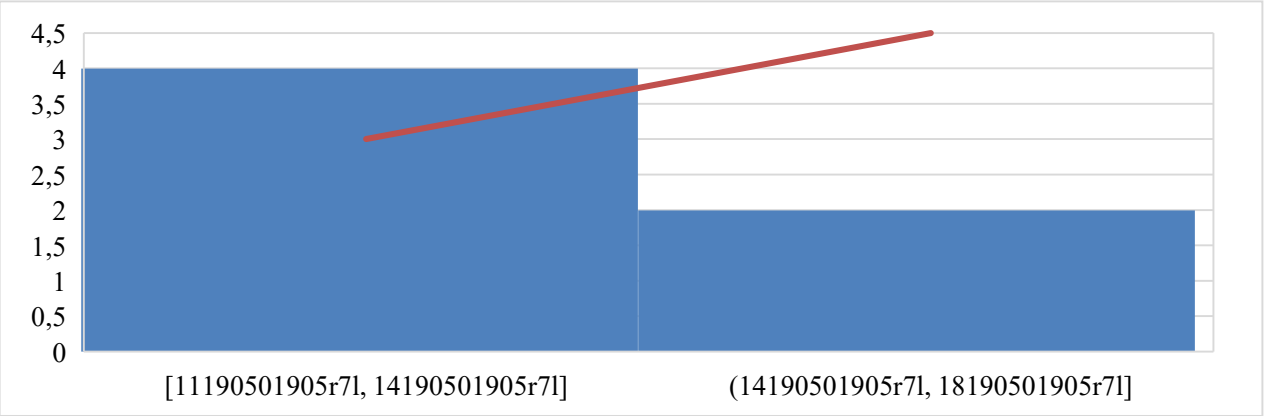
Source: Turkish Statistical Institute, 2024

Perhaps the most significant trend in the sample is the high volume of European travellers coming to Turkey, especially those from OECD countries, with Germany, England and the Netherlands serving as the leading markets for Turkey's inbound tourism. Arrivals from the countries in Europe have been gradually increasing and this indicates that the confidence in travel was regained and interest in Turkey as a destination was preserved. And one of the fundamental drivers of growth was also the increasing number of travellers from the Commonwealth of Independent States (CIS), including Russia, Ukraine, and Kazakhstan, especially in 2021 and onwards. Despite global geo-political uncertainties, there was a steady growth from 2.12 million in 2020 to 6.71 million in 2024, and Russia had sustained its position as one of the top source markets (Turkish Statistical Institute, 2024).

Other noteworthy trend is the rising interest from East Asian nations, especially China which witnessed a surge in arrivals from 89,515 in 2022 to4129,733 in 2024 (Investment Office of the Presidency of the Republic of Turkey, 2025).

That indicates a growing position of Turkey among the Asian travellers, possibly thanks to promotional campaigns targeting tourists, better connectivity facilities, and policies on visa facilitation.

Graphic 1. Foreigner total



Source: Turkish Statistical Institute, 2024

The data shows a stark decrease in 2020, with 45.05 million foreign visitors to Thailand in 2019 falling to just 12.73 million, as the COVID restrictions impacted globally when lockdowns were imposed. However, the recovery in subsequent years was robust, bringing the number of foreign visitors to 44.56 million in 2022, exceeding pre-pandemic levels in 2023 (49.20 million) and further increasing in 2024 (52.62 million).

However, various issues remained in April, such as the continuing economic instability and shifts in exchange rates, as well as external geopolitical tensions that could impact tourist arrivals. They need to adopt more sustainable tourism policies that consider the lessons learned from the post-pandemic tourism landscape and address the need for sustainable and resilient tourism policies to prevent further disruptions (Global Sustainable Tourism Council, 2025).

In conclusion, Turkey's tourism industry has displayed incredible resilience and adaptability, bouncing back in terms of foreign arrivals and broadening its market base. Sustaining this momentum will require further investments in tourism infrastructure, digital transformation, investment in technology and improvement in marketing strategies in the next two years. Moreover, the close diplomatic and economic ties developed with essential sourcing markets, most notably Europe, the CIS and East Asia, will ensure long-term development of inbound travel.

4. RESULTS

This study indicates that though digital transformation plays an important role in improved operational efficiency, customer engagement and business performance,

the effective transformation poses several challenges ranging from organizational aspects to difficulties faced on the financial and regulatory front. Companies that actively adopt digital tools and nurture innovative mindsets are poised to stay relevant in the changing tourism environment. Conversely, when we look ahead, we must remember that in order for Turkey's tourism sector to remain globally sustainable in the long-run, it needs to constantly adapt and strategically incorporate technology into its operations.

5. DISCUSSION / CONCLUSSION

The results of this study show how digital transformation and updated management practices changed Turkey's tourism industry. Our findings reveal that incorporating data-driven decision-making, smart tourism technologies, and customer-oriented strategies has significantly enhanced operational efficiency, customer satisfaction, and business sustainability. While digital transformation has much potential, its success largely comes down to addressing organizational inertia, skill shortages, and regulatory compliance.

The study adds that customer expectations are changing quickly, with travellers today expecting modernized service that is seamless, personalized, and tech-enabled. Mobile apps, AI-based recommendations, contactless payments, and virtual travel experiences create better customer engagement and give a competitive edge to businesses that invested in these areas. Customer data privacy and cybersecurity risks, however, remain major challenge. To gain trust and keep consumer confidence, company needs to create strong protection policies of their data and abide to digital security laws (Okuyucu, 2023).

On the policy forefront, regulatory challenges like data privacy laws, licensing needs for new technologies, and bureaucratic processes that move at a snail's pace remain challenges to rapid digital adoption. Although Turkey is on a path to developing its digital infrastructure, further government incentives, tax relief for digital investments and regulatory simplifications would better promote a broad adoption of smart tourism technologies. There is a need of public/private working to foster a conducive digital tourism environment.

This paper gives a thorough overview of Turkey's tourism industry restructured by digital transformation and innovative management practices. Though the generalization is vast, the finding bodes well for businesses that embrace digital solutions, as those that effectively implement current technology see increased efficiency, higher revenues and more loyal customers, while those that fail to incorporate these solutions stagnate or suffer destruction from their competitors (Global Sustainable Tourism Council, 2025).

Digital transformation is also not an end-state, but a continuum that necessitates agility, targeted investment, and training of the workforce. To this end, the study underlines that success lies in human elements that include sound leadership, digital upskilling programs and facilitative regulatory frameworks to support seamless adoption across the industry. Ultimately, it will be crucial to close the digital skills gap, which requires education and training initiatives that are vital for long-term sustainability.

In the end, this evolution of Turkey's tourism industry needs an innovative-driven culture that is customer-oriented in their digital strategies and must also invest by addressing regulatory and financial hurdles for innovatory action if Turkey wants to continue to be competitive in the global tourism industry. There is a great deal of valuable information that can support tourism marketers in adjusting to the digitalized environment, and future researchers can elaborate on these findings to discover the impacts of digitalization in the future, and their role on long-term employment trends, sustainable practices, and consumer behaviour.

6. REFERENCES

Turkish Statistical Institute. (2024). Tourism statistics quarter IV: October-December and annual, 2024. Retrieved from https://data.tuik.gov.tr/Bulten/Index?p=Tourism-Statistics-Quarter-IV:-October-December-and-Annual,-2024-53660&dil=2#:~:text=Tourism%20income%20in%202024%20increased,606%20million%20401%20thousand%20dollars.

Okuyucu, A. (2013). Tourism development in Turkey: Development process, challenges, and patterns. The Journal of Academic Social Science Studies, 6(7), 815-827. https://www.researchgate.net/publication/273878854_TOURISM_DEVELOPMENT_IN_TURKEY_DEVELOPMENT_PROCESS_CHALLANGES_AND_PATTERNS

Investment Office of the Presidency of the Republic of Turkey. (2025). Tourism industry in Turkey. Retrieved from https://www.invest.gov.tr/en/library/publications/lists/investpublications/tourism-industry.pdf

Mirzohmedov, A., & Azimov, I. (2023, June). Tourism in Turkey. Tashkent State University of Economics. https://www.researchgate.net/publication/371227222_tourism_turkey

Özcan, C. C. (2020). Economic and social impact of mass tourism developments in Turkey: A theoretical assessment. Necmettin Erbakan University. https://dergipark.org.tr/en/download/article-file/1488220

Global Sustainable Tourism Council. Retrieved from (2025). https://www.gstcouncil.org/wp-content/uploads/S16-Pelin-Rodoplu.pdf

Acetes Travel. (2025). Turkey travel guide. Retrieved from https://www.acetestravel.com/Turkey%20Travel%20Guide.pdf

Republic of Turkey Ministry of Culture and Tourism. (2023). Turkey tourism strategy 2023. Retrieved from https://www.ktb.gov.tr/Eklenti/43537,turkeytourismstrategy2023pdf.pdf

A Study on the Boundaries of Al-Rawda Al-Mutahhara

Ravza-i Mutahhara'nın Sınırları Üzerine Bir Değerlendirme

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Abstract

Al-Masjid an-Nabawi is the mosque in Medina that also contains the tomb of the Prophet Muhammad. Al-Rawda is located between the pulpit and the tomb of the Prophet Muhammad. In light of the Prophet Muhammad's declaration, *"The area between my house and my pulpit is a garden from among the gardens of Paradise."* this space possesses great spiritual significance for Muslims. Therefore, every Muslim who makes the Hajj and Umrah desires to visit this place. Therefore, Rawda has emerged as one of the most frequented areas for worship and prayer among Muslims. However, the limited physical space of the place, the increasing visitor density and the desire for worship sometimes lead to serious crowds and disruption of the peace of worship. The appointment system known as 'Nusuk,' which has been introduced to balance the intensity of visitation, seeks to regulate the process; however, it does not guarantee access for all pilgrims and at times results in overcrowding and contention. Indeed, even in front of the Prophet's tomb—where the verse *"Do not raise your voices above the voice of the Prophet!"* (al-Ḥujurāt 49:2) is inscribed—there are at times scenes that challenge the boundaries of reverence and are marked by noise and disorder.

This paper analyzes the current issues related to the boundaries of al-Rawda al-Mutahhara in light of relevant narrations and offers both scholarly and practical recommendations to address the challenges faced by pilgrims.

Keywords: Islamic history, Sīra, al-Masjid an-Nabawi, Al-Rawdah al-Mutahharah, Place, Shrine

Öz

Mescid-i Nebevî, Medine'de, içerisinde Hz. Peygamber'in kabrinin de bulunduğu mescittir. Ravza-i Mutahhara, bu mescidin içerisinde, minber ile Hz. Muhammed'in kabri arasında yer almaktadır. Bu mekân, Resûl-i Ekrem'in "*Evimle minberim arası, cennet bahçelerinden bir bahçedir*." beyanı hasebiyle Müslümanlar için büyük bir manevi değere sahiptir. Dolayısıyla hac ve umre ziyareti yapan her Müslüman için burayı ziyaret etmeyi arzulamaktadır. Bu sebeple Ravza-i Mutahhara , dua ve namaz için en çok rağbet gören alanlardan biri haline gelmiştir. Ancak mekânın

sınırlı fiziksel alanı, artan ziyaretçi yoğunluğu ve ibadet arzusu, zaman zaman ciddi kalabalıklara ve ibadet huzurunun sekteye uğramasına yol açmaktadır. Bu yoğunluğu dengelemek ve düzenlemek adına geliştirilen "nüsuk" isimli randevu sistemi, süreci yönetmeyi hedeflese de tüm ziyaretçilere erişim imkânı sağlayamamakta; yer yer izdihamlara ve tartışmalara sebep olabilmektedir. Hatta, "*Seslerinizi peygamberin sesinden daha fazla yükseltmeyin!*" (Hucurât Suresi, 49/2) ayetinin yazılı olduğu kabrin önünde, gürültü ve saygı sınırlarını zorlayan manzaralar da meydana gelmektedir. Bu tebliğde, Ravza-i Mutahhara'nın sınırlarına dair rivayetler ışığında yaşanan mevcut sorunlar tahlil edilmekte ve umrecilerin karşılaştığı zorluklara karşı hem ilmî hem de uygulamaya yönelik çözüm önerileri sunulmaktadır.

Anahtar Kelimeler: İslam Tarihi, Siyer, Mescid-i Nebevi, Ravza-i mutahhara, Mekân, Makam

1. GİRİŞ

Ravza-i Mutahhara, Mescid-i Nebevî'de, Hz. Peygamber'in kabri ile minberi arasında yer almaktadır. İslâmî literatürde bu alan hem fiziksel konumu hem de dinî anlamı itibarıyla son derece önemli bir mekândır. Ravza-i Mutahhara'nın fazileti, bizzat Hz. Peygamber'in, "*Evimle minberim arası, cennet bahçelerinden bir bahçedir; minberim de havuzumun üzerindedir.*" (Buhari, Fadlu's-salat, 5) hadisiyle beyan edilmiştir. Bu münasebetle her Müslüman Ravza'yı ziyaret etmek ister. Nitekim Hz. Peygamber'in, "*Kim kabrimi ziyaret ederse, ona şefaatim vacip olur.*" (Ṭayâlisî, el-Musned, 1/66) ve "*Kim hac yapar da ölümümden sonra kabrimi ziyaret ederse, beni hayatımda ziyaret etmiş gibi olur*." (Fâkihî, 1/435) rivayetleri, Resûl-i Ekrem'in vefatından sonra kabrine yapılan ziyaretin manevî bir buluşma, sevgi ve bağlılık ifadesi olduğunu göstermesi bakımından son derece dikkat çekicidir. Ayrıca bu husus Hz. Peygamber'in manevi huzuruna yakın olmanın zamanla sınırlanmadığını da ifade eder. Dolayısıyla, Ravza-i Mutahhara mekânla sınırlı fiziksel bir mekân olmanın ötesinde, Hz. Peygamber'in manevi huzuruna yakın olmanın bir tezahürü olarak görülmüştür.

Ravza, 22 metre uzunluğa, 15 metre genişliğe ve yaklaşık 330 metrekarelik bir yüzölçümüne sahiptir. (Bozkurt, 2007, 34/475) Mescid-i Nebevî'nin diğer bölümlerinden ayırt edilebilmesi için zemini yeşil halı ile kaplanmış olan bu alan, sınırlı kapasitesi nedeniyle aynı anda yalnızca birkaç yüz kişiyi ağırlayabilmektedir. (https://alharamain.gov.sa/19.04.2025) Fizikî açıdan dar bir alan olmasına rağmen, Ravza-i Mutahhara'nın İslâm dünyasında taşıdığı sembolik anlam son derece büyüktür. Dünyanın dört bir yanından gelen hacı ve umreciler Ravza'da namaz kılmak ve dua edebilmek adına büyük bir gayret göstermektedir. Ancak, Ravza-i Mutahhara'nın fizikî kapasitesinin sınırlılığı, günümüzde ciddi bir ihtiyaca cevap verememe sorununu da beraberinde getirmektedir. Aynı anda yalnızca birkaç yüz kişiyi ağırlayabilen bu alan, özellikle hac ve umre dönemlerinde yoğun bir ziyaretçi akınına uğramakta, bu durum ibadetlerin huşû içinde eda edilmesini zorlaştırmaktadır.

Bu tebliğde, söz konusu problem ele alınacak; klasik hadis literatüründe yer alan Ravza rivayetleri üzerinden bu soruna nasıl bir çözüm üretilebileceği tartışılacaktır.

2. RAVZA

2.1. Anlamı

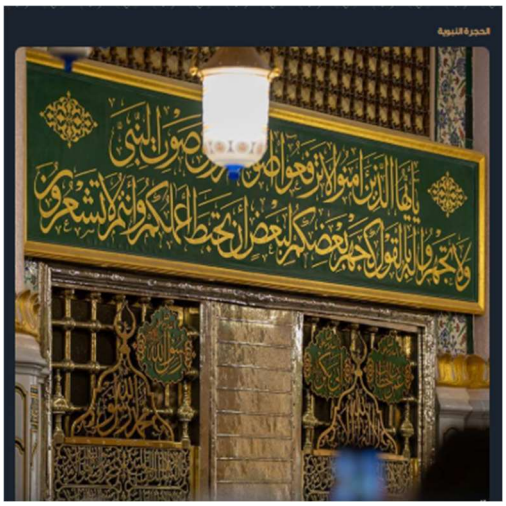
Ravza (الروضة) kelimesi, Arapça'da "bahçe" anlamına gelir. Genellikle çiçekli, yeşil ve ferah yerler için kullanılır. Özellikle yeşilliği, ferahlığı ve güzelliğiyle dikkat çeken, su ile beslenen ve çevresine hayat veren alanları tanımlamak için kullanılır. Er-Rîdân (الرّيضانُ)ve Riyâd(الرّياضُ) kelimeleri 'ravza' (الرَّوْضَة) kelimesinin çoğuludur ve bu kelime "bahçeler" anlamına gelir. (Ḫalîl b. Aḥmed, 1988, 7/55) Modern Arapçada "Riyâd" yani Suudi Arabistan'ın başkenti de buradan gelir. (https://www.almaany.com/tr/dict/ar-tr) Ravza (الروضة), Mescid-i Nebevî'de Hz. Peygamber'in evi ile minberi arasında yer alan mübarek mekâna atfen kullanıldığında, genellikle hürmet ve tazim ifade eden nitelemelerle birlikte anılır. Bu kullanım, yalnızca fiziksel bir alanı değil, aynı zamanda makam ifade eden manevî değeri haiz bir mekânı da işaret etmektedir. Kaynaklarda gördüğümüz söz konusu terkipler şunlardır: Ravza-i Mübâreke (الروضة المباركة) (Kürdî, 1420/ 2000, 1/247); Ravza-i Şerîfe (الروضة الشريفة): (Abdülgani, 1424, 32); Ravza-i Mutahhara (الروضة المطهرة) (Bozkurt, 2007, 34/475). Mezkûr terkiplerde kullanılan mübarek (bereketli), şerefli (saygıdeğer) ve mutahhar (tertemiz) gibi nitelemeler, Ravza'nın hem maddî hem de manevî açıdan eşsiz ve değerli bir mekân olduğunu vurgulamaktadır. Dolayısıyla "cennet bahçelerinden bir bahçedir" ifadesiyle mekânın genişliği kastedilebileceği gibi mecaz anlamlı olabileceği de belirtilmektedir. (Bozkurt, 2007, 34/475). Zira bazı hadislerde 'cennet' kelimesinin, teşvik edici ve manevi değeri vurgulayıcı bir anlamda, mecazî şekilde kullanıldığı görülmektedir. *"Kim bir hastayı ziyarete giderse, (onun yanından) dönünceye kadar cennet bahçelerindedir."*(Müslim, 6/432) hadisi, bu tür bir anlatımın örneklerinden biridir. Nitekim bu hadiste de 'cennet' ifadesi, belirli bir mekânı belirtmekten ziyade, sembolik olarak değerliliği ifade etmek amacıyla mecazen kullanılmış olabilir.

2.2 Mescid-i Nebevî Ziyareti

Kaynaklara göre Hz. Peygamber'in kabr-i şerifini ihtiva eden Mescid-i Nebevî, fazilet itibarıyla Mescid-i Harâm'dan sonra ikinci derecede yer almaktadır. Hz. Peygamber'in, "*Benim bu mescidimde kılınan bir namaz, Mescid-i Haram dışında diğer mescitlerde kılınan bin namazdan daha hayırlıdır.*" (Buhârî, Fadl es-Salat, 1) hadisi Mescid-i Nebevî'nin yüksek bir manevi değere sahip olduğunu ve buradaki kılınan namazların daha fazla sevap taşıdığını göstermektedir. Ayrıca Ravza'yı ziyaret bir inancın ve bir aidiyetin de sembolüdür. Bu nedenle, Mescid-i Nebevî'yi ziyaret eden müminler, buradaki manevi atmosferin faziletini en iyi şekilde değerlendirmek amacıyla özellikle nafile namazlarını burada kılmayı isterler. Bu noktada ise azami derecede sükûnete ihtiyaç duyulmaktadır. Ancak kalabalık nedeniyle sıkıntılar yaşanmakta, izdihamlar meydana gelmekte ve bazı ziyaretçiler Ravza'ya girememektedir. Bu nedenle mescidin dışında gürültü oluşmakta, hatta umreciler ile görevliler arasında zaman zaman çekişmeler yaşanmaktadır. İçeriye girebilenler arasında da kargaşa yaşanabilmektedir. Hatta *"Ey îmân edenler! Seslerinizi peygamberin sesinden daha fazla yükseltmeyin, birbirinize*

bağırdığınız gibi ona bağırmayın; sonra farkında olmadan amelleriniz boşa gider. (Hucurât, 2) ayetinin yazılı olduğu ve aşağıda resmi bulunan kabrin yakınında bu manzaralara şahit olunmaktadır. Bu mukaddes mekânda sükûnetin ve huzurun temini son derece elzemdir.

Resim 1: Hücretü'n-Nebî



Kaynak: https://alharamain.gov.sa/public/(22.04.2025)

Hz. Peygamber'den nakledilen *"Ölümümden sonra kabrimi ziyaret eden, beni hayatımda ziyaret etmiş gibi olur."* (Fâkihî, 1/435) beyanı gereği onun kabrini ziyaret ederken sükûneti korumak gerektirir. Nitekim Hucurât Suresi'nin 3. âyeti de bu hassasiyete işaret etmektedir. Hz. Peygamber dönemindeki insanlara hitaben adâb-ı muaşerete dikkat çeken "*Rasûlullah'ın huzurunda seslerini kısanlara gelince, Allah onların kalplerini takvâ ile imtihan etmiş, onlar da bu sınavdan başarıyla çıkmışlardır. Onlar için bir bağışlanma ve büyük bir mükâfat vardır."* âyetinin günümüz dünyasında da uygulamaya alınması gerekliliği Kur'ân-ı Kerîm'in çağlar üstü anlam taşıyan bir mesaj sunduğunu da göstermektedir.

2.3. Ziyaret Nizamı ve Günümüz Uygulamaları

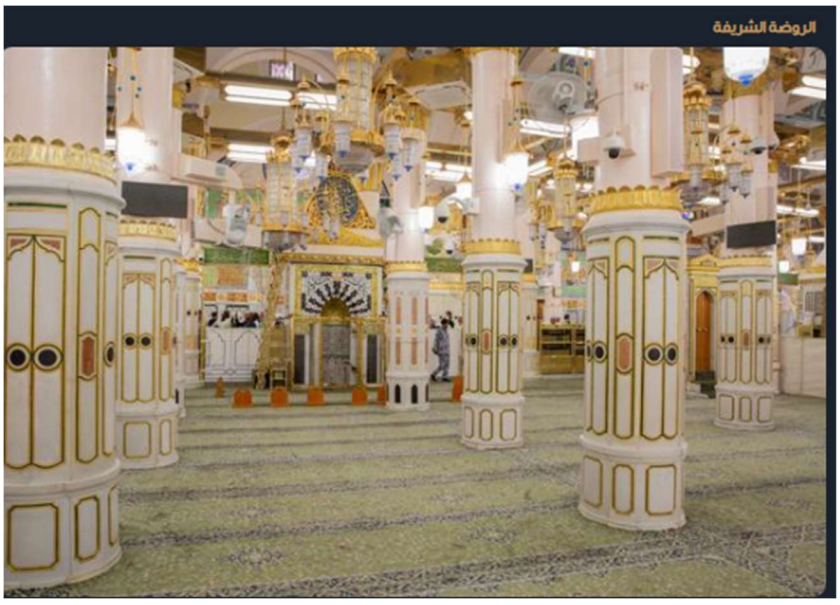
Mescid-i Nebevî'de ziyaretçi yoğunluğunu kontrol edebilmek ve süreci yönetebilmek adına Nüsuk randevu sistemi ziyaretçilerin planlı bir şekilde Ravza'ya girmesini amaçlamaktadır. (https://www.nusuk.sa/tr) Bu sistem dijital platformdan randevu sistemidir. Ravza'yı ziyaret için Nüsuk uygulaması üzerinden randevu alınması zorunludur. Bu uygulamada bireysel ve grup randevusu alınabilmektedir. (https://www.nusuk.sa/tr) Bu uygulama ile kadın ve erkek ayrı ayrı daha fazla ziyaretçinin düzenli bir şekilde Ravza'yı ziyaret etmesi amaçlanmıştır. Suud kaynaklarının verdiği bilgiye göre sistem üzerinden yapılan randevu sistemiyle Ravza-i Mutahhara'da 2024 yılı boyunca, günlük ziyaretçi sayısı: yaklaşık 48.000'dir. Bu bilgilere göre erkek ziyaretçi sayısı: 5.583.885; kadın ziyaretçi sayısı: 4.726.247 olmak üzere toplam 10 milyondan fazla kişi namaz kılma imkânı bulmuştur. (https://alharamain.gov.sa/public/?page=page_68207)

Özellikle son yıllarda ziyaretçi sayının artması münasebetiyle ziyaretlerde izdiham oluşmakta ve buna çözüm getirilmeye çalışılmaktadır. Bir süre bir kişinin senede bir kere Ravza ziyaretine izin verilerek yoğunluğa çözüm bulunmak istenmesine rağmen bu uygulamadan vazgeçilmiştir. Ocak 2025 tarihinde yaptığımız umre sonrasında, Mescid-i Nebevî ziyaretimiz sırasında bizzat şahit olduğumuz durum şudur: Grup ziyareti için alınan randevuya rağmen Ravza'ya girişimiz mümkün olmadı. Görevliler, sadece randevulu kişi sayısı kadar kişiyi içeri almakta; ancak araya karışarak usulsüz şekilde girenler nedeniyle sayı aşımı yaşanmakta ve bu durum, asıl girmesi gerekenlerin içeri alınmamasına yol açmaktadır. Neticede, içeri giremeyenlerle görevliler arasında ciddi tartışmalar ve zaman zaman bağrışmalar meydana gelmektedir. Öte yandan, bireysel randevu alan ziyaretçiler ise uygulama usulünü tam olarak kavrayamadıklarından, bazen yalnızca birkaç dakikalık gecikmeyle randevu saatini kaçırmakta ve bu sebeple haklarını kaybetmektedirler. Ravza-i Mutahhara'ya girememe durumu, özellikle tecrübe eksikliği yaşayanlar ile rehberlik hizmetine yeterince ulaşamayanlar için derin bir hüzne ve ciddi bir ızdıraba dönüşebilmektedir. Hacı ve mu'temir, içinde bulunduğu kutsal mekânda yaşadığı hayal kırıklığı sebebiyle, farkında olmadan ortama uygun düşmeyen sözler sarf edebilmektedir. Bu noktada, gönüllere ferahlık verecek bir katkı sunmak niyetiyle, Ravza-i Mutahhara'nın sınırlarıyla ilgili İslâmî literatürü gözden geçirme ihtiyacı duyduk. Aşağıda, bu konuya dair yer alan rivayetleri derleyerek okuyucunun istifadesine sunduk.

3. RAVZA-İ MUTAHHARA'NIN SINIRLARINA DAİR GÖRÜŞLER

Ravza-i Mutahhara, günümüzde resmî kaynaklara göre 22 metre uzunluğunda ve 15 metre genişliğinde olup, yaklaşık 330 metrekarelik bir alanı kaplamaktadır. Doğuda Hz. Âişe'nin evi, batıda minber, güneyde kıble yönü, kuzeyde ise Hz. Âişe'nin evinin kuzey hattına paralel bir çizgi ile sınırlandırılmıştır. (https://alharamain.gov.sa/public/?page=page_68207)

Resim 2: Ravza-i Mutahhara'nın mihrab ve minber tarafı



Kaynak: https://alharamain.gov.sa/public/?page=page_68207 (22. 04.2025)

Yukarıda görseli verilen Ravza-i Mutahhara'nın sınırlarına ilişkin klasik kaynaklarda farklı rivayetler bulunmaktadır.

3.1. Birinci rivayet

Ravza-i Mutahhara'nın sınırları Hz. Aişe'nin evi ile minber arasıdır. Aşağıda lafzen aynı ya da benzer olan rivayetler verilmiştir.

Birinci görüşü ifade eden rivayetler:

مَا بَيْنَ بَيْتِي وَمِنْبَرِي رَوْضَةٌ مِنْ رِيَاضِ الْجَنَّةِ، وَمِنْبَرِي عَلَى حَوْضِي

"*Evimle minberimin arası, cennet bahçelerinden bir bahçedir ve minberim havzımın üzerindedir*" (Mâlik b. Enes, *el-Muvaṭṭaʾ*, (1435/2015), s. 197)

مَا بَيْنَ بَيْتِي وَبَيْنَ مِنْبَرِي رَوْضَةٌ مِنْ رِيَاضِ الْجَنَّةِ، وَمِنْبَرِي عَلَى حَوْضِي.

"*Evimle minberimin arası, cennet bahçelerinden bir bahçedir ve minberim havzımın üzerindedir*" (ʿAbdurrezzâḳ, *el-Muṣannef*, 3/126)

ما بَينَ بَيتي ومِنبَري رَوضَةٌ مِن رياض الجَنَّة, ومِنبَري عَلَى حَوضي

"*Evimle minberimin arası, cennet bahçelerinden bir bahçedir ve minberim havzımın üzerindedir*" (İbn Saʿd, *eṭ-Ṭabaḳât*, (1421/2001), 1/218)

مَا بَيْنَ بَيْتِي وَمِنْبَرِي رَوْضَةٌ مِنْ رِيَاضِ الْجَنَّةِ وَمِنْبَرِي عَلَى حَوْضِي

"*Evimle minberimin arası, cennet bahçelerinden bir bahçedir ve minberim havzımın üzerindedir*" (Aḥmed b. Ḥanbel, *el-Musned*, (1431/2010), 3/978)

مَا بَيْنَ بَيْتِي وَمِنْبَرِي رَوْضَةٌ مِنْ رِيَاضِ الجَنَّةِ

"*Evimle minberimin arası, cennet bahçelerinden bir bahçedir*" (Buḫârî, *eṣ-Ṣaḥîḥ*, (1422H.), 2/61)

مَا بَيْنَ بَيْتِي وَمِنْبَرِي رَوْضَةٌ مِنْ رِيَاضِ الْجَنَّةِ

"*Evimle minberimin arası, cennet bahçelerinden bir bahçedir*" (Tirmiẕî, *es-Sunen*, (1395/1975), 5/718)

مَا بَيْنَ بَيْتِي وَمِنْبَرِي رَوْضَةٌ مِنْ رِيَاضِ الْجَنَّةِ

"*Evimle minberimin arası, cennet bahçelerinden bir bahçedir*" (Nesâʾî, *es-Sunen*, (1406/1986), 2/35)

Benzer mahiyette bir rivayetler ise şunlardır:

مِنْبَرِي عَلَى تُرْعَةٍ مِنْ تُرَعِ الْجَنَّةِ، وَمَا بَيْنَ الْمِنْبَرِ وَبَيْنَ بَيْتِ عَائِشَةَ رَوْضَةٌ مِنْ رِيَاضِ الْجَنَّةِ

"*Minberim, cennet ırmaklarından bir ırmağın üzerindedir. Minberim ile Âişe'nin evi arasındaki alan ise, cennet bahçelerinden bir bahçedir.*" (Ṭaberânî, *el-Muʿcemu'l-Evsaṭ*, (1415H.) 3/269)

إِنَّ مَا بَيْنَ مِنْبَرِي إِلَى حُجْرَتِي رَوْضَةٌ مِنْ رِيَاضِ الْجَنَّةِ، وَإِنَّ مِنْبَرِي عَلَى تُرْعَةٍ مِنْ تُرَعِ الْجَنَّةِ

"*Şüphesiz minberimle hücrem arasındaki alan, cennet bahçelerinden bir bahçedir. Ve şüphesiz minberim, cennet ırmaklarından bir ırmağın üzerindedir.*" (Aḥmed b. Ḥanbel, *el-Musned* (1421/2001), 23/367)

مَا بَيْنَ مِنْبَرِي إِلَى حُجْرَتِي رَوْضَةٌ مِنْ رِيَاضِ الجَنَّةِ، وَإِنَّ مِنْبَرِي عَلَى تُرْعَةٍ مِنْ تِرَعِ الجَنَّةِ

"*Minberim ile hücrem arasındaki alan, cennet bahçelerinden bir bahçedir. Ve gerçekten minberim, cennet ırmaklarından bir ırmağın üzerindedir.*" (Ebû Yaʿlâ, *el-Musned*, (1438/2017) 2/352)

Birinci görüş, en yaygın ve muteber kabul edilen rivayetlere dayanmaktadır. Hz. Peygamber'in evi ile minberi arasında kalan alanı ifade eden bu rivayetler, başta Mâlik b. Enes, Buhârî ve Tirmizî gibi sahih hadis kaynaklarında yer almakta; ayrıca farklı raviler tarafından benzer lafızlarla nakledilmektedir. Bu yönüyle hem rivayet hem de kaynak çeşitliliği açısından oldukça güçlüdür. Nitekim bugün Ravza-i Mutahhara olarak tanımlanan alan, bu görüşle örtüşmektedir.

3.2. İkinci rivayet

Ravza-i Mutahhara, Hz. Peygamber'in kabri ile minber arasıdır.

ما بين قبري و منبري روضة من رياض الجنة

"*Kabrim ile minberim arası, cennet bahçelerinden bir bahçedir*" (Beyhaḳî, *Şuʿabu'l-Îmân*, (1410h.) 3, 491)

İkinci görüşte ifade edilen "kabir" ifadesinden Ravza'nın Hz. Âişe'nin evinden başladığı anlaşılmaktadır. Zira Hz. Peygamber, Hz. Âişe'nin evinde vefat etmiş ve *peygamberler öldükleri yere defnolunurlar* (Tirmiẕî, *es-Sunen*, 1435/2015, 334) hükmünce eşinin odasına defnedilmiştir. Bu rivayette sözü edilen yer ile ilk rivayette kastedilen yer aynı mekândır.

3.3. Üçüncü rivayet

Ravza-i Mutahhara, Ümmühâti'l-mü'minin'in evleri ile minber arasıdır.

مَا بَيْنَ هَذِهِ الْبُيُوتِ ـ يَعْنِي: بُيُوتَهُ ـ إِلَى مِنْبَرِي رَوْضَةٌ مِنْ رِيَاضِ الْجَنَّةِ، وَالْمِنْبَرُ عَلَى تُرْعَةٍ مِنْ تُرَعِ الْجَنَّةِ

"*Şu evler –eşlerin evleri– ile minberim arasındaki alan, cennet bahçelerinden bir bahçedir. Ve minberim, cennetin ırmaklarından bir ırmağın üzerindedir.*" (Aḥmed b. Ḥanbel, *el-Musned*, (1421/2001) 26/383) Bu rivayet esas alındığında Ravza; Hz. Peygamber'in eşlerinin evlerinin tamamının sınırlarından başlamaktadır.

Bu rivayete göre yalnızca Hz. Âişe'nin evi değil, ümmehâtü'l-mü'minîn'in tamamının evlerinin sınırları esas alınmakta; böylece Ravza'nın daha geniş bir şekilde yorumlanmasına imkân tanınmaktadır.

Ancak bu rivayet, ilk iki rivayete kıyasla daha az kabul görmüştür.

3.4. Dördüncü rivayet

Ravza-i Mutahhara, "*Evim ile Musalla arasındaki alan, cennet bahçelerinden bir bahçedir.*" (Taberani, *el-Muʿcemu'l-Kebir*, (1983) 1/147)

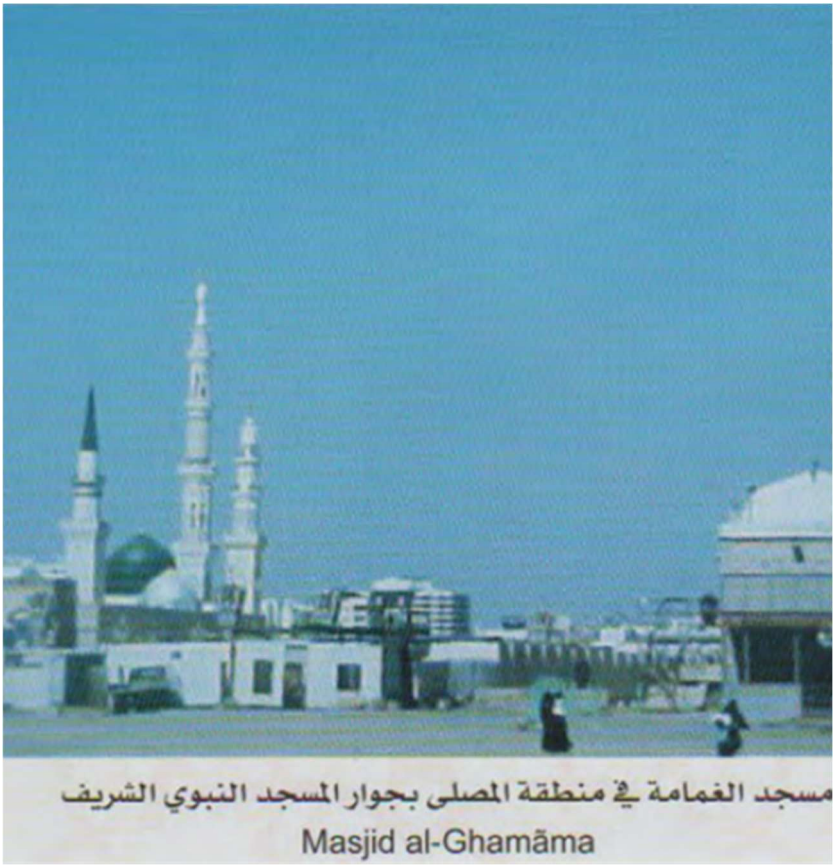
مَا بَيْنَ بَيْتِي وَمُصَلاي رَوْضَةٌ مِنْ رِيَاضِ الْجَنَّةِ

rivayetine göre Ravza'nın alanı Mescid-i Nebevî ile Musallâ (Ğamame Mescidi) arasıdır. Bu mescid, Hz. Peygamber'in bayram namazlarını kıldığı ve yağmur duası

yaptığı yer olarak rivayet edilir. (Semhûdî, *Vefâu'l-Vefâ,* (1419H), 2/30.) Ğamâme Mescidi (Mescidü'l-Ġamâme), Mescid-i Nebevî'nin güney batısında, Bâbü's-Selâm'a sadece 500 metre uzaklıktadır. (https://www.spa.gov.sa/1051581?lang=ar&newsid=1051581)

Mezkûr rivayetlerden anlaşıldığına göre, dördüncü görüş Ravza'nın sınırlarını oldukça geniş tutmaktadır. Hz. Peygamber zamanındaki mescidin tamamı ya da genişletilmiş mescidin tamamı Ravza kapsamında değerlendirilmektedir. (Hamid,1423, 49.) Bu yaklaşım, Hz. Peygamber dönemindeki Mescid-i Nebevî'nin tamamını daha sonra gerçekleşen genişletmeleri de içine alacak şekilde Ravza'nın kapsamını belirlemektedir. Aşağıda resmi yer alan Musallâ diğer ismiyle Ğamâme Mescidi sınır olarak kabul edildiğinde, Ravza oldukça geniş bir alana yayılmaktadır.

Resim: Mescid-i Nebevî ve Ğamame Mescidi



Kaynak: Hamid,1423, 49.

Bu görüş, Hz. Peygamber'in Mescid-i Nebevî'de Ravza haricinde namaz kıldığı mekânları da kapsamaktadır. Dolayısıyla Ravza sahasının genişliği diğer görüşlere kıyasla daha şümullü görünmektedir. Kanaatimizce, dördüncü rivayet Ravza'nın yalnızca fiziksel sınırlarıyla değil, aynı zamanda sembolik ve mânevî boyutlarıyla da ilgili olup "cennet bahçesi" ifadesini daha geniş bir bağlamda yorumlama imkânı sunmaktadır. Ravza-i Mutahhara'nın cennetle ilişkilendirilmesi, yalnızca mekânsal bir aidiyetin ötesinde; bu mekânda tecellî eden ilâhî rahmet, nübüvvet hatıraları ve

manevî huzur sebebiyle makamsal bir yüceliği de ifade etmektedir. Nitekim, Hz. Peygamber tarafından inşa edilen Mescid-i Nebevî'nin, onun sağlığında en yoğun şekilde kullanılan aktif alanı, ismi daha sonra "Ravza" olarak anılacak mekândır. Yukarıda "Ravza"nın anlamını açıklarken ifade ettiğimiz üzere, "cennet" kelimesi, çevresine hayat veren alanlar için kullanılmaktadır. Vahyin nazil olduğu, tebliğ faaliyetlerinin yürütüldüğü, ashâbın yetiştirildiği, iç ve dış işlerin koordine edildiği, askerî ve adlî düzenlemelerin gerçekleştirildiği bu alan, İslam toplumunun kurumsal yapısının temellendirildiği, sünnetin ihya edildiği merkezî bir mekân olma özelliğine sahiptir. Ravza-i Mutahhara, dönüşümün yaşandığı, Resûlullah'ın hem dini hem de toplumsal liderliğini ortaya koyduğu bir mekân olarak etrafına hayat veren bir alan olmuştur. Hem geçmişin hatıralarını taşıyan hem de İslam'ın geleceğini şekillendiren bir merkez olarak, Ravza hem dünyayı inşa etmeye hem de ahireti mamur etmeye vesile olan bir yer olarak mecazen "cennet"le tavsif edilmiştir denilebilir. Çünkü Kur'an-ı Kerîm'de "*İman edip dünya ve âhirete yararlı işler yapanlar güzel bir bahçede/cennette* (فِي رَوْضَةٍ) *ağırlanırlar*" (Rûm, 30/15) ve "*İman edip dünya ve âhiret için yararlı işler yapanlar cennet bahçelerinde* (فِي رَوْضَاتِ الْجَنَّاتِ) *olacaklar*" Şûrâ, 42/ 22) ayetlerinde belirtilen bu cennet bahçeleri, Ravza-i Mutahhara'nın manevi anlamı ile paralellik göstermektedir.

4. SONUÇ VE ÇÖZÜM ÖNERİLERİ

Mescid-i Nebevî, Medine'de Resûl-i Ekrem'in kabrinin bulunduğu ve İslam'ın ikinci önemli mescididir. Müslümanlar için, Rasûlullah'a duyulan sevgi ve saygının bir göstergesi olarak büyük manevi bir öneme sahiptir. Rasûlullah'ın hadislerinde geçen "*Kim kabrimi ziyaret ederse, ona şefaatim vacip olur*" ve "*Kim hac yapar da ölümümden sonra kabrimi ziyaret ederse, beni hayatımda ziyaret etmiş gibi olur*" mealindeki rivayetler, bu mekânın özel bir ziyaret alanı olarak değerini artırmaktadır. Ayrıca bu ziyaretin Hz. Peygamber'in manevi huzuruna yakın olmanın zamanla da sınırlanmadığını da ifade eder. Dolayısıyla, Ravza-i Mutahhara ziyareti mekânla sınırlı düşünülmemelidir. Bu kutsal alan, sadece fiziksel bir mekân olmanın ötesinde, manevi anlam ve sembol değer taşımaktadır.

Resûl-i Ekrem'in "*Evimle/evlerimle/kabrimle/Musalla ile minberimin arası, cennet bahçelerinden bir bahçedir*" şeklindeki beyanları da bu mescidi ziyaret etme arzusunu pekiştirmektedir. Ancak son yıllarda artan ziyaretçi yoğunluğu, Ravza-i Mutahhara'ya erişim konusunda bazı zorluklar yaratmaktadır. Bu durum, bazı ziyaretçilerin Ravza-i Mutahhara'ya girememesi nedeniyle hayal kırıklığına yol açmakta; zaman zaman mekâna duyulan saygı ve özlemin yol açtığı duygusal gerilimler, istenmeyen tepkilere ve yanlış söylemlere dönüşebilmektedir. Bu tür tepkiler, kutsal bir ziyaretin ruhunu zedeleyebilir. Bu noktada çözüm olarak, Ravza-i Mutahhara'nın sınırlarını belirleyen rivayetlerin tek bir mekâna işaret etmediği, birden fazla rivayet bulunduğu ve daha geniş bir alanın da Ravza-i Mutahhara olabileceği; ayrıca bu sınırların yalnızca fiziksel ölçülerle sınırlı olmayıp, aynı zamanda sembolik anlamlar taşıdığı vurgulanmalıdır. Zira, Ravza-i Mutahhara'ya dair mezkur rivayetlerde, bu mekânın yalnızca fiziksel bir alan değil, aynı zamanda metafiziksel bir anlam dünyasına sahip olduğu ortaya konmaktadır. Yine rivayetler "mekân" ile "makam" arasındaki alakayı gözler önüne sermektedir. Bu perspektif ile, hac ve umre öncesinde gerçekleştirilecek bilgilendirme ve eğitim çalışmaları ile ziyaretçilere Mescid-i Nebevî mekânının her bir parçasının kıymeti hatırlatılmalıdır. Ravza-i Mutahhara'nın taşıdığı manevi değer hakkında

farkındalık oluşturmalıdır. Bu bilinç ile mescidi ziyaret eden kimse; mekânın manevi boyutuna odaklanarak, daha huzurlu ve anlamlı bir ziyaret sağlayabilir. Ziyaretin manevi hususiyetini tam anlamak, hacı ve umrecilerin bulundukları alanın her bir metrekaresinin kıymetini anlamalarına yardımcı olacaktır. Bu bilinçle yapılan ziyaretler hem bireysel hem de toplumsal düzeyde daha saygılı, huzurlu ve şuurlu bir ibadet sağlayacaktır.

KAYNAKÇA

Abdülgani, Muhammad İlyas (1424). *Târîḫu'l-Medîneti'l-Münevvere.* Medine-i Münevvere: Mektebetü'l-Melik Fahd el-Vataniyye.

ʿAbdurrezzâḳ, Ebû Bekr ʿAbdurrezzâḳ b. Hemmâm es-Ṣanʿânî, 1435/2015. *el-Muṣannef* (nşr. Heyet), Kahire: Dâru't-Teʿṣîl.

Bozkurt, Nebi (2007). Ravza-i Mutahhara. *TDV İslâm Ansiklopedisi*, İstanbul: TDV İslâm Ansiklopedisi.

Aḥmed b. Ḥanbel Ebû ʿAbdullâh Aḥmed b. Muḥammed b. Ḥanbel eş-Şeybânî, (1421/2001). *el-Musned* (nşr. Şuʿayb el-ʾArnavûṭ, ʿÂdil Murşid v.dğr), Muessesetu'r-Risâle.

Aḥmed b. Ḥanbel, Ebû ʿAbdullâh Aḥmed b. Muḥammed b. Ḥanbel eş-Şeybânî, (1431/2010) *el-Musned* (nşr. Heyet), Cemʿiyyetu'l-Meknez.

Beyhaḳî, Ebû Bekr Aḥmed b. el-Ḥuseyn b. ʿAlî el-Ḫusrevcirdî. (1410H.) *Şuʿabu'l-Îmân* (nşr. Muḥammed Zağlûl), Beyrut: Dâru'l-Kutubi'l-ʿİlmiyye.

Buḫârî, Ebû ʿAbdullâh Muḥammed b. İsmâʿîl (1422H) *el-Câmiʿu'l-Musnedu'ṣ-Ṣaḥîḥu'l-Muḫtaṣar* (nşr. Muḥammed Zuheyr en-Nâṣır), Beyrut: Dâru Ṭavḳi'n-Necât.

Ebû Yaʿlâ, Ebû Yaʿlâ Aḥmed b. ʿAlî el-Mevṣılî, (1438/2017) *Musnedu Ebî Yaʿlâ* (nşr. Heyet), Kahire: Dâru't-Teʾṣîl.

Fâkihî, Ebû ʿAbdullâh Muḥammed b. İsḥâḳ el-Mekkî (1414H.) *Aḫbâru Mekke fî Ḳadîmi'd-Dehri ve Ḥadîsihi* (nşr. ʿAbdulmelik ʿAbdullâh Dehîş), Beyrut: Dâru Ḫaḍar.

Hamid, Hâlid Muhammed (1423), *Mealimü'l-Mescidi'n-Nebeviyyi'ş-Şerif = The Prophet's Mosque,* Medine: Mektebetü'l-Melik Fahd el-Vataniyye.

İbn Saʿd, Ebû ʿAbdullâh Muḥammed b. Saʿd b. Menîʿ, (1421/2001) *eṭ-Ṭabaḳât* (nşr. ʿAlî Muḥammed ʿOmer), Kahire: Mektebetu'l-Ḫancî.

Kürdî, Muḥammed Ṭâhir b. ʿAbdi'l-Ḳādir, Târîḫu'l-Ḳavîm li-Mekke ve Beyti'llâhi'l-Kerîm (1420/2000) Beyrût: Mektebetü'n-Nahḍa el-Ḥadîse.

Mâlik b. Enes, Ebû ʿAbdullâh Mâlik b. Enes b. Mâlik el-Medenî (ö.179/796), el-Muvaṭṭaʾ (nşr. Muḥammed Fuʾâd ʿAbdulbâḳî), Dâru İḥyâʾi Turâsi'l-ʿArabî, Beyrut 1406/1985.

Muslim, Ebû'l-Ḥuseyn Muslim b. el-Ḥaccâc el-Ḳuşeyrî en-Nîsâbûrî (1435/2014) *el-Musnedu's-Ṣaḥîhu'l-Muḫtaṣar bi Naḳli'l-ʿAdl ʿani'l-ʿAdl ilâ Resûlillâh* (nşr. Heyet), I-VII, Kahire: Dâru't-Teʾṣîl.

Nesâʾî, Ebû ʿAbdurraḥmân Aḥmed b. Şuʿayb el-Ḫurâsânî, (1406/1986) *el-Muctebâ mine's-Sunen es-Sunenu's-Ṣuğrâ* (nşr. ʿAbdulfettâḥ Ebû Ğudde), Halep: Mektebetu'l-Maṭbûʿâti'l-İslâmiyye.

Semhûdî, Ebû'l-Ḥasen ʿAlî b. ʿAbdullâh, (1419H.) *Vefâu'l-Vefâ bi Aḫbâri Dâri'l-Muṣṭafâ* (nşr. Ḫâlid ʿAbdulğanî Maḥfûẓ), Beyrut: Dâru'l-Kutubu'l-ʿİlmiyye.

Ṭaberânî, Ebû'l-Ḳâsım Suleymân b. Aḥmed eş-Şâmî, (1415H) *el-Muʿcemu'l-Evsaṭ* (nşr. Ṭâriḳ b. ʿİvaḍullâh b. Muḥammed, ʿAbdulmuḥsin b. İbrâhîm el-Ḥuseynî) Kahire: Dâru'l-Ḥaremeyn.

Ṭaberânî, Ebû'l-Ḳâsım Suleymân b. Aḥmed eş-Şâmî, (1983) *el-Muʿcemu'l-Kebîr* (nşr. Ḥamdî b. ʿAbdulmecîd es-Selefî), Beyrut: Dâru İḥyâʾi't-Turâsi'l-ʿArabî.

Ṭayâlisî, Ebû Dâvûd Suleymân b. Dâvûd el-Baṣrî, (1419/1999) *el-Musned* (nşr. Muḥammed b. ʿAbdulmuḥsin et-Turkî), Kahire: Dâru Hecer.

Tirmiẕî, Ebû ʿÎsâ Muḥammed b. ʿÎsâ, (1395/1975) *Sunenu't-Tirmiẕî* (nşr. Aḥmed Muḥammed Şâkir, Fuʾâd ʿAbdulbâḳî), Mısır: Şirketu Muṣṭafâ'l-Bâbî'l-Ḥalebî.

Tirmiẕî, Ebû ʿÎsâ Muḥammed b. ʿÎsâ (1435/2015), *es-Sunen* (nşr. Heyet), Kahire: Dâru't-Teʾṣîl.

İnternet Kaynakları

https://kuran.diyanet.gov.tr/ (10.04. 2025)

https://alharamain.gov.sa/(19. 04. 2025)

https://www.almaany.com/tr/dict/ar-tr. (20. 04. 2025)

https://www.nusuk.sa/tr (22. 04. 2025)

https://www.spa.gov.sa/ (23.04.2025)

Aspects of Forced Labor of Prisoners of War in 1940-1945 in Sudetenland

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Abstract

The contribution summarizes key findings on the forced labor of prisoners of war in the area of Sudetenland and examines its aspects in terms of the clasification of POWs based on racial-ideological criteria, as well as their working and living conditions, including new approaches to a comprehensive study of the issue. These new approaches rely on interdisciplinary research with significant involvement of sociological disciplines such as social psychology and historical sociology and their methods, aiming for a deeper understanding of the functioning of the specifically defined space of the POW camp, including an analysis of complex relationships between prisoners of war and the civilian population, everyday interactions, and their impact on local communities. The author works with the theory that the camp functioned as an isolated community with its own rules, in which each individual occupied a precisely defined place and adopted their social role within a strictly delineated space. The contribution applies sociological approaches to the still underexplored phenomenon of prisoners of war camps during World War II.

Keywords: Prisoners of War; World War II; Sudetenland; Forced Labor

World War II was the most extensive military conflict in modern history, eventually involving nearly every part of the globe. Today, we possess a thorough understanding of almost all aspects related to military operations, resistance movements, key historical figures, and Nazi ideology. However, over the past few decades, one area has remained relatively underexplored in public discourse: the study of forced labor involving civilian workers, concentration camp inmates, and prisoners of war – groups that were treated in accordance with racial and ideological principles.

This paper aims to introduce the scholarly community to the fundamental issues concerning the early deployment of prisoners of war in the specific context of the

Reichsgau Sudetenland, an administrative entity of Nazi Germany established on April 15, 1939, as part of the territorial reorganization of the former Czechoslovak state. The contribution also outlines the key terminology associated with this subject and presents new perspectives for research by employing interdisciplinary methodologies to achieve a deeper understanding of the mechanisms of forced labor involving prisoners of war.

The Origins and Development of the Deployment of Prisoners of War in the Reichsgau Sudetenland

Following the signing of the Munich Agreement and the subsequent occupation of the Czechoslovak borderlands in the autumn of 1938[1], this territory was incorporated into Nazi Germany as the Reichsgau Sudetenland.[2] This newly established administrative unit became one of the many instruments of the Nazi policy of Germanization, while also representing a strategically important region for wartime economic moblization. From the very beginning of the war, the Sudetenland became involved in military production. Local industry, agriculture, and transport infrastructure soon experienced a severe labor shortage due to the conscription of Sudeten Germans into the Wehrmacht. The Nazi regime responded to this shortage by progressively deploying forced laborers, including civilian workers and prisoners of war (POWs).[3]

Initally, POWs passed through collection and transport stations (*Sammelpunkte*) set up by Wehrmacht commanders behind the front lines. From there, they were transferred to transit camps known as Dulags (short term for *Durchganslager*), which were separated from other camps by barbed wire.[4] In the second stage, the prisoners were sorted by rank and allocated to different types of camps. Captured officers were

[1] The Munich Agreement was a pact between Nazi Germany, Italy, France and Great Britain to cede the border territories of Czechoslovakia to Germany. It was negotiated on 29 September 1938 in Munich without the participation of Czechoslovakia and represented a perfect example of the policy of appeasement, which characterised the concession to aggressive parties in the 1930s. In the Czech environment, the agreement became known as the „us without us agreement". Numerous scholarly literature has been published on the agreement. For example, Němeček, Jan (2011). Dlouhé stíny Mnichova. Mnichovská dohoda očima signatářů a její dopady na Československo. Prague: Auditorium; Šebková Jarmila (2024). Na cestě k Mnichovu. Runcimanova mise v Československu 1938. Prague: Citadelle.

[2] Liberec (Reichenberg in German language) became the seat of the Sudetenland and Konrad Henlein was appointed Reich Governor. The county was administratively divided into three administrative districts (Regierungsbezirks in German) in Cheb, Ústí nad Labem and Opava. The governmental districts were subsequently divided into urban and rural districts. On the functioning of the Sudetenland and its economic aspects see Kural, Václav, Radvanovský, Zdeněk (2002). „Sudety" pod hákovým křížem. Ústí nad Labem: Albis International.

[3] Forced labor is defined nder the International Labor Organization Forced or Compulsory Labor Convention, 1930, No. 29, as *„any work or service which is exacted from a person under pain of punishment and which the person has not volunteered to perform."* The Convention was adopted at the 14th Session of the International Labor Conference on 28 June 1930 and entered into force on 1 May 1932. Its full text is available on the official website of the Czech Ministry of Labour and Social Affairs under number 29 in the section of ratified conventions.

[4] These camps, created in the immediate vicinity of the front, had the task of concentrating, sorting and sending prisoners of war to other camps. Kocourková, 2002: 263.

sent to officer camps (*Oflags*, from *Offizierlager*)[5], while the rest were assigned to regular base camps (*Stalags*, from *Stammlager*).[6]

The first POWs deployed in the Sudetenland were primarily from Poland and France. Initially, they were concentrated in small collection camps and labor detachments (*Arbeitskommandos*), which were formed according to the needs of local industrial enterprises and agricultural estates. This early phase was characterized by improvised and poorly coordinated deployments, managed mainly by the Wehrmacht – which oversaw POW affairs – and local district authorities.[7] Prisoners were not permitted to have contact with the civilian population, both in the Sudetenland and in the Protectorate of Bohemia and Moravia, where they were typically not sent due to concerns about potential solidarity from the Czech population.[8]

From 1942 onward, the deployment of forced labor became significantly more organized. As German military losses mounted and more civilians were mobilized for the war effort, POWs were systematically assigned to individual enterprises within the framework of *Arbeitskommandos,* which were subordinate to larger base camps (*Stalags*) located outside the Sudetenland, such as Stalag VIII B in Lamsdorf.[9] Each labor detachment was supervised either by a military guard or a cooperating civilian employee who was responsible for taks fulfillment and discipline. POWs were registered using personal files that tracked attendance, work performance, and any infractions.[10] Correspondence was strictly censored, and contact with civilians was oficially prohibited.

As the war progressed, the deployment of POWs became increasingly intensive and diversified. In addition to French and Polish prisoners, Italian[11] and especially Soviet POWs were brought in great numbers – often under the harshest conditions. Their treatment was shaped by Nazi racial ideology, which viewed them as „inferior" laborers. POWs worked in a variety of sectors, most commonly in agriculture, but increasingly also in industry, armaments production, and forestry, including logging operations.

[5] The prisoners stayed exclusively in the camp and did not have to work. An exeption was made for Soviet officers who were transported to Stalags or directly to concentration camps and murdered immediately upon arrival. Lusek, 2015: 3.

[6] Stalags were intended for regular soldiers and non-commissioned officers and assigned larger groups of prisoners to individual companies, which then established branches or commandos of basic camps. Bubeníčková, 1969: 28.

[7] Immediately after the outbreak of war by the invasion of Poland, Polish prisoners of war were deployed in the Reich's agricultural and forestry factories. Bubeníčková, 1969: 35.

[8] The term Protectorate of Bohemia and Moravia was used for the residual Czechoslovakia, which was established on 15 March 1939. Konečný, 1967: 43.

[9] Stalag VIII B Lamsdorf was located near the village of Lambinovice in Silesia, today this area belongs to Poland and was later renumbered Stalag 344 as a result of reorganisation. In various places in what is now southern Poland and northern Bohemia, there were more than 700 labor detachments (Arbeitskommandos in German) originating from this main basic camp. More detailed information about the POW camp is provided by, among others, the Central Museum of POWs, which is currently located there.

[10] To this day, there are still records of forced prisoners of war from various factories and diaries with attendance lists. See e.g. State Regional Archive in Zámrsk in Czech republic.

[11] The Italian prisoners were classified only as „Italian interned soldiers" („italienische Militärinternierte" or IMI in German), which should have separated them from other prisoners and excluded any assistance under the Geneva Convention guidelines. Bohr, Schnurr, 2023: 131.

The Status of Prisoners of War and Racial-Ideological Considerations

Racial-ideological considerations played a central role in Nazi policy towards prisoners of war. Hitler's régime did not view prisoners as neutral opponents protected by international law but judged them through the lens of Nazi racial idelogy, which established a hierarchy of nations – from „racially related" people to „racially inferior" or „racial enemies." This ideological categorization had direct consequences for the treatment, labor deployment, living conditions and survival prospects of prisoners.[12]

The Nazi regime's racial ideology was based on the concept of the "Aryan superhuman," considered the bearer of culture and empire; "racially related" nations, intended for assimilation and utilization; "racially inferior" nationalities, including Slavs and Roma, designated for enslavement; and "racial enemies," particularly Jews and Slavs, marked for extermination.[13] The treatment of prisoners was further influenced by military, economic, and political-propagandistic interests. After 1942, economic imperatives increasingly overshadowed racial-nationalist policies, as Germany's deteriorating situation at the front demanded the efficient exploitation of all available labor. This tension between economic needs and racial-political aims ultimately resolved in favor of maximizing labor output, regardless of racial considerations.[14]

In dealing with prisoners of different nationalities, the Nazis applied the principles of so-called National Socialist racial policy (nationalsozialistische Fremdvolkpolitik). Based on the aforementioned categories, an ideological hierarchy was established in which each prisoner occupied a predetermined place. French, Belgian, and British prisoners were viewed as racially akin to the Germanic race due to cultural and biological criteria and were mostly afforded the protections of the Geneva Convention.[15] Nevertheless, the French found themselves in a relatively worse position, shaped by Germany's deep-seated enmity toward France, which had its roots in the humiliations of the Treaty of Versailles after World War I and led to stricter measures.[16] Still, in practice, French prisoners often experienced relatively lenient conditions: they were allowed excursions to nearby towns and villages, engaged in barter to acquire other goods, and interacted with the civilian population, particularly German women. They could also attend cultural events, theater performances, local cinemas, and public houses, fostering social interaction with civilians. These circumstances sometimes caused resentment among the Sudeten German population, ultimately prompting stricter regulations, particularly when relationships between French prisoners and Sudeten German women became deemed intolerable.[17] French prisoners were typically

[12] Rass, 2020: 62.
[13] Rass, 2020: 62.
[14] In 1941-1942, the Reich Ministry for Eastern Territories issued instructions according to which economic interests were to be disregarded.
[15] The Geneva Conventions date from 1929, and according to them, prisoners of war here are members of the armed forces of the belligerent states who have fallen into enemy captivity, and members of the militia and volunteer corps. The Convention did not apply to Red Army soldiers because the Soviet Union did not ratify it and Nazi Germany refused to apply it to Soviet prisoners of war.
[16] The idea was fostered in German society that the Germans were starving and dying en masse as a result of these degrading conditions, leading to the future destruction of Germany and the extermination of the German nation. Chapoutot, 2021: 357.
[17] The tightening of surveillance over French prisoners of war began to be addressed by the High Command of the Wehrmacht (Oberkommando der Wehrmacht, OKW) as early as October 1941. A directive issued on 14 January 1942 acknowledged that the gradual relaxation of regulations had led to situations exceeding the original intentions of the command. It newly stipulated, in its key points, a prohibition on movement outside

employed in agriculture or light industry. Those assigned to farms often enjoyed better food and living conditions compared to those in regular POW camps, further facilitating contacts with the local civilian population.

By contrast, Soviet prisoners of war were subjected to extraordinarily harsh treatment. Since the Soviet Union had not acceded to the Geneva Conventions, Soviet POWs were denied any legal protection by the Wehrmacht and SS. Moreover, within the framework of National Socialist doctrine, ideological and racial motivations converged to justify their extermination and exploitation through exhaustive labor. Consequently, large numbers of Soviet prisoners perished early in the war due to starvation, disease, and brutal mistreatment. Soviet POWs were assigned the harshest types of labor, predominantly in mining, forestry, and construction and maintenance of roads.[18] Initially, they were forbidden from working in the armaments industry due to ideological concerns about the spread of "Bolshevik contagion" (communist ideology). However, by late 1942, as Germany's military fortunes worsened, economic necessities prevailed, and Soviet prisoners were increasingly deployed as cheap labor in armaments production.[19]

Unlike prisoners from Western countries, Soviet POWs were to be strictly isolated and segregated from other groups of forced laborers, and any contact with the civilian population was prohibited. This policy was partly driven by fears of their sabotage capabilities and combat experience.

A comparison of conditions between Western prisoners of war and Soviet prisoners starkly illustrates the impact of racial-ideological principles on treatment. While prisoners from Western countries generally benefited from the protections of the Geneva Convention, including access to better food and opportunities for interaction with civilians, Soviet prisoners were stripped of their human dignity, subjected to catastrophic conditions, and suffered extraordinarily high mortality rates. The treatment of Soviet POWs followed a doctrine aimed at their gradual physical annihilation, with no regard for their survival.

Research Approaches and Methodologies

A fundamental shift in the historiographical examination of the topic occurred after that fall of communist regimes in Europe following 1989. Research opened up to microhistorical, interdisciplinary, and comparative approaches, among which historical sociology, oral history, social psychology, legal history, and local and regional history have become particularly significant disciplines.

Microhistorical approaches focus on the detailed analysis of small, specifically defined historical units such as communities or events, with the aim of uncovering deeper structures and mechanisms within broader historical processes. In relation to the

designated areas without supervision and forbade visits to public places, particularly restaurants and cinemas.

[18] A report by the Prisoners of War Office in May 1944 spoke of more than five million Soviet soldiers who had been taken prisoner by the German. More than half of them perished; the final figure speaks of more than three million Soviet POWs, the fate of most of whom is still unknown. Bubeníčková, 1969: 34.

[19] For example, Chief of the General Staff general Halder noted in his diary: *„Bolshevism equals social crime. Communism is an unheard-of danger to the future. We must give up military comradeship: a Communist is no friend before or after.*“ Pecka, 1995: 38.

study of prisoners of war (POWs) and captivity during the World War II, these approaches offer valuable insights, particularly regarding to everyday life in captivity, interactions between prisoners and civilians, individual survival strategies, and personal experiences.[20] Typical methods applicable to POW research include detailed archival reconstruction[21], the biographical method[22], oral history[23], spatial analysis[24] and comparative case studies.[25] Specific examples of microhistorical research focus on individual camps or daily life within the camps.[26]

Historical sociology employs methods that facilitate the integration of historical analysis with theoretical frameworks from the social sciences. The method of comparative historical analysis, for instance, compares conditions of captivity across different countries and examines differences in the treatment of prisoners based on nationality, status, and other criteria. It is particularly applicable to comparisons between the treatment of Western and Soviet prisoners.[27] Institutional analysis examines the functioning and development of institutions responsible for the administration of POW camps and can be applied, for example, to the gradual shift in Wehrmacht policies toward prisoners, as well as the role ideology and military practice played in this process.[28] Another valuable method is the analysis of power and state violence, which can be used to study the deployment of prisoners of war as labor within the wartime economy and the disciplinary practices within camps.[29]

Oral history methods have become essential tools for examining POW experiences during the World War II, especially when capturing individual memory, emotionality, subjective experiences, and the cultural meanings of war and captivity. Essentially, the methodology employs biographical and thematic interviews. Biographical interviews aim to capture a comprehensive life story, with captivity framed as a key life experience, offering material for the analysis of the long-term impact of captivity. Thematic interviews focus on specific aspects, enabling structured comparisons between respondents.[30]

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[20] Levi, 1991: 93-113.

[21] The study of one particular camp in the Sudetenland for example.

[22] Relating to the fate of individual prisoners of war according to the files or correspondence.

[23] Memories of civilian contact with prisoners.

[24] Focused on mapping specific camps, workplaces and prisoner movement routes.

[25] Focused on a specific region or location according to well-defined criteria.

[26] For examples of monographs working with microhistorical approaches in POW research for example. Scheck, Raffael (2006). Hitler's African Victims. The German Army Massacres of Black French Soldiers in 1940. Cambridge: Cambridge University Press. In this book, the author reconstructs the fate of a particular group of African POWs in German captivity, focusing on ethnicity, racial ideology and regional perspective. Kühne, Thomas (2010). Belonging and Genocide. Hitler's Community 1918-1945. Yale: Yale University Press. The author combines microhistory, social psychology and ideological analysis in this book.

[27] In major synthesizing work Bob Morre clearly applies a comparative analysis of the institutional, ideological and practical aspects of captivity and the post-war fate of POWs. Moore, Bob (2022). Prisoners of War. Europe 1939-1956. Oxford: Oxford University Press.

[28] An example is the now classic work by Rolf Keller, which maps in detail the institutional layout of the prison camp systém in the Third Reich, mostly at the turn of 1941/1942. Keller, Rolf (2011). Sowjetische Kriegsgefangene im Deutschen Reich 1941/42. Eine Dokumentation. Göttingen: Wallstein Verlag.

[29] Ben Sheperd's book combines power analysis and military operations in the East with everyday violence, including the treatment of prisoners. Shepherd, Ben (2004). War in the Wild East. The Germany Army and Soviet Partisans. Harvard: Harvard University Press.

[30] An example of this approach is the Oral History Archive project of the Stiftung EVZ, which focuses on thematic interviews with former forced laborers, including prisoners of war.

Methods derived from social psychology in the context of POW research allow for a deeper understanding of interpersonal interactions, mechanisms of adaptation, and collective behavior under extreme conditions. The study of group cohesion, hierarchy, and conformity explains the emergence of informal leaders, moral norms within the camps, and conflicts between groups. A crucial concept here is that of the „captured society," which views the POW camp as a microcosm with its own set of rules.[31] Retrospective anallysis of memories and autobiographies assists in mapping the long-term psychological impact of captivity on individuals as well as collective narrative within communities.[32] Another method draws on findings from experiments, most notably the Stanford Prison Experiment conducted by American psychologist Philip Zimbardo, whose conclusions can be applied to the study of POW camps, raising questions about individuals as instruments of the regime and the power of uniforms in establishing authority.[33]

Legal history represents a specific research direction that connects the history of armed conflicts with the development of international humanitarian law, institutional power structures, and legal treatment. In this context, it examines the legal status of prisoners of war according to international treaties in force during the war, such as the Geneva Convention, and their application in practice.[34] It also focuses on systematic violations of prisoners' rights through killings, forced labor, or denial of POW status, seeks to identify responsible individuals and institutions within the Nazi or Allied administrations, and reconstructs legal arguments used postwar, with reference to the Nuremberg Trials. The legal framework concerning the forced labor of prisoners of war is based on the interpretation of the legal distinction between "prisoner of war" and "civilian forced laborer." Issues of repatriation, retribution, and the legal status of POWs after the war, including the approaches of postwar judicial bodies toward crimes committed against prisoners, are also addressed.[35]

Local and regional history focuses on specific geographic areas and their particular experiences with prisoners of war. It mainly utilizes local archival documents and eyewitness testimonies, which are instrumental in researching specific camps within regional contexts or the local impacts of POWs on everyday life. It often examines the integration of POWs into the labor force in occupied areas through forced labor and their interactions with the local civilian population and specific industrial enterprises where the prisoners were employed.[36]

[31] Streit, Christian (1978). Keine Kameraden. Die Wehrmacht und die sowjetischen Kriegsgefangenen 1941-1945. Bonn: Deutsche Verlags-Anstalt.

[32] For example, Pavel Mücke's monograph focusing on the memorial works of Czechoslovak soldiers from the World War II, works with this concept in the Czech environment. Mücke, Pavel (2013). Rámce paměti druhé světové války v českých zemích. Prague: Ústav pro soudobé dějiny AV ČR.

[33] Zimbardo, Philip (2007). The Lucifer Effect. United States: Random House.

[34] S.P. Mackenzie's comparative study covers the treatment of prisoners of different nationalities in the light of legal frameworks in all the major belligerent countries. Mackenzie, S.P. (1994). The Treatment of Prisoners of War in World War II. Chicago: Chicago University Press.

[35] Chinkin, Christine (2015). International Law and the Protection of Prisoners of War. Oxford: Oxford University Press.

[36] For example in Czech historiography. Rous, Ivan (2023). Zbrojní průmysl a tábory. Liberec: Kalendář Liberecka.

Conclusion

The aim of this text was not only to inform about the deployment of prisoners of war (POWs) for labor in the Reichsgau Sudetenland, but also to stimulate interest in this still relatively underexplored issue, particularly in relation to the ideological framework of Nazi policy, the social realities of POWs—including their status, everyday life, and relations with the civilian population—and the transformations of the wartime economy. Emphasis was also placed on interdisciplinary approaches and the necessity of further research through microhistorical, sociological, and legal-historical studies.

The treatment of POWs evolved depending on the course of the war. Economic pressures increasingly prevailed over ideological considerations, though racial prejudices never fully disappeared; rather, they were pragmatically mitigated. Racial ideology was not merely a propagandistic formula but functioned as a concrete matrix of power and organization, decisively influencing matters of life and death for individuals. Violence became normalized through bureaucracy and institutional authority.

Prisoner-of-war captivity was not an isolated phenomenon; interactions with the civilian population created a distinct microcosm in which the boundaries between captivity and civilian life were blurred. Moreover, it becomes evident that even within the confines of the regime, there existed spaces for social deviance and resistance against official norms.

The study of POW forced labor is not merely a subsidiary historical topic; rather, it reflects broader structures of Nazi governance, the hierarchization of human lives, and the interconnectedness of power, economy, and ideology. At the same time, it opens critical questions concerning memory, marginalized historical actors, and the ethical dimensions of scholarly research.

References and Bibliography

Bohr, Felix, Schnurr Eva-Maria (2023). Kriegsgefangene. Die vergessen Soldaten des Zweiten Weltkriegs. Münich: Spiegel.

Bubeníčková, Růžena (1969). Tábory utrpení a smrti. Praha: Svoboda.

Chapoutot, Johann (2021). Zákon krve. Myslet a jednat jako nacista. Praha: Rybka Publishers.

Kocourková, 2002, 263.

Konečný, Zdeněk (1967). Pracovní nasazení válečných zajatců a obyvatel Evropy v ČSR (1939-1945). Brno: Univerzita Jana Evangelisty Purkyně.

Lusek, Joanna (2015). Zajatecké tábory Teschen v letech 2. světové války. Český Těšín: Muzeum Těšínska.

Pecka, Jindřich (1995). Váleční zajatci na území Protektorátu Čechy a Morava. Praha: Ústav pro soudobé dějiny AV ČR.

Rass, Christoph (2020). Menschmenmaterial. Deutsche Kriegsgefangenen des Zweiten Weltkrieg und ihre Repatriierung. Schöningh: Brill.

The European Convention on Human Rights and the American Convention on Human Rights in A Comparative Mechanism System

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Abstract

The European Convention on Human Rights (1953) and the American Convention on Human Rights (1969) are two regional convention that were born in difference times and geopolitics situation but with the same objective: human rights.

The ECtHR has its origins after the finalization of WWII in Rome. Because European societies wanted to live in safety without repeating the traumas suffered. Italian, Germany, French and other European countries started to create new types of Constitutions were the protection on human rights to be more appreciate.

The ACtHR was adopted after a long series of struggles for the protection of human rights in Latin America. This Convention can be seen as the outcome of the Organization of American States which had the ability to create a regional system of protection on human rights in a military and political conflict time in that region.

Both Conventions are legal instruments that have been evaluated with the aim of protecting human rights in different historical and geographical territories.

Keywords: ECtHR, ACtHR, human rights, protection, Latin America, Rome

I. Introduction

After World War II and its terrors, the European government's societies observed an official document to maintain the protection on human rights without any difference of race, origins, religion, language. In this context immediately after the end of the war, in 1949 the Committee of juridical and administrative problems studied a proposal about a new,, organization created by the Council of Europe (CoE) with the main objective: *the protection of human rights* (Dinu, 2022).

In American system, the American Convention on Human Rights was created after twenty (20) years after the European convention. The context of this Convention was marked by political instability, military dictatorships and violations on human rights. We can see this convention as a direct juridical instrument created against the violation on human rights that were observant in the counties like: Brazil, Argentine or Chile.

Both Conventions are like a fresh are after events like: World Wars, colonial dominance, military dictatorship.

II. The Three European Constitutions that established Human Rights after World War II

After the end of the war the European societies started to create their own national legislation with the main purpose: the protection on human rights. In this context we remember that the Italian Constitution created a legal system where the human rights started to be inviolable, so the article two (2) from the Italian Constitution (1948) represent the main center of human rights transformation because these are guaranteed and recognized in an individual and collective way (Dinu, 2022). In general, in the Italian jurisprudence the article two (2) was interpreted extensive and collaborate with the article 3 from Constitution know as, the principle of equality, The Italian Constitution premised other human rights as:

- Freedom of association
- Freedom of thought
- Rights of family members
- Right to health

The German society developed a direct legislation to obtain a protect human rights system. This legislation was promulgated on May 23, 1949, and represented a historical event for the juridical and moral reconstruction after the Nazi events from Germany (Timu, 2023). The human rights are introduced in the beginning of the German Constitution (FRG, 1949), articles 1-19 and the article 20 represented the 5 fundamental principles: democracy, rule of law, federal state, social state, republic. The Constitutional Court of Germany is in Karlsruhe and played an essential role to establish the human rights in effective protection by showing:

- Showed state authorities their constitutional limits
- Contributed to the consolidation of the democratic order
- Earned public trust as a defender of fundamental rights

The French Constitution (1958) (Consel Constitutionel, 1948) is known as the ,, five Republic of French,, and repressed a crucial role in the French political evolution system (Les, 2023) and was adopted in October 04, 1958. In that time the French Republic was confronted with the political instability, decolonization and was needed a transformation after all these events. The preamble of the French Constitution guaranteed the inviolability of human rights regardless of origin, ethnicity and others.

III. The History of the European Convention on Human Rights

After all of these, the French, Germany and Italian Constitutions represented an historical moment on established the human rights protection after the traumas of the Second World War (GHIȚĂ, 2023). These 3 (three) constitutions show us the beginning of the protection on human rights in a democratic and European society. All these Constitution are taking about the human dignity and the Constitutional Court from all these country plays a crucial role because:

- *The German Constitutional Court* (German Court, 2025): started to have extensive power to guarantee the human right protection in a high level. It started to have the capacity to examinate the constitutional law and administrative acts and being able to cancel regulations that were discovered to be against human rights. The German citizens started to have the possibility to notice the official authorities when their fundamental rights were violated.
- *The Italian Constitutional Court* (Corte Constitutione, 2025): started to have more power in evaluation, interpretation on human rights
- *The French Constitutional Court* (Constitutional Council, 2025): protect the human rights has an original jurisprudence and original fundamental principles which maintain a democratic standard by preventing the abuses in legislative system and guaranteed the human rights

In this context in 1950 was drafted the European Convention on Human Rights (Concil of Europe, 1953) and was inspirated by the Universal Declaration on Human Rights that was created by the United Nations in 1948 (United Nations, 1948). The Germany, Italy and France countries were in the first ten (10) counties which signed the European Convention on Human Rights (Council of Europe, 1950) in 1950 in Rome. The Convention established the European Court of Human Rights which permitted any individual who feels that he or her right that is guaranteed by the Convention was violated to address to the Court. The Convention has international power, and the main purpose is to guarantee human rights protection for all people which are in European territory.

In the European Convention on human rights and in the European Court on Human Rights are eligible to apply for membership, just the states which guarantee the: democracy, rule of law and human rights. Guido Raimondi who was an Italian-judge to European Court on Human Rights between 2015-2019 said that we do not have a protection of democracy if we do not protect the human rights (Giampiero, 2016). Other states are not eligible to become a member state in the Court.

In the historical time, the protection of the European Convention on Human Rights was maintained by three (3) institutions (Council of Europe, 2025):

A. *European Commission of Human Rights*: was an institutional mechanism which was created to protect human rights to recreate the juridical system in Europe. European citizens were able to come with a notification to them if their rights that were established by the Convention were violated.
B. *The European Court of Human Rights*: was created in a historical time after the end of World War II when European societies needed to create a mechanism for a better life for them and their children. At the same time, the European court was forced to have a continuous evolution to be capable of surviving in the modern and contemporary eras with all their criteria: technology, artificial intelligence and others.
C. *Committee of Ministers of the Council of Europe*: the main objective is to maintain a protection on human rights and to monitor the implementation on human rights in the European societies effectively. This Committee can send resolutions and recommendations if it is necessary.

IV. Human rights in European systems in present

In our days the Human Rights are protected by a very complex mechanism structure that have the capacity to guaranteed them in the way that are mentioned in the Convention (Gutan, 2023, p. 69):

a. *Plenary Meeting*: has the main objectives: choose the president for three (3) years and two (2) vice-presidents, adopted the Court Regalement.
b. *Unique Judge*: has a Mandate for nine (9) years. The national judge cannot judge alone on a procedure where The National country is involved. The Unique judge can judge some cases that are simple.
c. *Committee:* are formed by 3 judges and are established for twelve (12) months, the presidency is made by the older judge. The main objectives are: to establish the admissibility of the cases, to declare an invalid case **obviously unfounded**
d. *Chambers*: are formed by seven (7) judges, one of the judges needs to be the judge that was chosen by the national state which had the litigation, and his role is consultative.
e. *Grand Chamber*: is formed by seventeen (17 judges) and 3 substitutes for three (3) years). They judge the complex causes, interpret the Convention.

The total number of judges that are in the European Court of Human Rights are *46: 1 judge for 1 state-member.*

In case the national judge cannot judge a case, the Ad-hoc Judge takes the place. Some purposes of unable are abstention, dispensation from exercising the function, interest conflicts and other purposes.

Other ways that are used to protect human rights are: juridical organizations: for example, the examination criteria for an admissible notification. The procedural conditions that need to be passed are: all the national instances to be finished, the time of four (4) months after the final decision from the national instance. The found criteria: to be violated by a right from the Convention, demonstrated a prejudice.

The recent data show us that most notifications that are needed to be judged by the Court are referring to (Voicu, 2020):

- The equitable process – article six (6) Convention - 25percent

- The right to be free and safety – 15 percent
- Property protection- 10 percent

The European Court on Human Rights was created after the Second World War by the European convention with the main objective: to sanction the states which do no respect the human rights, but because the number of causes that are send to the Court are bigger and bigger, the Court become the victim of its destiny (Lambert, 2017). In 2023 there were more than 68.000 pending applications and in 2024 were more than 60.000 pending applications with six (6) percent less in generally but this does not means that the Court has less notification to judge because the number of pending applications that were sending to Chamber and Grand Chamber and single Judge increased by six (6) percent (European Court, 2024). This can be interpreted as that the complex causes started to grow in the last years. Turkey is the country with the greatest number of pending applications in 2024: 21613 and the second place is Russia with. 8130 (European Court, 2024, p. 36).

We need to understand that protection on human rights is very important for a better life in this World. In our days to be feeling safe and to be not discriminate need to be fundamental. All the world feels the transformations that are made by technology and trying to maintain protection on human rights in technological times.

The human rights that are mentioned in the European Convention on Human rights are guaranteed to everyone no matter of what kind of citizen is as soon as the human right that was violated was in the territory of the Convention (we need to mentioned that are some causes when the human right violation can be made in an extra-Convention territory for example in a military operations when a country is responsible for the human rights protection even if the events are in another part of the Continent and the Convention is not applicable there (CASE OF HASSAN v. THE UNITED KINGDOM, 2014)). The European court is trying to put the people in the main center to help him to have a better place in this world (PĂVĂLUCĂ, 2024). The main types of rights that are established by the convention:

- Civil and political rights such as: the right of life that is regalement in the second (2) article of the convention, all the states have the obligation to protect the live of any individuals. The capital punishment was abolished by the all the states which adopted the European Convention on human Rights.
- Equitable process that is observant to article six (6) of the convention, all people have the right to have a equitable judgement. The judgement needs to be transparent and to be solved in a reasonable time.
- The European society can have a right to free expression: thinking, opinion, religion but the European Convention on human rights we cannot find the right to be informed, which is mentioned in the American Convention on Human Rights.

In this convention we can find just five (5) rights that are absolute untouchable: the right to life, prohibition of torture, Prohibition of Slavery and Forced Labor, prohibits the retroactive application of criminal law, ne bis in ibidem. The last human right protection is mentioned in article four (4) from the Protocol seven (7). These rights means that no government system that signed the European Convention on Human Rights cannot limited them even if the world is confront with an emergency

like the Pandemic of covid-19 when some human rights were limited to protect the societies.

1. *The right to live*, we are considering that is linking with the right not to be subjected to the death penalty which can be found in the protocols no six (6) and thirty (13). The Protocol no six (6) abolished the death penalty in the peace time and the last one abolished the death penalty in all circumstances like: in the case of war (APADOR-CH, 2025). The abolished penalty is found in in more than 80 nations, in 2022, Papua New Guinea, The Central Africa abolished the death penalty in all circumstances (Death Penality, 2025). The death penalty is considering a cruel and inhuman treatment, the Universal Declaration created by the United Nations in 1948 guarantee the right to life and a life of freedom from torture or other degrading treatment. At the end of 2023 were registered 112 countries which abolished the death penalty (Amnesty International, 2025).
2. *Prohibition of Torture* is can be found in the article 4 of the European Convention on human rights, the torture can be mental or physical and the torture can be degrading treatment. The torture in a cruel treatment that is applicable to an individual because of different reasons. All people must be protected and have the principle of dignity applicable. In 1996 was an Indian man Sikh living who lived in United Kingdom he could not be transported in India because there he could become a real victim of torture (case - Chahal v United Kingdom , 1996).
3. *Prohibition of Slavery and Forced Labor* is founding In article 4 on European Convention on Human Rights, the modern slavery means any type of control that is made to another person and put in dangerous the liberty and dignity. Forced labor means a work that is made without a consent we need to observe the type of work and the volume that need to be made for this kind of work. The contemporary states need to take some measures to prevent them using legislative national and international regulations.
4. *Prohibits the retroactive application of criminal law* is founded in article 7 on European Convention, this means that a person cannot be condemned for an act that did not constitute a crime at the time it was committed. This article was created to protect the people against possible abuse, guarantee that no one can be judge for an act that was not a crime in that time. This article respects at the same time the principle of dignity and offers a transparent and predictable juridical system.
5. *Ne bis in ibidem*: is a Latin metaphoric motto, is referring that no individual can be judge twice is an essential protection. It can be found in article 4 on Protocol 7 on European convention and the main objective is to prevent any type of juridical error and protect human rights, the dignity and the transparency of the juridical system.

These five (5) articles cannot be limited in any type of circumstances and in general time are known as,, the hard core of legal protection,, are inalienable and fundamental in any type of circumstance. The rest of the articles are relative rights because they can be limited in some conditions. In this context we mention that article fifty (15) on the Convention says that in some cases the human rights can be limited is the national or international conditions impose them. The conditions to limit human rights are:

- To be provided by the European convention
- To have a legitimate scope

- To be necessary: this means that the measure needs to achieve an important objective and need to be just for a limited time, after the danger disappears the limited human rights is no longer legitimate (Act Human Rights, 2025).
- To be proportionate with the objective:

Human rights can be limited in exceptional circumstances such as: war time, pandemic time, emergency. During the pandemic time the European societies could not go out without a real reason this limitation was to protect the human natural against the Covid-19. In that time the European Convention observant that the limitation of the human rights was proportional with the danger that could be found outside (Juridice.ro, 2022).

The classification between absolute and relative human rights is to have a flexible and complex legislative system where the Human rights to be protected in any type of circumstances. The classification should not be interpreted like the most important human rights and the not so important human rights but should be interpreted like a complex human rights protection system where the European societies need to have a rigorous and permanent balance between free of individual and the collective security.

V. The American Convention on Human Rights

In 1969 was signed the American Convention on Human Rights know as: Pact of San Jose, which is an international instrument of human protection (Antkowiak & Gonza, 2017) and it is coming in force in 1978 after a ratification on eleven (11) countries. In the preamble we can found that the American Convention spirit is to protect the democratic institutions and a system where the liberty freedom and social justice are guarantee (American Convention, 1969). During that time, the American people were found in in a critic situation because of political and social times that comes under the Latin America. This Convention was created in America after twenty (20 years after the European system and it comes with a complex of human rights: social and political rights that are structured in fundamental principles of human rights such as: dignity and social justice.

The American convention is based on four (4) fundamental principles:

- prohibition of discrimination
- Equal protection before the law
- Respect for human dignity
- Guarantee of individual and collective rights

The American Convention has a protection mechanism: called: the Inter-American Court of human rights and the International Commission on Human Rights

The Inter-American Court of Human Rights (Inter-american, 2025), is an international Court that is located in San Jose-Costa Rica, is a permanent court that was established in 1979 thankfully to the Organization of American States and the main objective is to interpret the human rights that are mentioned in Convention (Wikipedia, 2024). This Court is more a specific Court which is trying to comes with a solution for the human rights that are not protected in the American region. The Court comes with a development type of approach, it is trying to see the human rights under the formal protection.

The Court is composed by seven (7) judges that are chosen by the states for seven (7) years with the possibility for another mandate (Inter-american Court, 2025). The President and the vice-president of the Court are elected for two (2) years and can be re-elected for another 2 years. The tree (3) functions that are observant in the American Court are (Inter-american, 2025):

- Contentious: The Court can judge a notification when an individual mentioned that a right from Convention was violated. Its decisions are binding and may include reparation measures and financial compensation.
- the power to issue provisional measures: very serious causes that cannot be put on hold.
- advisory function: observant the compatibility with the internal national legislation and Convention, The Court comes with personal opinions about the interpretation of Convention or other American Human Treaties.

The Inter-American Commission on Human Rights (Inter-american Commission, 2025), is an autonomous organ created by Organization of American States located in Washington D.C. and it is a permanent Commission that is meeting regular and in special session all of the year. It's obligations come from three (3) regional human rights acts:

- OAS Charter
- American Declaration of the Rights and Duties of men
- The American Convention on Human Rights

It is composed from seven (7) independent members that are chosen by the General Assembly of the Organization of American States for four (4) years with the possibility to be re-elected. The Commission functions are (OAS, n.d.):

- The investment: receive and analyzed the notifications that are sending from the American people
- The consultative: opinions in the American Convention interpretation
- The mediation: it is trying to comes with a friendly judgement, amicable solution, between parties.

The relationship between Commission and Court is based on a long partnership to offer real and efficient protection in human rights. The Commission has the possibility to analyzed the notification that are coming from Americans that are feeling that their rights offered by the Convention were violated and prepared a real rapport that can be send to the Inter-American Court. To be send a notification to the Court need to have some criteria:

- Exhaustion of domestic remedies in the State concerned
- Existence of clear evidence of violation of fundamental rights
- Impossibility of achieving an amicable solution between the parties

We can observant that the American and European Courts are the same, this means that these regionals Court have the possibility to come with a decision about if the human rights that are mentioned is violated or not by the state-member.

The American Court has the possibility to come with a mandatory decision for the states, to ask for reparations and imposes reparations and institutional reforms. In the cause Maria da Penha Fernandes v. Brazil, the Inter-American Commission invested the domestic violence her husband was trying for many times to kill her. The

Commission observed the way in which the Brazilian system protect right the human-her husband was found guilty and sent to prison for eight (8) years. The Commission sent the report to the Inter-American Court which came with a decision which changed the Brazilian system of law (Cornell Law School, 2025). The Brazilian system created a legislation which officialize the recognition of the domestic violence as a form of the violation of human rights no just a private conflict and come with some specific criteria of protection (Maria da Penha Law, 2006):

- Creation of specialized police stations for domestic violence
- Possibility of issuing rapid protection orders
- Provisions for free legal aid for victims
- Protective measures prohibiting contact between the aggressor and the victim

This new legislation created in Brazil a better place for women, the results of this, comes with 2.3 million decisions on protective measures and 64 percent of causes has a final decision in the favor of the victims (Folha de S.Paulo, 2024).

The Commission and Court is more than a simple collaboration between institutions, it is a real complex mechanism of human rights protection where the investigation need to be transferred in justice.

The absolute human rights that are mentioned on American Convention are:

- the right to live
- the prohibition on torture (physical, mental)
- Prohibition of Slavery and servitude
- The Principle of Legality
- Non-Retroactivity of Criminal Law

The absolute human rights that are mentioned by the American Convention are more than formal declaration on human rights because are the real mechanism that are established to guarantee the human dignity. Because the same human rights are absolute in the European Convention, we can say that these rights transcend geographical and cultural boundaries been international absolute human rights.

The relative human rights that are mentioned in American Convention can be limited in some specific criteria: the proportion. To have a human right limited, this means that need this limitation to be observant by the law and the scope of this limitation need to be legitimate and necessary for a democratic state, national security, public safety. Some examples of human rights that can be limited (Christina Binder, 2022):

- The expression right: if the scope is to protect human rights, to protect national security
- The propriety: if we have fair compensation if the law is respected

VI. Conclusion

The human rights need to be protected in an international level, by all the states, the absolute human rights are the rights that cannot be limited neither in European region neither in American region. Both Convention was an answer after the traumas from the Second World War: the protection and the prevention.

Although both conventions have specific criteria for rights, they regulate absolute and relative rights, conferring the universal character of human rights, transforming moral principles into true sources of law that maintain a better world and greater protection.

<table>
<tr><th colspan="2">European Convention on human rights</th><th>American Convention on Human Rights</th></tr>
<tr><td>Signing force

Significance</td><td>In 1950 it was signed in November on the 4th, in Rome and came into force in 1953.
Rome was chosen as the place of signing because after the war this country was desirous of having a democratic basis where human rights would be respected.</td><td>In 1969 it was signed in November, on the 22nd in Costa Rica. It entered into force in 1979.
The choice to sign in Costa Rica was based on its history of respect for human rights and democracy.</td></tr>
<tr><td colspan="3">Similitudes between European Convention and American Convention</td></tr>
<tr><td colspan="3">1. Main object: human protection.
2. They are structured in detail and explain the rights and freedoms guaranteed
3. They are influenced by the Universal Declaration of Human Rights
4. Both have monitoring mechanisms: individual petitions made by individuals, NGOs</td></tr>
<tr><td colspan="3">Differences between European Convention and American Convention</td></tr>
<tr><td></td><td>European Convention</td><td>American Convention</td></tr>
<tr><td>geography</td><td>Countries that are in Council of Europe</td><td>American States, Latin America and Caribe</td></tr>
<tr><td>Human rights that are important</td><td>the right to life, the right to expression, due process and the right to property</td><td>social, economic, cultural rights such as: work, education, Security</td></tr>
<tr><td>Traditions</td><td>cultural historian on: Roman law, common law</td><td>the Ibero-American tradition which is composed of Roman and indigenous law</td></tr>
</table>

Bibliography

Act Human Rights. (2025). *Laws and policies which limit human rights*. Retrieved 03 19, 2025, from https://www.hrc.act.gov.au/humanrights/limitations-on-human-rights

American Convention. (1969). *American Convention on Human rights*. Retrieved 03 19, 2025, from https://www.oas.org/dil/treaties_b-32_american_convention_on_human_rights.pdf

Amnesty International. (2025). *We know that, together, we can end the death penalty everywhere*. Retrieved 03 18, 2025, from https://www.amnesty.org/en/what-we-do/death-penalty/

Antkowiak, T., & Gonza, A. (2017). *The American Convention on Human Rights: Essential Rights*. Oxford : Oxford Press.

APADOR-CH. (2025). *Drepturi absolute şi drepturi relative*. Retrieved 03 16, 2025, from https://www.drepturicivile.ro/drepturile-omului/ce-sunt-drepturile-omului/drepturi-absolute-si-drepturi-relative/#dreptul-de-a-nu-fi-supus-pedepsei-cu-moartea

case - Chahal v United Kingdom , Application no. 22414/93 (Strasbourg 11 15, 1996). Retrieved 03 18, 2025, from https://hudoc.echr.coe.int/fre#{%22fulltext%22:[%22Chahal%22],%22itemid%22:[%22001-58004%22]}

CASE OF HASSAN v. THE UNITED KINGDOM, 29750/09 (Grand Chamber 09 16, 2014). Retrieved 03 15, 2025, from https://hudoc.echr.coe.int/fre?i=001-146501

Christina Binder, M. N. (2022). *Elgar Encyclopedia of Human Rights.*

Concil of Europe. (1953). European Convention on Human Rights. Retrieved 03 18, 2025, from https://www.echr.coe.int/documents/d/echr/convention_ENG

Consel Constitutionel. (1948, 10 4). The French Constitution (1958. Retrieved 03 20, 2025, from https://www.conseil-constitutionnel.fr/en/constitution-of-4-october-1958

Constitutional Council. (2025). *Conseil Constitutionnel*. Retrieved 03 20, 2025, from https://www.conseil-constitutionnel.fr/en

Cornell Law School. (2025). *Maria da Penha Fernandes v. Brazil*. Retrieved 03 19, 2025, from https://www.law.cornell.edu/gender-justice/resource/maria_da_penha_fernandes_v._brazil

Corte Constitutione. (2025). *The Constitutional Court*. Retrieved 03 20, 2025, from https://www.cortecostituzionale.it/jsp/consulta/istituzioni/la_corte_costituzionale_italiana_EN.do

Council of Europe. (1950). *European Convention on Human Rights*. Retrieved 03 20, 2025, from https://www.echr.coe.int/documents/d/echr/convention_ENG

Council of Europe. (2025). *European Convention on Human Rights.* Retrieved 03 20, 2025, from https://www.echr.coe.int/european-convention-on-human-rights

Death Penality. (2025). *Countries That Have Abolished the Death Penalty Since 1976*. Retrieved 03 17, 2025, from https://deathpenaltyinfo.org/policy-issues/policy/international/countries-that-have-abolished-the-death-penalty-since-1976

Dinu, R. (2022, 10 05). Protecţia drepturilor omului la nivel european. Retrieved 03 18, 2025, from https://www.juridice.ro/684042/protectia-drepturilor-omului-la-nivel-european.html

European Court. (2024). *Annual Report.* Retrieved 03 16, 2025, from https://www.echr.coe.int/documents/d/echr/annual-report-2024-eng

Folha de S.Paulo. (2024, 08 24). *The Maria da Penha Law, A Legal Norm that Criminalized Violence against Women in Brazil, Turns 18 Years Old*. Retrieved 03 20, 2025, from https://www1.folha.uol.com.br/internacional/en/brazil/2024/08/the-maria-da-penha-law-a-legal-norm-that-criminalized-violence-against-women-in-brazil-turns-18-years-old.shtml

FRG. (1949, 05 23). The Basic Law of the FRG. Retrieved 03 20, 2025, from https://www.cvce.eu/content/publication/1999/1/1/7fa618bb-604e-4980-b667-76bf0cd0dd9b/publishable_en.pdf

German Court. (2025). Retrieved 03 20, 2025, from https://www.bundesverfassungsgericht.de/EN/TheFederalConstitutionalCourt/thefederalconstitutionalcourt_node.html

GHIŢĂ, D.-A. (2023, 03 23). Fondul istoric care a deservit la formarea și adoptarea Declarației din 1948. Retrieved 03 20, 2025, from https://www.juridice.ro/499088/fondul-istoric-care-a-deservit-la-formarea-si-adoptarea-declaratiei-din-1948.html

Giampiero, B. (2016). *Allocuzione del presidente Raimondi alla presentazione dello Scudo in Ara Coeli.* Retrieved 03 20, 2025, from https://www.academia.edu/22369691/Allocuzione_del_presidente_Raimondi_alla_presentazione_dello_Scudo_in_Ara_Coeli

Gutan, B. S. (2023). *Protectia Europeana a Drepturilor Omului* (3 ed.). Bucuresti: Hamangiu.

Inter-american. (2025). *Interamerican court of Human rights*. Retrieved 03 19, 2025, from https://www.corteidh.or.cr/index.cfm?lang=en

Inter-american. (2025). *What is the I/A Court H.R.?* Retrieved 03 19, 2025, from https://www.corteidh.or.cr/que_es_la_corte.cfm?lang=en#collapse1-2

Inter-american Commission. (2025). Retrieved 03 19, 2025, from https://www.oas.org/en/iachr/Default.asp

Inter-american Court. (2025). *I/A Court H.R. Composition*. Retrieved 03 19, 2025, from https://www.corteidh.or.cr/composicion.cfm?lang=en

Juridice.ro. (2022, 03 11). *Restrângerea libertăţilor fundamentale în context pandemic*. Retrieved 03 19, 2025, from https://www.juridice.ro/690798/restrangerea-libertatilor-fundamentale-in-context-pandemic.html

Lambert, A. É. (2017, 06 06). *Measuring the judicial performance of the European.* International Journal for Court Administration . Retrieved 03 15, 2025, from https://hal.science/hal-03447994/document

Les, I. (2023, 06 14). Reflecţii despre Constituţia Italiei în viziunea unui reputat magistrat. Retrieved 03 20, 2025, from https://www.juridice.ro/essentials/6866/reflectii-despre-constitutia-italiei-in-viziunea-unui-reputat-magistrat

Maria da Penha Law. (2006). Retrieved 03 20, 2025, from https://www.institutomariadapenha.org.br/assets/downloads/maria-da-penha-law.pdf

OAS. (n.d.). *Inter-american Commission on Human Rights*. Retrieved 03 20, 2025, from https://www.europarl.europa.eu/meetdocs/2004_2009/documents/fd/iachr_/iachr_en.pdf

PĂVĂLUCĂ, A. G. (2024, 08 24). *Aspecte privind protecţia drepturilor fundamentale recunoscute prin Carta Drepurilor Fundamentale a Uniunii Europene*. Retrieved 03 16, 2025, from juridice.ro: https://www.juridice.ro/732146/aspecte-privind-protectia-drepturilor-fundamentale-recunoscute-prin-carta-drepurilor-fundamentale-a-uniunii-europene.html

Senato della Republica. (n.d.). Constitution of the Italian Republic. Retrieved 03 20, 2025, from https://www.senato.it/documenti/repository/istituzione/costituzione_inglese.pdf

Timu, C. (2023, 05 24). La mulţi ani, Grundgesetz! Constituţia Germaniei împlineşte 75 de ani – Demnitatea umană ca parte strictă a identităţii constituţionale. Retrieved 03 20, 2025, from https://www.juridice.ro/737216/la-multi-ani-grundgesetz-constitutia-germaniei-implineste-75-de-ani-demnitatea-umana-ca-parte-stricta-a-identitatii-constitutionale.html

United Nations. (1948). Universal Declaration on Human Rights. Retrieved 03 18, 2025, from https://www.ohchr.org/sites/default/files/UDHR/Documents/UDHR_Translations/eng.pdf

Voicu, M. (2020, 06 11). *Consiliul Europei la 70 de ani şi CEDO la 60 de ani. Viitorul CEDO în viziunea judecătorilor şi a preşedinţilor Curţii*. Retrieved 03 14, 2025, from https://www.juridice.ro/essentials/3937/consiliul-europei-la-70-de-ani-si-cedo-la-60-de-ani-viitorul-cedo-in-viziunea-judecatorilor-si-a-presedintilor-curtii

Wikipedia. (2024, 11 24). *Inter-American Court of Human Rights*. Retrieved 03 19, 2025, from https://en.wikipedia.org/wiki/Inter-American_Court_of_Human_Rights

The Figure of the Scribe in the Albanian Area as Part of the Byzantine Heritage

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Abstract

The object of our study is the examination of the figure of the scribe in the philological manuscripts of Albania, in the "Fund 488", located in the AQSH.

It seems that the Albanians were far from the cultural centers and Byzantine civilization, but despite the conquests, the Adriatic Sea remained a Byzantine sea, and contacts between Puglia and Dalmatia, Greece and Constantinople were frequent.

The tradition of Christian writings in Albania begins from the beginnings of Christianity and continues until the 19th century.

The definition of the parameters to identify the so-called 'albanian' copyist is complicated.

It is understandable that this selection criterion to define the figure of the 'Albanian' copist cannot be of the political type, and even less of the geographical type, but only of the cultural type.

If language is an expression of cultural identity, in this case it cannot be accepted because the scribe, the copist, wrote in the official language, in Greek and Latin.

We are of the opinion that the activity of the 'Albanian' scribe, copyist, or the space where he was formed goes beyond the Illyrian-Albanian area.

Keywords: Scribe, copist, manuscript, Albania, Byzantine heritage.

As for the Byzantine scribal world, there is still a lack of reflection on the graphic education of Byzantine scribes, as we have for the early Latin Middle Ages. However, there is an awareness that the written culture in Byzantium, at least for the middle and late Byzantine era, testifies to a set of phenomena quite different from that of the Latin Middle Ages.

The ways of writing did not necessarily depend on the social class or on the environment in which the scribe, the copyist, operated at the activity of copying: a

monk, in general a religious person, before becoming a monk or even in his new status, was part of an elevated cultural world and wrote precisely like a secular intellectual.[1]

In Byzantium in the 14th century, copyists, especially experts, were able to use at the same time the two models of writing, calligraphic and cursive.

Based on the analysis of several manuscripts, which create a partial and temporary panorama, for Byzantium has been extracted the image of a graphic education that was not codified, not organized from above, but with results that were too diverse to make classifications in rigid schemes.

In the philological manuscripts of Albania, in the "488 Fund", which constitutes the object of our study, to notice the figure of the scribe, the copyist, we have only one codex written in Latin according to the Roman rite, the "83rd Codex of Shkodra", dated in the 14th century.

The other manuscripts of "Fund 488" are in Greek and, in terms of the type of writing, with the exception of the earliest codex, *Codex Purpureus Beratinus* Φ or Beratinus-1 (6th century), which is written in "maiuscola biblica", uncial, and *Codex Aureus* Anthimi or Beratinus-2 (9th century), written in semi-uncial, the other manuscripts are written in small letters according to a more or less cursive model in varying degrees and are defined as small-letter codices.

Codex Purpureus Beratinus Φ", the Purple Codex of Berat, is the oldest manuscript, written no later than the middle of the 6th century. Regarding the origin of the manuscript and the copyist of this codex, the studies are divided without reaching any definite conclusions.

To research the figure of the copyist, it is first necessary to note whether there were *scriptoria* as calligraphic schools in the Albanian area?

In the Middle Ages, Albania was covered with churches and monasteries. This is evident not only from the scant medieval sources, but also from the numerous ruins of medieval churches, from documents of later times, as well as from the topographical nomenclature. Here, of course, it should not be forgotten that Albania, Greece and Dalmatia belong to the old Christian countries, which were destroyed by the Slavic invasions less than other countries, and in the 4th-6th centuries, had a topography with very widespread names of saints. In the Late Middle Ages, we encountered remnants of a very old ecclesiastical culture. Thus, we encounter names of saints and erased traces of small churches, once built on the sites of pagan temples.[2]

We agree with the opinion that in the Albanian area the existence of a local school of the Holy Scriptures is linked to other cultural traditions developed continuously since ancient times, especially those of applied ecclesiastical arts, such as the craftsmanship of iconostasis carving, iconography and mural paintings, liturgical music, the very art of building churches and monasteries.

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[1] Giuseppe de Gregorio, *Καλλιγραφεῖν / ταχυγραφεῖν. Some reflections on the graphic education of Byzantine scribes, in* E. Condello and G. De Gregorio, Scribes and Colophons: Copyists' Subscriptions from the Origins to the Advent of Printing, Centro italiano di studi sull'Alto Medioevo, Spoleto, 1995, p. 434.

[2] Milan Shuflaj, "The situation of the church in pre-Turkish Albania, the area of Orthodox penetration into the Catholic dam", Franciscan Publications, Shkodër, 2013, p. 122.

This is also linked to the inclusion of the Illyrian-Albanian area in what is called the "biblical source area" since the 1st century AD. It is an area that, like other areas of the medieval West or East, if it had its own centers of culture, its own scholars, its own books, it also had masses of illiterate and semi-illiterate people.

With the change in the Christian social climate, from the 4th century, scribes could be not only individuals of the religious community, but also monks through whom the sacred codex was produced in copying centers, who wrote even to gain the kingdom of heaven and, undoubtedly, later there would have been professional copyists who taught the art of writing, in calligraphic schools. Undoubtedly, if he wanted to practice the art of writing, the copyist had to be *litteratus*, to know how to read and write in Latin or Greek and better if he understood literary usage.

The tradition of Christian writings in Albania begins since the beginning of Christianity and continues until the 19th century.

According to a note found by Batiffol, the font of the gospels of "Beratinus - 1" is the same as that of the "Liturgy of Saint John Gojarti", a manuscript about which nothing is known anymore. In the local church tradition, this codex was presented to the faithful once a year, on January 27, on one of the two name days of Saint John Gojarti. The note cited by Batiffol expressly states that the font of this gospel is the same as that of Patmos and both are by the hand of Saint John Gojarti himself (345-407).[3]

In favor of a real connection between the name of "Beratinus-1" and the name of this saint comes the conclusion of some contemporary scholars, according to whom a local school of Holy Scriptures existed in the proto-Albanian area. On the other hand, it is historically proven that Saint John Gojarti was a monk exiled in Epirus at the beginning of the 5th century (403). But it remains to be proven that the manuscript is from an earlier time than what is known today, to accept this connection.

However, the uncial script of "Beratinus-1" or *Codex Purpureus Beratinus* Φ (6th century), the script par excellence of Christian books, and the semi-uncial script of "Beratinus-2" or *Codex Anthimius* (9th century), the script that was used not so much to transmit biblical or liturgical texts, for which the uncial script was reserved as more canonized, but for study and reading texts used by the community and by religious schools, both scripts of these manuscripts, the earliest, we do not encounter later.

According to K. Naço, we can prove the existence of scriptoria in our country by relying on: "… first, on the data provided by the codices, and mainly on their bibliographical notes and marginal notes, and, secondly, on the information provided by historical sources from other fields, which are directly or indirectly related to the issue we are dealing with. In general, the copyist, after copying the codex, left a bibliographical note at the end of the text, in which he emphasized the time when he finished copying it, the place where he wrote it, his name, the name of the person or institution that financed the work of copying the codex, the owner of the codex, who could be a person or an institution (church or monastery in general), and the reason why he wrote the codex… These notes show that in the ecclesiastical centers,

[3] Dario Del Corno, "Greek Literature", Principato, Milan, 2004, p. 610. In the Middle Ages, there are many works that are discussed as belonging to several authors. Saint John is one of those authors to whom an infinite number of anonymous works are assigned, which can be seen in the compilation of the "Codices Chrysostomici graeci" in five volumes.

monasteries and other centers of our country, codices were copied, which have a diverse nature in terms of content. "They contain gospel texts, biographies of saints, psalms, Byzantine music and literature, and even historical and philosophical texts."[4]

Another characteristic is the wide geographical distribution of manuscripts within the country. We have codices from Vlora, Gjirokastra, Voskopoja, Korça, Elbasan, Berat, etc. Most of them were found in Berat, but it does not mean that they all belong to the churches and monasteries of Berat. When Berat became an episcopal center, it collected the archives, consequently the codices of Vlora, Apollonia, Bylis, Gllavenica, which is why the number of codices from Berat is greater.

So, medieval codices were not found in two or three isolated centers, but have a wide geographical spread, just as they also have an amazing variety of texts in terms of content.

Berat inherited a special tradition of writers and writings, it was the center of writing skills. Alongside the schools of Berat, there is talk of a writing tradition for the codices of Vlora, Gjirokastra, and the writing schools of Korça, Shkodra, and Durrës.

In "Fund 488" we also have the "*41st Codex of Berat*", which based on the miniature figures, suggests that it must have been commissioned in the West, in the 14th century, by the Albanian prince Karl Topia, who was Catholic, or it must have been commissioned by the Balshaj princes, who had Berat under their control at that time.

The "*41st Codex of Berat*" has a high artistic level for the time, likewise, the writing of "4th Codex of Berat" has rare calligraphic values, it is a model where writing becomes creative mastery. The script of the text can be said to have been taken from the most prominent calligraphers, in general, in the art of Byzantine calligraphy, it is a script of first-hand from every aspect.[5]

The definition of the parameters to identify the so-called 'Albanian' copyist is complicated. Who is 'Albanian' in the Middle Ages? Is it enough to have been born, lived, or worked in the Illyrian-Albanian area?

It is understandable that this selection criterion to define the figure of the 'Albanian' copyist cannot be of the political type, and even less of the geographical type, but only of the cultural type.

Every person, whether this writer or not, regardless of the overall formation he has, carries within himself an identity of his own and writing is an opportunity to express it. An expression of the copyist's individuality is the errors within the text, which are almost always conceptual errors, but also the marginal notes and bibliographical notes of philological manuscripts, which express with their content a secular 'text' in a manuscript with a canonical text.

There is no copying of a manuscript without errors. According to statistics, an average copyist, who reproduces a moderately varied text, escapes one error per page.

[4] Kosta Naço, About the "Birthplace" of Medieval Codices of Albania, in Codices of Albania, DPA, Tirana, 2003, p. 209.

[5] Theofan Popa, Catalogue of Medieval Church Codices of Albania, in Codices of Albania, DPA, Tirana, 2003, p. 89.

The activity of the copyist has the special characteristic of being an intellectual work and at the same time manual work. So, there is a psychological aspect to the work of copying. It is undeniable that the text read and memorized by the copyist is copied by him with the phonetic features that belong to him himself.

This also explains the spelling errors made by Albanian copyists during the writing of the philological manuscripts of the "488 Fund" in the Greek language.

All pronunciation errors are found in the writing. There are cases in which a single word can be written incorrectly even though it is not read incorrectly. One of the most common consists of the partial assimilation of a word that is nearby.

There are also numerous psychological errors, because of distraction. Not many studies have been done on this type of error, because ultimately you must understand the psychology of every copyist.

In manuscripts, errors are found that depend on the mental categories and the culture or literacy of the copyist, but according to researcher L. Canfora, almost all errors are conceptual, which stem from the sufficient knowledge that the copyist must put into the text.

An important aspect to get to know the copyist of a given manuscript is the marginalia. Apart from two special cases, coded marginalia and a palimpsest marginalia, we note these marginalia according to the data they contain: colophon' marginalia, informative marginalia, curse marginalia, comment marginalia and chronicle marginalia.

After the copyist has finished copying, if he is a careful person, he has added the date and a note on the conditions of his copying work and has written his own name and/or that of the client, the occasion or purpose of the work at the end of the manuscript. Often religious formulas accompany this colophon that serves as a peritext for the manuscript, as we see in the following codices:

"The 11th Codex of Vlora", contains 254 parchment leaves, measuring 320 mm x 250 mm, (in the "Catalogue …" of Theofan Popa the possible time of the manuscript's decorations is mentioned - the second half of the 12th century, according to Roderic L. Mullen's assessment, the codex should be, perhaps, earlier, from the 11th century, but, certainly, not later than the 12th century). On p. 81 of the manuscript, it is stated that the book "was written by the hand of the monk John". According to Roderic L. Mullen, another note is found on p. 93 and proves that the work was written "by Joan Meshtari"; it must be about the same person. In a note by the Metropolitan of Berat Antim Alexoudes, dating from 1886 (March 30), it is expressly stated that this codex belongs to the church of Saint Vlash in Vlora.[6]

In the "Codex 93 of Korça", a four-gospel manuscript, written on 308 parchment leaves, dated no later than the 13th century, at the end of the Gospel according to John, there is this note: "In the month of June 1182, this manuscript with the four gospels was purchased/ordered by me, Luke [...]inuri, for the holy monastery of Peribleptus with 21 hyperpyres, from the monk and grammarian Mr. Luke. I have donated this gospel forever even after my death", and, on page 309r, there is a later

[6] Shaban Sinani, "Codices of Albania in the Memory of the World", Academy of Sciences of Albania, Tirana 2010, p. 111.

note which states: “I, priest Vasil, wrote this, therefore bless it! Amen! Look down, O Father, to see your children, who remain undivided”.

The increase in the circulation of books, readers, and copyists seems to have increasingly necessitated, from the end of the 13th century onwards, an explicit localization of the codex, especially if it was made to order.

This new need to place the book in space, in addition to time, is expressed on the one hand by paid scribes, professional copyists, clerics or laymen, who find themselves working far from their place of origin, while preserving their own – let's say "national" – way of dating, such as the one found on p. 398r of the last leaf of the "37th Codex of Berat" - on a 398-page paper, containing patrology and martyrology - "This book was written in the year 6835 (year 1327), in the time of the devout and Christian-loving king Andronicus Palaeologus and the devout and Christian-loving wife of Andronicus Palaeologus, emperor of the Romans" (Byzantium), but on the other hand also by underlining their new foreign location, mentioning the place of origin and the one in which they are working, or only the latter.

In the “86th Codex of Elbasan” - a nomocanon, on 185 sheets of paper - on the first page verso of which this inscription is preserved: “It was written in the time of the grace of the metropolitan and exarch of all .... (illegible) Joasaph ... of the friends and the honored priests ... . with his surname Makri, while my homeland above the earth (is) Zaqinthi (?). (Written) by me, the youngest and the poorest, Emanuel, the weak son of the former economist of the metropolitan church of the St. Mithris pier. In the year 7071 from the creation of the world and from the birth of our Lord Jesus Christ in the year 1562, March 5”.

From the middle of the 14th century the text of the signatures appears richer than in the past with biographical, chronological, and topographical data.

Thus, in the “Codex 50 of Berat”, on 198 leaves of paper, the psalter of David - Book of Psalms, we have one of the most complete colophons, quite well structured as a text with a scheme like what we find in the colophons of Latin rite manuscripts in the West.

Colophons often represent the best information we can discover about the circumstances of the copying of the manuscript. They have often been used as the most valuable data to identify the copyist, for dating and localizing the copy, and moreover serve as a basis for including or excluding manuscripts in some paleographic and codicological research. Sometimes the information in a colophon may not be as straightforward as it seems, and it should even be noted whether the colophon is authentic or a copy.

In the Albanian area, during the period of Byzantine influence, as mentioned above, there were schools of calligraphy, where monks and copyists worked on copying and illustrating codices, which they decorated with miniatures, making their contribution to both Byzantine and local calligraphic art. Some of the marginal inscriptions, as well as some colophons found in manuscripts, prove that the copyists had a certain training and undoubtedly moved to different writing centers, for various reasons keeping alive the Byzantine manuscript tradition in the Albanian area and beyond.

We are of the opinion that the activity of the 'Albanian' copyist, or the area where he was formed goes beyond the Albanian area.

Bibliography

Dario Del Corno, "Greek Literature", Principato, Milan, 2004.

Giuseppe de Gregorio, *Καλλιγραφεῖν / ταχυγραφεῖν. Some reflections on the graphic education of Byzantine scribes, in* E. Condello and G. De Gregorio, Scribes and Colophons: Copyists' Subscriptions from the Origins to the Advent of Printing, Centro italiano di studi sull'Alto Medioevo, Spoleto, 1995.

Kosta Naço, About the "Birthplace" of Medieval Codices of Albania, in Codices of Albania, DPA, Tirana, 2003.

Milan Shuflaj, "The situation of the church in pre-Turkish Albania, the area of Orthodox penetration into the Catholic dam", Franciscan Publications, Shkodër, 2013.

Shaban Sinani, "Codices of Albania in the Memory of the World", Academy of Sciences of Albania, Tirana 2010.

Theofan Popa, Catalogue of Medieval Church Codices of Albania, in Codices of Albania, DPA, Tirana, 2003.

The Role of Islamic Banking to Increase Halal Industry in Indonesia: Bibliometric Approach

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Abstract

Islamic Banking and Halal industry have the strong power to have good collaboration to increase the development of halal industry in Indonesia. Many sectors of industry both of financial and non financial industry show the good performance. According to the Islamic business ethic, the business must fulfill the requirement of Islamic business which refers to the halal industry. This paper uses qualitative methodology with bibliometric analysis approach. The result of this paper can give explanation regarding the role of Islamic banking to increase halal industry

Keywords: Islamic banking, Halal industry

INTRODUCTION

Indonesia has good potential to develop the halal industry. These potentials include the abundant Muslim population that is projected to reach 256 million people by 2050, the growth of various halal industrial sectors, especially the finance, tourism, and fashion sectors, the recognition of Indonesia's achievements in the eyes of the world, Indonesia's geographical conditions and demographic bonuses, technological developments. as well as the ratification of the Halal Product Guarantee Act number 33 of 2014. This potential can encourage economic growth by increasing the value of exports and foreign exchange reserves. But on the other hand, Indonesia also has challenges in developing this halal industry. The challenges facing Indonesia come from external and internal sources. From an external point of view, the challenges faced by Indonesia are the number of competing countries, the absence of an internationally valid halal certificate. Meanwhile, from an internal point of view, the challenges faced by Indonesia are the lack of halal awareness among the Indonesian people, problems in the implementation of the Halal Product Guarantee Act, and the low awareness of the Indonesian people to competition (Fathoni, 2020) in (Trimulato et al, 2021).

The role of sharia banking in developing the halal industry in Indonesia must receive full support, both morally and materially, from the central government and local governments as well as interested stakeholders. Opportunities and challenges in

developing the halal industry will be even greater. These opportunities and challenges will affect the development and growth of the halal industry. Therefore, an institutional synergy between Islamic banks and the government as well as related ministries and institutions is needed. What Islamic banks can do in optimizing their role in developing the halal industry in Indonesia is through institutional synergy. An institutional synergy that can be carried out by Islamic banks is first, institutional synergy with the government. The forms of institutional synergy carried out by Islamic banks with the government are identification and mapping of areas for the halal tourism sector; support for strengthening regulations, standardization, and supervision processes for halal products. Second, the institutional synergy of Islamic banks with halal industry players. The form of institutional synergy with Islamic banks and the halal industry can be done by identifying and developing industrial models; support for strengthening and providing outlets and market access; provision of financing funds; education and assistance (Husain, 2021) in (Trimulato et al, 2021).

The development of halal industry grows significantly in line with the growing awareness of the need for halal products and services in Indonesia. The halal industry which is part of the development of the Islamic economy needs to be continuously improved with the support of Islamic banking that the development of Islamic economy is not only focus on developing Islamic finance industry such as banking, capital markets or the non-Islamic financial industry, but also developing Islamic business that products and services of industry (Kamaruddin et al, 2023).

According to the research of Putriani and Shofawati (2015) have research that aims to know how Islamic Pattern Behavior Consumption of Students Faculty Economics and Business University Airlangga in in Choosing Halal Food and Thayyib reviewed by level of religiosity. The method that used is qualitative approach with a case study strategy. Data was collected by interviews and direct observation of the object research. The analysis technique that used is descriptive qualitative analysis that is narrating the results of interviews and direct observation. Based on the results of the study concluded that the Faculty of Economics and Business University Press Islamic behavior patterns of consumption good and there is no difference between students of each program of study. Suggestions for further research should deepen the Islamic consumption behavior of various faculties at the University of Airlangga.

In addition, in order to increase the market share of Islamic banking that the development of market share also needs to get support a stable and sustainable Islamic economic and financial ecosystem that halal life style industry as part of Islamic economy ecosystem is one of potential market can be explored for market share of Islamic banking (Kamaruddin et al, 2023).

Based on the OJK Islamc Banking Statistics Report (2022), the total assets of Islamic banking were 661 trillion Rupiah with the number of sharia banks about 12 banks, the office network reached 676 branch offices throughout Indonesia, during 2021 the total profit of Islamic banking reached 6 trillion Rupiah. OJK reports that the performance of Islamic banking has grown positively each period based on various performance indicators of national Islamic banking financial ratios such as the Capital Adequacy Ratio (CAR), Return on Assets (ROA), Finance to Deposit (FDR) and Non-Performing Finance (NPL) (Kamaruddin et al, 2023).

The development of the halal product industry has received regulatory support from the government through Law Number 33 of 2014 concerning Halal Product Guarantee. The law covers protection, justice, legal certainty, accountability and transparency, effectiveness and efficiency as well as professionalism. Through the guarantee

of halal products, small medium entreprises can increase added value to produce and sell their halal products as well as guarantee halal products (JPH) as well as increase product competitiveness in the global market (Kamaruddin et al, 2023).

The State of The Global Islamic Economy 2016-2017 report by Thomson Reuters shows that growth in various halal industry sectors including halal food, finance, travel, fashion, cosmetics and medicine, media and entertainment, as well as other sectors such as healthcare and education (Kamaruddin et al, 2023).

In Act No. 33 year 2014 about halal product assurances, it is explained that products are goods and services as well as related food, beverage, drugs, cosmetics, chemical products, biological products, genetically engineered products, used goods that mandatory to apply a halal certification. Meanwhile, the definition of halal product is product that is declared halal in accordance with Islamic law (Kamaruddin et al, 2023).

The objectives of the halal industry are as a form of embodiment of Law No. 33 year 2014 about halal product guarantees. The existence of Halal regulation is to guarantee the independence of each person to embrace their respective religions, which state is obliged to provide protection and guarantees regarding the halalness of products because the products in society that distributed, there is no guaranteed to be halal. Hence, necessary to have legal certainty in a law on guaranteeing halal products (Faried, 2019) in (Kamaruddin et al, 2023).

RESEARCH QUESTION

How about The Role of Islamic Banking to Increase Halal Industry in Indonesia with Bibliometric Approach?

LITERATURE REVIEW

Islamic Banking/Sharia Banking

Sharia Banking is a Bank that runs its business activities based on Sharia Principles and by type consists of Sharia Commercial Banks and Sharia People's Financing Banks. Sharia Banking is everything related to Sharia Banks and Sharia Business Units, including institutions, business activities, as well as methods and processes in carrying out their business activities. Sharia principles are principles of Islamic law in banking activities based on fatwas issued by institutions that have the authority to determine fatwas in the field of sharia. The principles of Islamic Banking are part of Islamic teachings related to the economy. One of the principles in Islamic economics is the prohibition of usury in various forms and using a system, including the principle of profit-sharing (UU. Nomor 21 Tahun 2008) in (Trimulato et al, 2021).

Sharia banking as an intermediary institution was not known at the time of the Prophet or his companions. However, investment cooperation activities in trade (buying and selling) and other transactions have been carried out individually by market participants who must follow Islamic sharia rules. Theoretically, the purpose of sharia banking is to facilitate the flow of investment from parties who have excess (surplus spending units) channeled to parties who need funds (spending unit deficit) and ultimately facilitate the circulation of economic resources. Thus, it will smoothen the flow of the economy, expedite the activities of the real sector, to be able to grow the economy. Sharia banking industry services to customers are equipped with various financial instruments that are expected to meet the needs of financial transactions that comply with sharia principles. In addition to being economically profitable, it can also not vio-

late sharia principles, so it's not just material. The Islamic financial instruments offered must of course be able to cover various levels of society and industry, including transaction needs for the consumption sector. Likewise with productive products (Trimulato et al, 2021).

In general, Islamic financial products can be divided into two main groups, namely; basic Islamic financial products used in traditional banking activities and development products. Products that need to be designed can meet the needs of the community but are also in line with sharia principles. The basic products of Islamic finance are used by Islamic banking institutions in carrying out their basic activities as intermediary institutions whose function is to transform the community's liquid assets into various long-term investments. However, in line with the development of activities that occur, Islamic banking products need to develop a variety of financial products to be able to flexibly facilitate transactions in different currencies and hedging instruments. As well as many more Islamic banking products that will meet the needs of the community, innovation is very much needed (Darsono.et al, 2017) in (Trimulato et al, 2021).

The Growth of Financing Sharia Banking

No	Type Of Sharia Banking	Type Of Financing	December 2020	August 2020	Growth (%)
1	**Bank Umum Syariah (BUS)**	Working Capital a. SMEs b. Non SMEs Investment a. SMEs b. Non SMEs Consumption a. Non SMEs	 a. 35.579 b. 45.386 a. 21.739 b. 34.464 a. 109.364	 a. 37.291 b. 41.928 a. 23.602 b. 33.424 a. 116.351	 a. 4,81 b. -7,62 c. 8,57 d. -3,02 a. 6,39
2	**Unit Usaha Syariah (UUS)**	Working Capital a. SMEs b. Non SMEs Investment a. SMEs b. Non SMEs Consumption a. Non SMEs	 a. 7.300 b. 26.643 a. 4.917 b. 26.066 a. 72.486	 a. 6.539 b. 27.505 a. 4.959 b. 24.232 a. 80.979	 a. -10,42 b. 3,24 a. 0,86 b. -7,04 a. 11,72
3	**Bank Pembiayaan Rakyat Syariah (BPRS)**	a. Working Capital b. Investmen c. Consumption	a. 4.842.629 b. 1.437.931 c. 4.400.939	a. 4.943.829 b. 1.523.657 c. 4.783.157	a. 2,09 b. 5,96 c. 8,69
4	**Total**		**394.625**	**408.061**	**3,41**

Source; Financial Services Authority. (OJK) Sharia Banking Statistics August 2021 (processed)

Source: Trimulato et al (2021).

Sharia banking need to be encouraged to channel them for productive activities that support the real sector, especially in the form of working capital. Sharia banking as sharia finance industry are expected to support real sector economic activities, including the halal industry (Trimulato et al, 2021).

If sharia banking has a major role in the halal industry in Indonesia, not only sharia banking will progress, but also the Indonesian economy as a whole will also advance. There are four major sectors that represent great opportunities in developing the halal industry, namely, the food industry, the pharmaceutical industry, the fashion industry and the tourism industry. Sharia banking can have a role in developing these four sectors, including cooperation with companies that will issue products with halal labeling to financially use sharia banking (Handayani, 2017) in (Trimulato et al, 2021).

On the other hand, the increasing Muslim middle class in Indonesia makes the halal industry will continue to grow in the future. The growing middle class is a sign that the consumption ability is also increasing. On the other hand, the development of information technology is one of the triggers for increasing public awareness of halal products in Indonesia. The link between Indonesia's economy which is dominated by consumption, the increasing middle class, and increasing public awareness of the existence of halal products is a big opportunity for Islamic Banking (LPPI, 2019) in (Trimulato et al, 2021). Halal is a universal indicator to improve the quality of living standards. The halal industry is a necessity so that it can participate in promoting sustainable economic growth. Therefore, the halal industry must be fought for and maintained for its existence (Sungkawaningrum, 2019) in (Trimulato et al, 2021).

The development of the halal industry is growing rapidly. However, in its development, these industries are often constrained by the funds and sources of capital needed by the company. Several products from the Islamic capital market that can be selected and used by the halal industry in obtaining funding are IPO, Sukuk, and ECF. It is hoped that this research can be useful for the development of the halal industry through the Islamic capital market in the future (Melisa & Khikmawati, 2021) in (Trimulato et al, 2021).

Halal Industry

Concept of Halal. The meaning of halal comes from the Arabic words, namely halla, hillan, yahillu, and wahalalan which means permissible or permitted by sharia law. Therefore, the halal industry has the concept of producing industrial products that must comply with sharia law (permissible in Islam). Based on the sharia concept, whatever is consumed by Muslims, both food and services must come from halal sources. Moreover, government regulated under the ACT No. 33 year 2014 about Guarantees for Halal Products that the State must provide protection and guarantees regarding the halal status of a product. Halal labeling from industrial products has an important role in seeing the quality of a product, because halal reflects the goodness of intrinsic value, both from the process and the final product or service produced (Mohamad & Backhouse, 2019) in Kamaruddin et al (2023). Annisa (2019) in Kamaruddin et al (2023) states that Halal Value Chain Ecosystem is a set of institutional and organizational arrangements, policies, processes, procedures, regulations and laws that direct organizations or companies implementing the halal industry towards sharia compliance. Meanwhile, the halal industry ecosystem is influenced by (i) demographic developments of Muslims; (ii) people's lifestyles that are driven by sharia principles that pri-

oritize good and avoid evil; (iii) sharia-based trade growth; (iv) development of halal industry players; (v) development of regulations that are able to provide strong opportunities for the growth of supply and demand for the halal industry; and (vi) information technology development, including Financial Technology or Fintech. (Fauzi, Karia, & Mokhtar, 2017) in Kamaruddin et al (2023).

Halal Industry often associated with an attempt to produce a product (goods and services) that are following the provisions of the Islamic religion (sharia). This definition began to emerge recently due to the high demand for halal products and services in the world. Previously, it was known that the halal industry was associated with the halal economy, where the mention of the halal economy was much earlier known than the halal industry. Thomson Reuters in collaboration with Dinar Standard contained in the 2019 edition of the State of the Global Islamic Economy Report stated that the halal economy consists of sectors whose main products and services are structurally influenced by Islamic law, driven by values, consumer lifestyles. and business practices. The definition of the halal industry in language consists of two words, namely industry and halal. According to the Big Indonesian Dictionary (KBBI), it is stated that industry is the activity of processing or processing goods using facilities and equipment, such as machines. Meanwhile, halal means permitted (not prohibited by sharia), so the halal industry is defined as the activity of processing or processing goods using facilities and equipment permitted by Islamic sharia. In its implementation, the halal industry, among others, has been regulated in Law no. 33 of 2014 concerning the Guarantee of Halal Products (Sukoso, et al. 2020) in (Trimulato et al, 2021).

Halal Products are products that have been declared halal following Islamic law. Halal Product Processing, hereinafter abbreviated as PPH, is a series of activities to ensure the Halalness of Products including the supply of materials, processing, storage, packaging, distribution, sales, and presentation of Products. Halal Product Guarantee, hereinafter abbreviated as JPH, is legal certainty regarding the halalness of a Product as evidenced by a Halal Certificate. The halal label is a sign of the halalness of a product. Halal Certificate is an acknowledgment of the halalness of a Product issued by BPJPH based on a written halal fatwa issued by MUI (UU Nomor 33, 2014) in (Trimulato et al, 2021).

Four main industries can be developed optimally by Indonesia as a country with the largest Muslim population in the world, namely the halal tourism industry, the halal food industry, the halal fashion industry, and the halal finance industry. Mapping and identification of the potential of each type of industry are very important as the first step in developing the halal industry. What is very important to do is to create an ecosystem that can develop the four halal industries at the same time by ensuring the optimization of the performance of halal value chain management so that the quality and standards of the products and services produced are very important in addition to prioritizing halal. In the mapping process, it is known that each halal industry has potential that can be improved so that it has added value while maintaining Indonesian culture. Five strategic steps need to be taken, namely increasing competitiveness, certification, coordination, publication, and cooperation. For this reason, it requires the involvement and coordination of the government, policymakers and cross-sectoral industry players in building the halal industry in Indonesia, as well as the active role of the community as agents of promoting sharia products in thedigital world so that the development of the halal industry can enter the global market immediately (Saputri, 2020) in (Trimulato et al, 2021).

The Growth of Halal Industry

The Growth Of Number Certificate Halal Industry LPPOM 2021

No	Components	2015	September 2021	Growth (%)
1	Number Of Companies	1052	16.856	1502,28
2	Number SH (Halal Certifacate)	1404	40.732	2801,14
3	Number Of Producte	46260	1.217.328	2531,49

Source: LPPOM MUI. Statistics of MUI Halal Certified Products for the Period 2015 to 2021 (data processed)

From the data above, it shows that there is a development in the number of halal certification products issued by LPPOM from 2015 to September 2021, all of which have a very significant increase. The number of companies that gave business labels to their products grew by 1,502.28 percent, then the number of halal certificates grew by 2,801.14 percent, and the number of products that had obtained halal certification grew by 2,531.49. Thus, the development of the goods and service industry will continue to grow, which obtains the MUI halal certificate, to increase public access to halal products (Trimulato et al, 2021).

Total World Industry Halal Expenditure

No	Halal Industry Sector	Nilai (USD, Miliar)	Porsi
1	Halal Foods	173	77,23
2	Halal Travel	11	4,91
3	Halal Fashion	21	9,38
4	Halal Media and Tourism	10	4,47
5	Halal Farmacy	5	2,23
6	Halal Cosmetics	4	1,78
7	Total	224	100

Source: Thomson Reuters in Halal Ekosistem Halal, 2020 Bank Indonesia

Source: (Trimulato et al, 2021).

The data shows that there is a portion of each halal product spent globally in the world in 2018. The largest sector in shopping for halal products, namely the halal food and beverage sector, takes the largest portion, which is 77.23 percent, then the halal fashion sector at 9.38 percent., and 4.91 percent halal travel. From this condition, various halal sectors still have great opportunities and potential to be developed globally, with various supports from various parties so that the halal industry can develop and compete in the global arena. As the country of Indonesia is the world's largest Muslim, everything requires halal legality so that it can be used and consumed safely, comfortably, and quietly. The potential for halal products to be accepted in the global realm can continue to grow with support from the government and other industries to be able to support it, including in its development which requires no small amount of capital. In this position, the Islamic finance industry is an institution that can support the development of the real sector, including the halal industry sector, and SMEs. This is an opportunity for Islamic banks and Islamic finance to be able to increase their productive portion, not just increase consumption(Trimulato et al, 2021).

Halal certification by MUI plays an important role because it is defined as the inspection of certain production processes and meets the hygienic, sanitary, and safety

requirements. Products certified Halal by the board may use the registered trademark halal logo. Currently, halal certification is voluntary but in 2019 it will be mandatory. By having a halal certificate, the product will have many competitive advantages. Today, a halal certificate is a guarantee that a particular product has been thoroughly investigated and declared compliant with Islamic sharia law. Hence convincing Muslims to consume the product (BAPPENAS, 2018) in (Trimulato et al, 2021).

Figure Halal Product Consumption from Dinar Standar (2022)

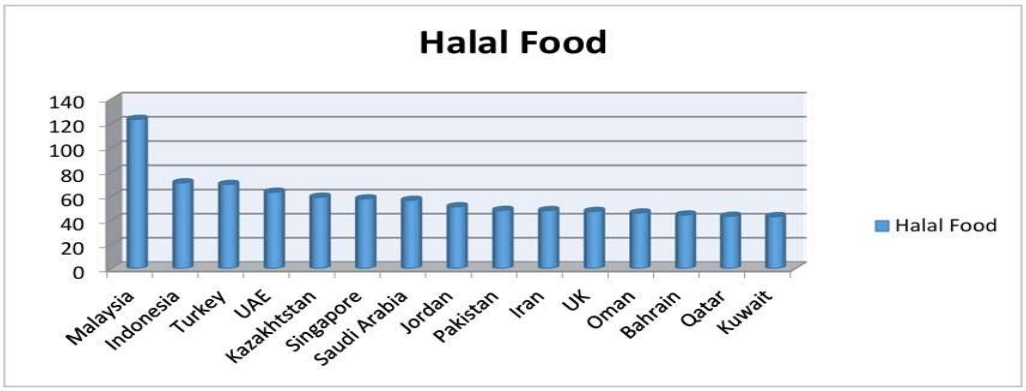


Figure 2 Indicator Score Breakdown for Top 15 Ranking Countries

Source : State of the Global Islamic Economy (2022)

Source: Siregar and Siregar (2024).

According to research from Dinar Standard (Fgure 1), consumption of halal goods is anticipated to rise to US$ 282 in 2025, up 53% from US$ 184 in 2020. Food and drink consumption, which accounts for the largest portion of the sector's output and makes Indonesia the world's largest consumer of food and drink, is expected to rise through 2025. The growing demand for halal goods is directly influenced by the halal way of life. In order to assure product safety and hygiene and to boost product competitiveness for export to nations that are highly concerned about halal products, micro, small, and medium-sized businesses must acquire halal product certification. The Free Hala Certificate initiative (Sehati), which aims to issue 25,000 halal certificates in order to hasten the production of 10 million halal certified items, is backed by the Halal Product Assurance Organizing Agency initiative (Siregar and Siregar, 2024).

Indonesia's Halal Food Products are ranked second in the world according to the State of the Global Islamic Economy (SGIE) in 2022. From a consumer standpoint, Indonesia is the world's biggest market for halal food items. The abundance of halal food items in Indonesia presents a fantastic potential to boost halal food production each year for both domestic and international markets. Indicators for halal food in Indonesia are still becoming better, and halal food exports to OIC nations rose by 16%. In addition, this gives Bank Syariah Indonesia a fantastic chance to assist and finance MSMEs with halal roots amidst the rapid development of digital in the industrial era. 5.0. There are still numerous challenges facing Indonesia's halal industry, which is driven by micro, small, and medium-sized businesses. The topic of capital and finance is one of the most significant. Many micro, small, and medium-sized businesses have finished the halal certification procedure for their products, but due to capi-

tal/financial issues, their business development is stagnant. The authors of this study also want to emphasize how Islamic banks' responses take the shape of special policies that help them contribute to the growth of the halal sector both globally and in Indonesia specifically. Of course, the special capital/finance policy that supports micro, small, and medium-sized businesses that already have halal certificates is the function that the halal industry is waiting for (Siregar and Siregar, 2024).

Total Revenue and Estimated Revenue of the Halal Industry

Sector	Revenue (2015)	Estmated Revenue (2021)
Halal Food	$ 1,17 Triliun	$ 1,9 Triliun
Finance	$ 2 Triliun	$ 3,5 Triliun
Travel	$ 151Miliar	$ 243 Miliar
Fashion	$ 243 Miliar	$ 368 Miliar
Pharmaceutical & Cosmetics	$ 78 Miliar	$ 132 Miliar
Media & entertainment	$ 189 Miliar	$ 262 Miliar
Healthcare	$ 436 Miliar	-
Education	$ 402 Miliar	-

Source: State of The Global Islamic Economy 2016/2017

Source: Kamaruddin et al. (2023).

Table shows that the need for halal products and services is very huge both in the world and in Indonesia, while the need for halal products is not only limited to food productions. The sector in the halal industry consists of 10 sectors that economically and business make a major contribution to the halal industry which the food productions, tourism and travel, clothing and fashion, cosmetics, finance, pharmaceutical, media and recreational, fitness, education and cultural arts industries. Based on data from the Global Majlis, the global Muslim population in 2012 was 1.8 billion people, in 2030 it is projected that the world's Muslim population will reach 2.2 billion people. The growing population is a potential market for the growth and investment of the halal industry (Kamaruddin et al, 2023).

The development of micro, small and medium enterprises (MSMEs) as part of the halal industry in Indonesia has made a major contribution to the national economy that MSMEs have specific advantages to contribute to national economy that support local economy by use local raw materials with relatively affordable prices, easy labor and unique product specifications that potential for international markets. In terms of the halal certification process that businessmen of micro, small and medium enterprises (MSMEs) face obstacles in the halal certification process which is expensive and needed a long process of bureaucracy whereby in halal certification process, it involves various parties, not only the Ministry of Religion but involve cross-ministerials such as the Ministry of Health, Ministry of Trade, Ministry of Industry and Ministry of MSMEs and Cooperatives, therefore it needs a strong coordination and cooperation among them so the potential of halal industry can be optimatimazing for national economy. Hence, the ease of access for the halal certification process and detailed information about halal procedure needed to improve the halal certification process (Haliding, 2018) in (Kamaruddin et al, 2023).

METHODS

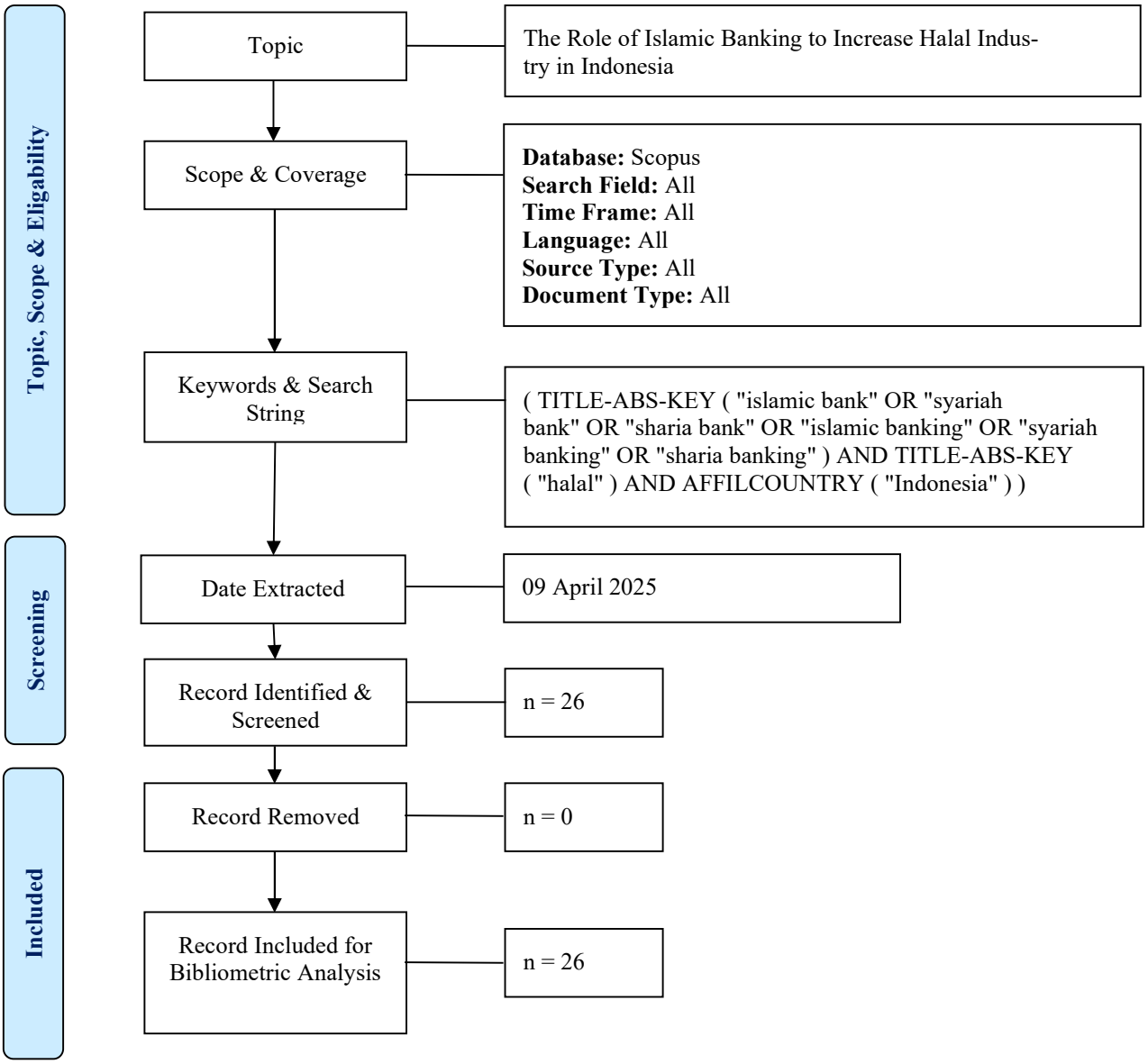


Figure 1. Flow diagram of the search strategy

Source: Customized based on Zakaria (2020) and Moher (2009)

This study explores the complexities of The Role of Islamic Banking to Increase Halal Industry in Indonesia through a bibliometric analysis. By examining a variety of studies, it aims to identify research gaps and current perspectives within the field. The analysis utilizes CSV and RIS files from the Scopus database, which are processed using Excel and Publish or Perish software. To visualize frequently used keywords and concepts, the VOS Viewer tool is employed. The study analyzes a total of 26

publications selected from existing literature, providing a comprehensive overview of the field's intricacies.

RESULTS

Table 1. Document and Source Type

Document Type	Total Publications (TP)	Percentage (%)
	Document	
Article	24	92.31%
Book Chapter	1	3.85%
Review	1	3.85%
	Source	
Journal	25	96.15%
Book	1	3.85%

Source: Data Processed

Table 1 provides an overview of the distribution of documents and sources within the study, detailing their respective total publications and percentages. In terms of document types, articles dominate the dataset, consisting of 24 publications and accounting for 92.31% of the total. Meanwhile, book chapters and reviews each contribute one publication, representing 3.85% each. Regarding source types, journals serve as the primary medium for publication, encompassing 25 entries and making up 96.15% of the total. Books, in contrast, constitute a minor share with only one publication, equating to 3.85%.

Table 2. Languages

Language	Total Publications (TP)	Percentage (%)
English	25	96.15%
Arabic	1	3.85%

Source: Data Processed

Table 2 presents an analysis of the total number of publications (TP) categorized by language, along with their respective percentages. The data reveals that English dominates as the primary language of publication, accounting for 96.15% of the total, with 25 publications. In contrast, Arabic represents a minor proportion, comprising only 3.85% with a single publication. The data suggests a strong preference for English in academic and scholarly dissemination within this dataset.

Table 3. Subject Area

Subject Area	**Total Publications**	**Percentage (%)**
Business, Management and Accounting	15	26.79%
Social Sciences	14	25.00%
Arts and Humanities	9	16.07%
Economics, Econometrics and Finance	6	10.71%
Decision Sciences	4	7.14%
Environmental Science	3	5.36%
Computer Science	2	3.57%
Energy	2	3.57%
Psychology	1	1.79%

Source: Data Processed

Table 3 presents a detailed overview of the distribution of publications across various academic disciplines. The data reveals that Business, Management, and Accounting is the most extensively studied field, accounting for 26.79% of the total publications, with 15 documents. Following closely, Social Sciences comprise 25.00% of the total with 14 publications, demonstrating significant research activity in these areas. Arts and Humanities hold a notable share, contributing 9 publications (16.07%). In contrast, Economics, Econometrics, and Finance represent 10.71% of the total publications, amounting to 6 documents. Furthermore, Decision Sciences accounts for 7.14% of the total, with 4 publications, while Environmental Science comprises 5.36% with 3 publications. Research output in Computer Science and Energy is relatively modest, each contributing 2 publications (3.57%). Lastly, Psychology exhibits the least representation, encompassing only 1 publication, which equates to 1.79% of the total.

Table 4. Year of Publications and Citations

	Papers	Citations	Cites per Year	Cites per Paper	Cites per Author	Paper per Author	Authors per Paper	h-index	g-index
2013	1	180	15.00	180.00	22.50	0.13	8.00	1	1
2018	1	14	2.00	14.00	3.50	0.25	4.00	1	1
2019	2	11	1.83	5.50	4.33	0.83	2.50	2	2
2020	2	5	1.00	2.50	1.25	0.75	3.00	1	2
2022	2	6	2.00	3.00	1.50	0.50	4.00	1	2
2023	10	103	51.50	10.30	29.65	2.87	3.90	5	10
2024	6	14	14.00	2.33	4.83	2.00	3.17	1	3
April 2025	2	0	0.00	0.00	0.00	0.83	2.50	0	0

Source: Data Processed

The table above presents an analysis of academic output and citation impact across years, from 2013 to April 2025. In 2013, one paper was published with 180 citations, yielding an average of 15 citations per year and an exceptionally high 180 citations per paper. In 2018, there was also one publication with 14 citations and an average of 2 citations per year. Research activity increased slightly in 2019, with two papers published, garnering 11 citations, which is 5.5 citations per paper. In 2020, two papers were also produced, but they received fewer citations (5 total, 2.5 citations per paper). A similar trend continued in 2022, where two publications recorded 6 citations, an average of 3 citations per paper. However, 2023 marked a significant spike in academic output, with 10 papers published, generating 103 citations. This results in an impressive 51.5 citations per year and a substantial h-index of 5. Momentum slows in 2024, with 6 papers garnering 14 citations (2.33 citations per paper). As of April 2025, 2 papers have been published, although they have not received any citations.

Table 5. Citations Metrics

Metrics	**Data**
Publication Years	2013- April 2025
Citation Years	12 (2013-2025)
Papers	26
Number of Citations	333
Citations per Year	27.75
Citations per Paper	12.81
Cites per Author	67.56
Papers per Author	8.17
Authors per Paper	3.62
h-index	7
g-index	18
hI,norm	4
hI,annual	0.33
hA-index	4

Source: Data Processed

The table above provides a comprehensive overview of citation-related indicators for the analyzed publications spanning from 2013 to April 2025. The dataset comprises 26 papers with a total of 333 citations, reflecting an average of 12.81 citations per paper. Over the 12-year citation period (2013-2025), the average number of citations per year stands at 27.75, indicating a steady citation impact across time.The author-based citation metrics further highlight scholarly influence. Each author, on average, has accumulated 67.56 citations, while individual authors have contributed to approximately 8.17 papers, with 3.62 authors per paper, suggesting a strong collaborative research environment. Several indices are presented to gauge research impact. The dataset exhibits an h-index of 7, indicating that at least 7 papers have received 7 or more citations each, signifying both productivity and citation impact. The g-index of 18 suggests that the top-cited papers collectively contribute to a high citation count.

Table 6. Most influential institutions and countries with minimum of two publications

AFFILIATION	PUBLICATION
Universitas Airlangga	2
Universitas Diponegoro	2
Universitas Negeri Semarang	2
Universitas Islam Negeri Sunan Kalijaga, Yogyakarta	2
Institut Agama Islam Negeri Palopo	2

Source: Data Processed

The table above highlights five universities that have contributed at least two publications. The listed institutions include Universitas Airlangga, Universitas Diponegoro, Universitas Negeri Semarang, Universitas Islam Negeri Sunan Kalijaga Yogyakarta, and Institut Agama Islam Negeri Palopo. Each university has met the threshold for at least two publications, indicating a significant presence in academic research.

Table 7. Top 10 Highly cited articles

Cited by	Authors	Title
180	(Wilson et al., 2013)	Crescent marketing, Muslim geographies and brand Islam: Reflections from the JIMA Senior Advisory Board
48	(Berakon et al., 2023)	An expansion of the technology acceptance model applied to the halal tourism sector
22	(A. A. N. Pratama et al., 2023)	The effect of halal brand awareness on purchase intention in indonesia: the mediating role of attitude
14	(Nurkhin et al., 2018)	The role of the Sharia Supervisory Board and corporate governance mechanisms in enhancing Islamic performance-evidence from Indonesia
13	(Windasari et al., 2024)	Assessing consumer preferences on halal service: the emergence of Sharia hospitals for Muslim consumer

8	(Mujiatun et al., 2023)	The Impact of Marketing Communication and Islamic Financial Literacy on Islamic Financial Inclusion and MSMEs Performance: Evidence from Halal Tourism in Indonesia
7	(Syatar et al., 2023)	Examining Call for the Dissolution of Indonesian Ulema Council: Siyāsah Syar'íyyah Perspective
7	(A. P. Pratama et al., 2019)	Existence and Position of Islamic Economic Laws in Indonesia
6	(Mukhibad et al., 2022)	Corporate Governance And Islamic Law Compliance Risk
6	(Iswanto & Hadinatha, 2023)	Sharia Constitutionalism: Negotiating State Interests And Islamic Aspirations in Legislating Sharia Economic Law

Source: Data Processed

The table above presents a ranked list of the most influential research publications in the field, based on citation counts. The highest-ranked article, authored by Wilson et al. (2013), has garnered 180 citations and explores branding in Islamic markets. The second most-cited work, by Berakon et al. (2023), focuses on the expansion of the technology acceptance model in the halal tourism sector, receiving 48 citations. Other notable publications include Pratama et al. (2023), which investigates halal brand awareness and its effect on purchase intention, accumulating 22 citations. Research on governance and financial literacy by Nurkhin et al. (2018), alongside studies on Islamic marketing and legal frameworks by Windasari et al. (2024) and Mujiatun et al. (2023), respectively, have also made significant academic contributions, with citation counts ranging from 14 to 6.

Table 8. Keywords with minimum of two publications

Author Keywords	**Total Publications**	**Percentage (%)**
Indonesia	6	4.26%
Islamic Bank	3	2.13%
Banking	2	1.42%
Conventional Bank	2	1.42%
Halal	2	1.42%

Islamic Banks	2	1.42%
Marketing	2	1.42%
Non-halal Income	2	1.42%
Religiosity	2	1.42%
Trust	2	1.42%
Zakah	2	1.42%

Source: Data Processed

The table above provides an analysis of frequently used author keywords in scholarly publications. The most prominent keyword is "Indonesia," which appears in six publications, accounting for 4.26% of the total. The keyword "Islamic Bank" is featured in three publications, representing 2.13% of the total, highlighting the significance of Islamic banking discussions. Several other keywords, including "Banking," "Conventional Bank," "Halal," "Islamic Banks," "Marketing," "Non-halal Income," "Religiosity," "Trust," and "Zakah," each appear in two publications, making up 1.42% of the dataset.

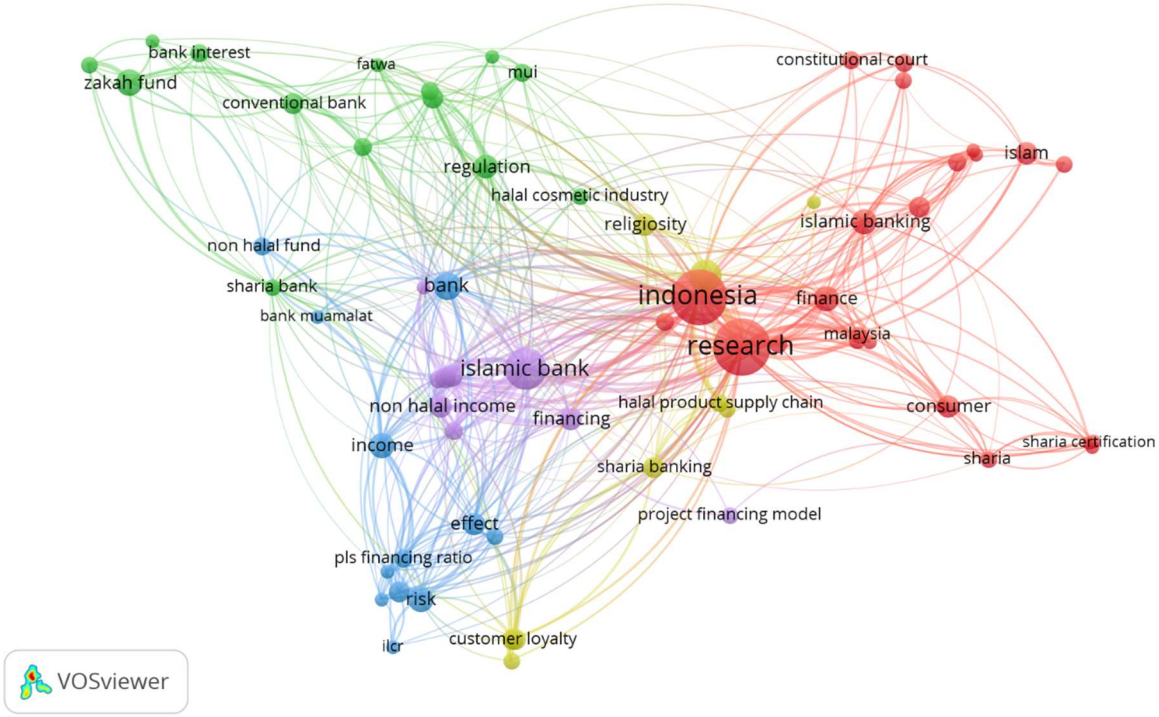


Figure 2. VOSviewer Network Visualisation of a term co-occurrence network based on title and abstract fields (Full Counting)

Source: Data Processed by VOSviewer (2025)

In VOSviewer, interconnected keywords are referred to as items and are visually represented by small colored circles, illustrating their association with document metadata, as shown in Figure 2. The network visualization employs distinct colors to differentiate clusters of related items, while connecting lines denote the strength of relationships or co-occurrences between them (Van Eck & Waltman, 2010). According to Nurhadi and Meilinda (2024), larger circles indicate highly relevant keywords with stronger connections, whereas smaller circles correspond to less frequently linked keywords. The VOSviewer analysis identifies five clusters, encompassing a total of 68 items (see Table 9).

Table 9. Cluster-Based Grouping Of Keyword Circles

Clusters	Colors	Items
Cluster 1	Red	(24 Items) Constitutional Court, Consumer, Finance, Halal Industry, Halal Tourism, Indonesia, Islam, Islamic Banking, Islamic Economic, Islamic Economic Law, Islamic Financial Inclusion, Islamic Financial Literacy, Islamic Marketing, Malaysia, Marketing Communication, Muslim Friendly Tourism, Research, Sharia, Sharia Certification, Sharia Economic, Sharia Economic Law, Sharia Hospital, Sharia Label, Sharia Lodging Business.
Cluster 2	Green	(14 Items) Bank Interest, Conventional Bank, Conventional Bank Account, Fatwa, Halal Cosmetic Industry, Haram, Indonesian Ulema Council, MUI, Qualitative Approach, Regulation, Sharia Bank, Sharia Compliance, Sharia Mutual Fund, Zakah Fund.
Cluster 3	Blue	(12 Items) Bank, Bank Muamalat, Corporate Governance, Effect, ILCR, Income, Non Halal Fund, PLS, PLS Financing Ratio, Risk, Ssb, Zakah Performance.
Cluster 4	Yellow	(9 Items) Costumer Loyalty, Halal Product, Halal Product Commerce, Halal Product Supply Chain, Loyalty, Religiosity, Religiosity Commitment, Sharia Banking, Technology Acceptance Model.
Cluster 5	Purple	(9 Items) Financing Performance, Financing, Health Level, Islamic Bank, Islamic Fund, Non Halal Income, Policymaker, Project Financing Model, Sharia Principle.

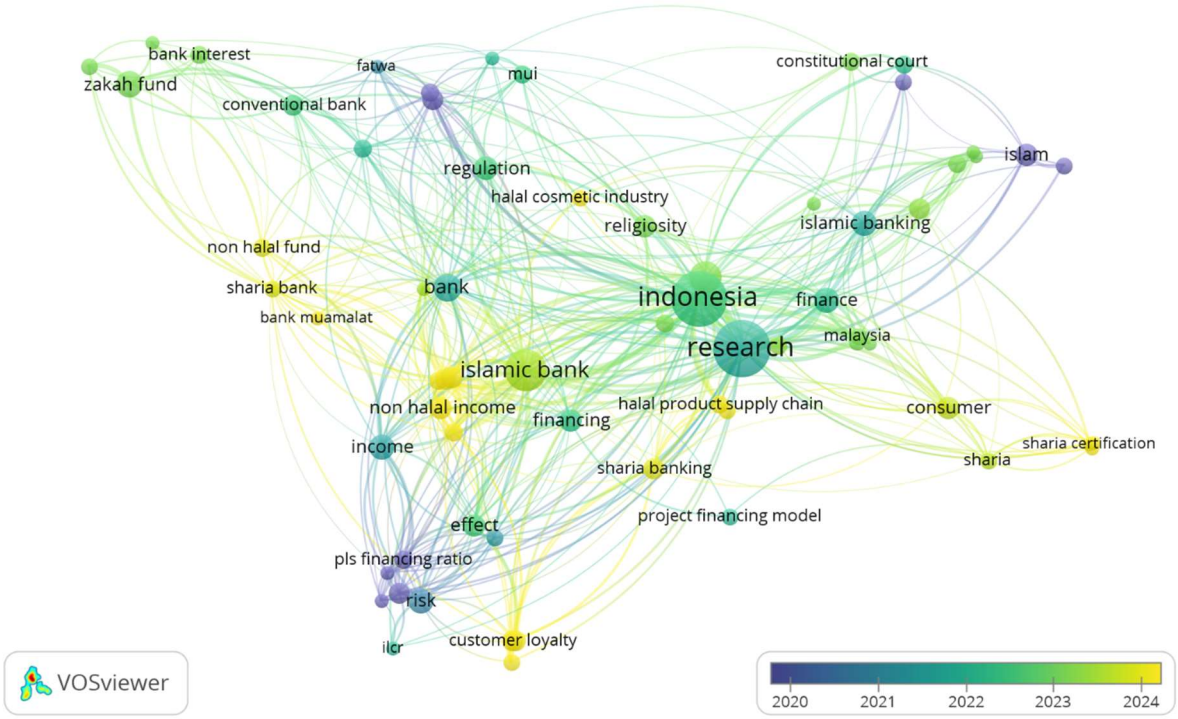


Figure 3. VOSviewer Overlay Visualisation of a term co-occurrence network based on title and abstract fields (Full Counting)

Source: Data Processed by VOSviewer (2025)

The overlay visualization uses a color gradient to represent the average publication date in the period 2020–2024. Items within the same time period are given a uniform color, while connecting lines indicate relationships or patterns of co-occurrence (Van Eck & Waltman, 2010). This visualization method captures the evolution of a research topic over time, with older publications depicted as darker circles and newer documents as lighter circles (Dagiene & Xie, 2021). The impact of publications is represented by a blue-green-yellow spectrum, where yellow corresponds to the highest impact score (3), and blue indicates the lowest (1) (Van Eck & Waltman, 2023; Nurhadi & Meilinda, 2024). As shown in Figure 3, 2020 (dark blue) shows the lowest impact (score 1), while 2024 (yellow) shows the highest impact (score 3). The keyword Tosca, with a score of 2, was associated with the largest number of keyword documents during the 2021–2023 time period.

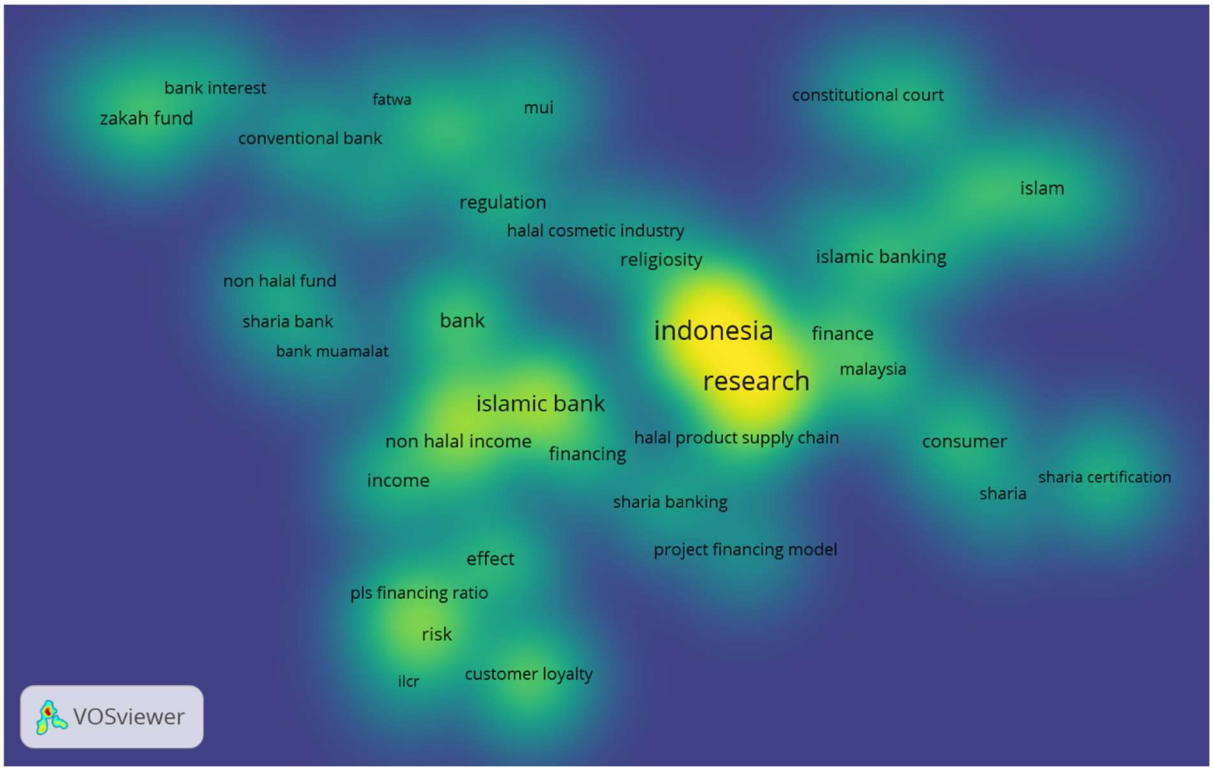


Figure 4. VOSviewer Density Visualisation of a term co-occurrence network based on title and abstract fields (Full Counting)

Source: Data Processed by VOSviewer (2025)

Figure 4 presents a density visualization that utilizes color gradients to represent the distribution of items within a network. Warm colors, such as yellow, indicate areas of high density, while cooler tones, including blue and green, correspond to regions of lower density (Van Eck & Waltman, 2010). Frequently discussed topics, such as Indonesia and Research, are depicted in warmer hues, signifying their prominence within the dataset. In contrast, less frequently explored subjects, such as Bank Muamalat and Fatwa, appear in cooler tones, reflecting their lower occurrence within the analyzed network.

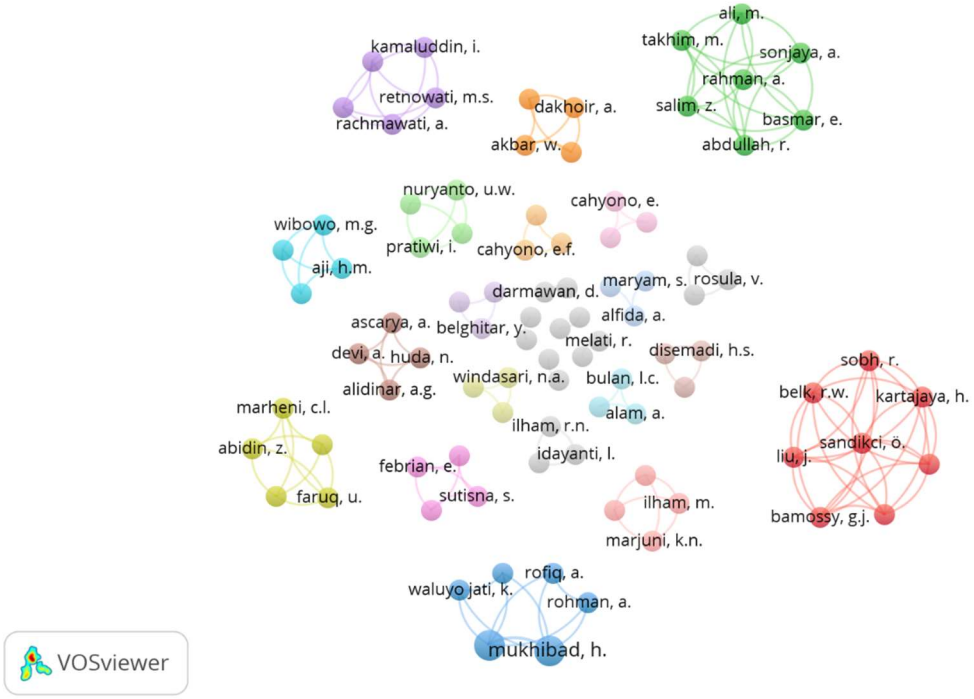


Figure 5. Vosviewer Network Visualisation Map of The Co-Authorship (92 tems)

Source: Data Processed by VOSviewer (2025)

Figure 5 provides an in-depth visualization of the strength of co-authorship relationships. Isolated gray components indicate no connections (van Eck & Waltman, 2013). Meanwhile, there is a visualization map of the co-authorship network. Authors showing strong collaborative relationships are grouped into clusters distinguished by uniform colors on the author density map, where each connecting line indicates a co-citation (Ahmi and Mohd Nasir, 2019; Cheng et al., 2022). After setting a minimum document threshold of one per author, a total of 367 items were identified, with the largest interconnected set consisting of 8 items (depicted by red circles). The colored circles, larger and interconnected, represent well-connected and highly cited authors. These eight items include Bamossy, G. J; Belk, R. W; Kartajaya, H; Lui, J; Sandikci, Ö; Scott, L; Sobh, R; Wilson, J. A. J.

CONCLUSION

The aim of this research is to examine bibliometric literature on the The Role of Islamic Banking to Increase Halal Industry in Indonesia. Bibliometric Approach. In the search process, the keyword was used. "The mapping procedure at that time was completed using VOSviewer based on the results of analysis and mapping with VOSviewer, there are clusters identified in the period. From the network visualization results, gaps or loopholes are found that researchers can use to find new things to determine relevant research themes. So through Bibliometric analysis of the The Role of Islamic Banking to Increase Halal Industry in Indonesia. Bibliometric Approach using the VOSviewer application, themes for novelty in research were obtained

REFERENCES

Ahmi, A., & Mohd Nasir, M. H. (2019). Examining the trend of the research on extensible business reporting language (XBRL): A bibliometric review. *International Journal of Innovation, Creativity and Change*, *5*(2), 1145–1167.

Berakon, I., Wibowo, M. G., Nurdany, A., & Aji, H. M. (2023). An expansion of the technology acceptance model applied to the halal tourism sector. *Journal of Islamic Marketing*, *14*(1), 289–316. https://doi.org/10.1108/JIMA-03-2021-0064

Fitri Ana Siregar and Erwin Saputra Siregar. 2024. Indonesian Islamic Bank Financing In Increasing Halal Based Micro, Small And Medium Enterprises In The Industrial Era 5.0. MALIA: Journal of Islamic Banking and Finance (2024, Vol. 8 No. 1) 2654-8569 (E-ISSN)/2654-8577 (P-ISSN)

Iswanto, B., & Hadinatha, M. F. (2023). SHARIA CONSTITUTIONALISM: NEGOTIATING STATE INTERESTS AND ISLAMIC ASPIRATIONS IN LEGISLATING SHARIA ECONOMIC LAW. *Ahkam: Jurnal Ilmu Syariah*, *23*(1), 235 – 258. https://doi.org/10.15408/ajis.v23i1.32899

Kamaruddin, Ilham Gani , Safri Haliding. 2023. Contribution of Islamic Banks in the Development of the Halal Industry in South SulawesiAl-Mashrafiyah: Jurnal Ekonomi, Keuangan dan Perbankan Syariah ISSN (p): 2597-4904 ISSN (e) : 2620-5661 Volume 7, Nomor 2, Oktober (2023), h.43-54 10.24252/al-mashrafiyah.v7i2.38587

Mujiatun, S., Trianto, B., & Cahyono, E. F. (2023). The Impact of Marketing Communication and Islamic Financial Literacy on Islamic Financial Inclusion and MSMEs Performance: Evidence from Halal Tourism in Indonesia. *Sustainability (Switzerland)*, *15*(13). https://doi.org/10.3390/su15139868

Mukhibad, H., Nurkhin, A., Waluyo Jati, K., & Yudo Jayanto, P. (2022). Corporate governance and Islamic law compliance risk. *Cogent Economics and Finance*, *10*(1). https://doi.org/10.1080/23322039.2022.2111057

Nurkhin, A., Rohman, A., Rofiq, A., & Mukhibad, H. (2018). The role of the Sharia Supervisory Board and corporate governance mechanisms in enhancing Islamic performance-evidence from Indonesia. *Banks and Bank Systems*, *13*(4), 85–95. https://doi.org/10.21511/bbs.13(4).2018.08

Pratama, A. A. N., Hamidi, M. L., & Cahyono, E. (2023). The effect of halal brand awareness on purchase intention in indonesia: the mediating role of attitude. *Cogent Business and Management*, *10*(1). https://doi.org/10.1080/23311975.2023.2168510

Pratama, A. P., Disemadi, H. S., & Prananingtyas, P. (2019). EXISTENCE AND POSITION OF ISLAMIC ECONOMIC LAWS IN INDONESIA. *Legality: Jurnal Ilmiah Hukum*, *27*(2), 222–231. https://doi.org/10.22219/jihl.v27i2.10159

Syatar, A., Imran, M., Ilham, M., & Marjuni, K. N. (2023). Examining Call for the Dissolution of Indonesian Ulema Council: Siyāsah Syar'íyyah Perspective. *Juris: Jurnal Ilmiah Syariah*, *22*(2), 199–211. https://doi.org/10.31958/juris.v22i2.6678

Trimulato, Ahmad Rodoni, Euis Amalia. 2021. Linkage Sharia Banking and Sharia Fintech to Support Halal Industry in IndonesiaAnnual International Conference on Islamic Economics and Business, 2021, 138-151

Van Eck, N.J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics, 84(2), 523–538.

Van Eck, N. J., & Waltman, L. (2012). Manual for VOSviewer version 1.5.2. Leiden Univeristy, (September), 1–28. Retrieved from http://www.vosviewer.com/documentation/Manual_VOSviewer_1.5.4.pdf

Van Eck, N.J., & Waltman, L. (2014). Visualizing bibliometric networks. In Y. Ding, R. Rousseau, & D. Wolfram (Eds.), Measuring scholarly impact: Methods and practice (pp. 285–320). Springer

Van Eck, Nees Jan, and Waltman,Ludo. (2023). VOSviewer Manual

Wilson, J. A. J., Belk, R. W., Bamossy, G. J., Sandikci, Ö., Kartajaya, H., Sobh, R., Liu, J., & Scott, L. (2013). Crescent marketing, Muslim geographies and brand Islam: Reflections from the JIMA Senior Advisory Board. *Journal of Islamic Marketing*, *4*(1), 22–50.

https://doi.org/10.1108/17590831311306336
Windasari, N. A., Azhari, N. P. D. A., & Putra, I. F. (2024). Assessing consumer preferences on halal service: the emergence of Sharia hospitals for Muslim consumer. *Journal of Islamic Marketing*, *15*(1), 22–41. https://doi.org/10.1108/JIMA-07-2022-0192
Yolanda Hani Putriani and Atina Shofawati. 2015. Pola Perilaku Konsumsi Islami Maha siswa Muslim Fakultas Ekonomi Dan Bisnis Universitas Airlangga Ditinjau Dari Tingkat Religiusitas. JESTT Vol. 2 No. 7 Juli 2015.
Zakaria, R., Ahmi, A., Ahmad, A. H., & Othman, Z. (2020) Worldwide Melatonin Research: A Bibliometric Analysis of the Published Literature between 2015 and 2019, Chronobiology International. https://doi.org/10.1080/07420528.2020.1838534

Extraordinary Events and Their Impact on Tourism Development In The Slovak Republic

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Abstract

Extraordinary events significantly influence the development of various sectors of the national economy, with tourism being one of the most sensitive. This scientific paper focuses on the impacts of three key extraordinary events — the Covid-19 pandemic, the military conflict in Ukraine, and the energy crisis — on the tourism industry in the Slovak Republic.

The Covid-19 pandemic caused an unprecedented decline in tourism due to restrictions on movement, border closures, and changes in tourist behaviour. The following military conflict between Ukraine and the Russian Federation, which began in 2022, brought new challenges. Slovakia, as a neighbouring country, faced the arrival of a large number of Ukrainian refugees, which temporarily altered the structure of guests in accommodation facilities. The state financially compensated entrepreneurs for providing accommodation to refugees, but after these compensations ended, many businesses lost a substantial part of their clientele.

Simultaneously, the escalating energy crisis has increased operating costs in tourism, while inflation and government tax measures have further burdened businesses in the sector. This paper analyses these events cumulative effects on tourism development in Slovakia, evaluates the changes in demand and supply, and outlines possible strategies for future recovery and stabilization of the sector.

Keywords: tourism**,** extraordinary events, Covid-19, Russian-Ukrajine conflict, energetic crisis

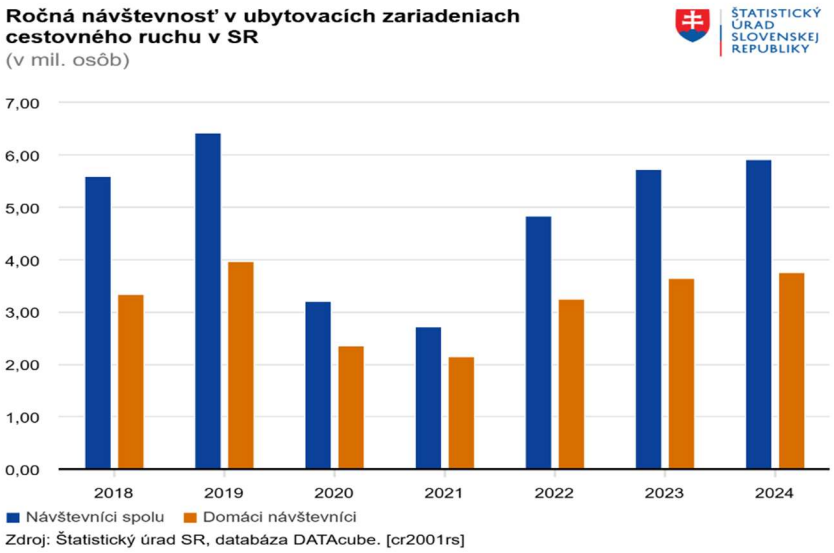
JEL Classification: M31, Z32

1. Introduction

Tourism is an important part of the national economy of the Slovak Republic. The theoretical definition of tourism in Slovakia is characterized as "a set of activities aimed at satisfying the needs related to travel and the stay of individuals outside their

permanent residence, usually during their free time. The goal is rest, exploration, health, entertainment and amusement, cultural and sports activities, business trips—in other words, gaining a comprehensive experience."[1] It contributes to job creation, regional development, and increased state budget revenues. However, it is also one of the most sensitive sectors to changes in the external environment. Its position in the Slovak Republic is not dominant. Tourism accounts for only about 5% of the gross domestic product (GDP) on average, but its share of created jobs is higher (6.3%) in this sector. Among European Union countries, the Slovak Republic ranks among the lowest in terms of tourism's share in GDP, as shown in the following overview:[2]

Graph 1: Annual visitation of tourism accommodation facilities in the Slovak Republic



Despite this share, the Slovak Republic has the potential for massive tourism development. Slovakia is a country with the highest number of castles and chateaux relative to its area and can rightly be called a castle superpower. It has 220 castles and castle ruins, and 425 manor houses. The country boasts a wealth of mineral springs (1,650 registered mineral and thermal springs), which are also used in water parks and spa treatments. There are over 7,000 caves, 60 of which are open to the public, as well as 7 national parks. Tourist centres suitable for hiking, sports, leisure, and relaxation have been developed. For the development of tourism, there is also a sufficient number of accommodation facilities and gastronomic establishments.

[1] Ministry of Travel and Construction of the Slovak Republic, online: : https://www.mindop.sk/ministerstvo-1/cestovny-ruch-7/informacie/cestovnyruch/terminologia-v-cr-pdf-183-kb

[2] World Travel & Tourism Council (WTTC), 2019. online: https://wttc.org, p. 37

1.1. Tourism in Slovakia from the Perspective of Organization

Tourism services in Slovakia are provided by businesses that have specific characteristics:

- **High dependence on human resources –** it is a service industry where the human factor plays a key role. However, the location of tourism enterprises in some regions does not provide a sufficiently suitable workforce for these businesses.

- **Seasonality of service provision –** depending on the location of the enterprise, the tourist season varies. The summer and winter seasons are the most utilized, while spring and autumn seasons are typically much weaker.

- **Highly competitive environment –** although Slovakia has a sufficient number of accommodation facilities, their average occupancy rate is only 29%. This creates significant pressure on service quality, as well as on reducing prices and profit margins for accommodation providers.

- **Location –** the area in which a tourism business operates and how well the business can utilize natural and local externalities, while also potentially influencing its surroundings in a positive or negative manner. The location can be defined as "a naturally delimited unit which, in terms of tourism development, has unique characteristics distinguishing it from other destinations. These unique characteristics include attractions, services offered, and infrastructure."[3]

Entities providing tourism services are, according to the purpose of providing services:

- business with the aim of achieving maximum profit while minimizing costs,

- non-business with the aim of improving the infrastructure of the region, e.g. information services.

The highest share in tourism in Slovakia is held by small and medium-sized enterprises, which account for up to 99% of all enterprises. In this case, these are business entities. Currently, the largest share of enterprises in terms of the tourism sector is made up of enterprises in the field of gastronomic services (60%), the second sector is passenger transport (almost 22%). The third sector is accommodation services (9.3%). The rest is made up of travel agencies, other reservation and related activities, rental of equipment for passenger transport and sports and recreational activities.

1.2. Internal and external influences on tourism in Slovakia

The development of each sector of the country's economy is influenced by internal and external factors. Internal factors are factors of the country, the business environment and incentives for the development of business activities, external factors are factors of an international and global nature that have an impact on entire economies**.**

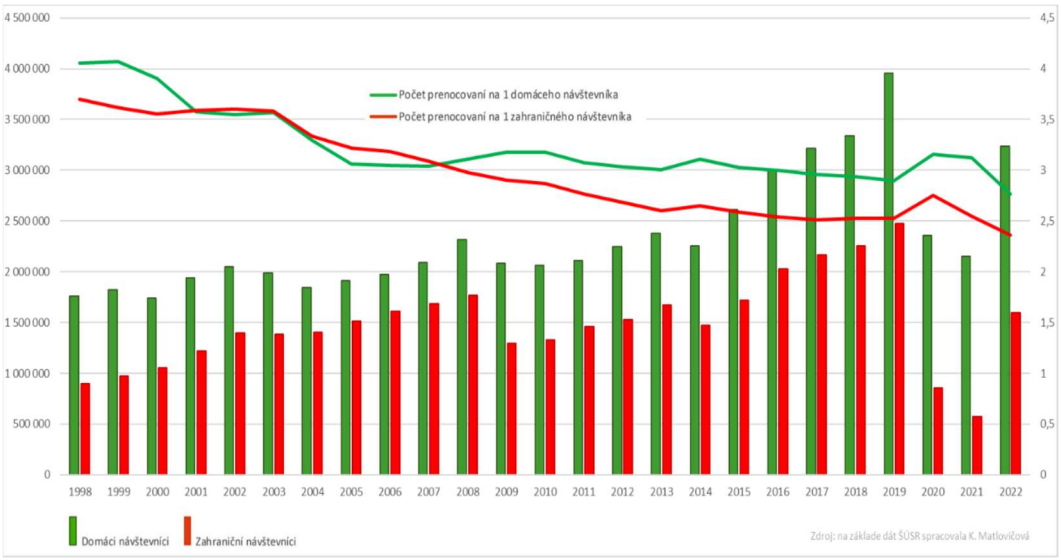
[3] GREGOROVÁ, NERADNÝ, KLAUČO, MASNÝ, BALKOVÁ. 2015. Tourism and Regional Development. p. 12

1.2.1. Internal influences on tourism in Slovakia

For a long time, the business environment in Slovakia has been considered insufficiently stimulated in the field of tourism. The absence was primarily reflected in the low support for entrepreneurs in this sector. Businesses were burdened by high value-added tax, income tax. Its organization until 2024 belonged to the Ministry of Transport and Construction of the Slovak Republic, where tourism was on the edge of attention. From 2021 to the present, some incentives for tourism in Slovakia have changed, which can be assessed as positive influences:

- valid from 1.1.2019, a change in value-added tax rates was adopted by Act 369/2018 Coll., which reduced the value-added tax to half the rate from 20% to 10%. This adjustment brought about tourism performance in terms of achieved sales, the reduced VAT rate became a positive stimulus for the development of tourism. This can be seen from the following overview:

Graph 2 Development of performance of accommodation facilities in Slovakia for the period 1998 - 2022



Zdroj: Matlovičová, Šprochová, Morong: Economic development of the territory through tourism and market setting. 2023.[4]

- valid from 1.1.2025, another stimulus for tourism was adopted in the form of a further reduction in the VAT rate from the current 10% to 5%, from which only the development of tourism can be expected, especially in the context of other extraordinary events that represent external influences on tourism,

- the introduction of so-called recreational vouchers for employed citizens of the Slovak Republic, which, however, was not and is not widespread. An employee of a large employer (over 50 employees) can apply to his employer for a recreation allowance in

[4] Matlovičová, Šprochová, Morong, 2023. Economic development of the territory through tourism and market setting.

Slovakia if the accommodation during the recreation lasted at least 2 nights. The amount of the allowance is a maximum of EUR 275 per employee. Given the fact that up to 99% of business entities in Slovakia are micro and small enterprises, the number of employees who can use the above-mentioned benefit is limited. On the other hand, much more employees are concentrated in medium and large enterprises, and it is necessary to add to them employees of the state administration and state organizations, which also employ a large number of employees. Recreation vouchers are in any case a positive state incentive for tourism. For a better overview of the number of individual enterprises in Slovakia, the following data are provided:

Table 1 Size structure of the business sector in the Slovak Republic and in the EU in 2019

		Enterprises size category				
		Mikro (0 - 9)	Small (10 - 49)	Mediun (50 - 249	Large (250 +)	SMEs
EÚ-27	*Number of busines subjects in the non-financial corporate economy*	21 553 17	1 361 58	210 000	43 000	23 124 75
	Share in the number business subjects	93,0%	5,9%	0,9%	0,2%	99,8%
Slovaki	*Number of busines subjects in the non-financial corporate economy*	497 812	11 172	2 505	594	511 489
	Share in the number business subjects	97,2%	2,2%	0,5%	0,1%	99,9%

Source: Eurostat. The data includes enterprises operating in industries that cover S NACE sections B[5]

- until 2014, tourism was managed by the Ministry of Transport and Construction of the Slovak Republic, where sufficient positive incentives were not created for this area of business. The establishment of an independent Ministry of Tourism of the Slovak Republic from 1.2.2024 can be considered a positive incentive,

[5] Eurostat. Database. 2020

- the insufficient state aid during the Covid-19 pandemic, which was limited to only partially covering employees' wages during the complete prevention of tourism activities,
- the absence of incentives is also reflected in the insufficient number of calls for funds from European Union funds. Tourism therefore does not have sufficient resources for its development, the possibilities of obtaining credit resources are significantly undersized and tourism business is still considered risky.

1.2.2. External influences on tourism in Slovakia

In addition to the above internal influences, of which only some are listed, the global situation also affects the tourism business. Extraordinary events, such as global pandemics, military conflicts, energy crises or economic recessions, have a significant impact on tourism, affecting consumer behaviour, the availability of services and the security situation in individual countries. In recent years, Slovakia has faced several such events that have fundamentally influenced the development of tourism.

Of the most important extraordinary events, we have focused on the following events, the impact of which on tourism in Slovakia will be described in more detail:

a) Covid-19 pandemic,

b) Ukrainian-Russian military conflict,

c) Ongoing energy crisis.

In addition to the above events, there are also other, local extraordinary events that have an impact on tourism in individual regions, e.g. floods, consequences of adverse weather, etc

2. Methodology

This final thesis was developed using a combination of qualitative and quantitative research methods. The main objective was to collect relevant data and information on the impacts of extraordinary events – specifically the COVID-19 pandemic – on tourism in the Slovak Republic, and to analyse them in order to identify the most significant effects.

2.1 Data Collection

The primary source of information was secondary data obtained from official statistical databases, such as the Statistical Office of the Slovak Republic, the Ministry of Transport of the Slovak Republic, the Slovak Tourist Board (SACR), national database FinStat.sk, the World Tourism Organization (UNWTO), as well as scientific studies, professional articles, and analytical reports by both domestic and foreign authors. Where necessary, data from research surveys conducted during the pandemic (e.g., Eurostat, OECD, World Travel & Tourism Council) were also used. Relevant data was drawn from the Register of Financial Statements of the Slovak Republic. .[6]

[6] Register of Financial Statements of the Slovak Republik.

2.2 Analytical Methods

Time series analysis, comparative analysis, and SWOT analysis were used to process and evaluate the collected data. The aim was to assess the development of tourism before, during, and after the pandemic, war and energetic crisis and to identify the main trends and deviations

The entire research is a theoretical and practical summary of the most important impacts of extraordinary events on tourism in Slovakia. Questionnaires for tourism enterprises in three regions of the Slovak Republic were used as a research method. The research sample consists of a total of 60 enterprises providing accommodation and catering services, including related services (wellness, entertainment, relaxation, preferential treatment of tourist and sports activities). which are divided into stratified sets (each group of 20 enterprises):

- Facilities with a bed capacity of up to 20 beds,
- Facilities with a bed capacity of 21 - 100 beds,
- Facilities with a bed capacity of over 100 beds.

When processing human resources data, a total of 100 questionnaires were sent to employees who had terminated their employment in the tourism industry, focusing on identifying the reasons for their reluctance to work in this industry.

3. Results

We focused the formulation of the results on the extraordinary events that had and have the greatest influence and impact on the development of tourism in Slovakia, as they were already formulated in the previous section. The analysis provides only generalized statements, as well as exact indicators**.**

3.1. The Covid-19 pandemic a its impact on tourism

The Covid-19 pandemic, which broke out in early 2020, brought unprecedented travel restrictions, border closures, lockdowns and significant restrictions on the movement of residents. These measures caused a dramatic decrease in the number of tourists in Slovakia. Accommodation facilities, restaurants and travel agencies experienced a significant decrease in sales, which led to employee layoffs and closures. At the same time, the pandemic changed the behaviour of tourists, who preferred individual travel, natural locations and safe forms of accommodation.

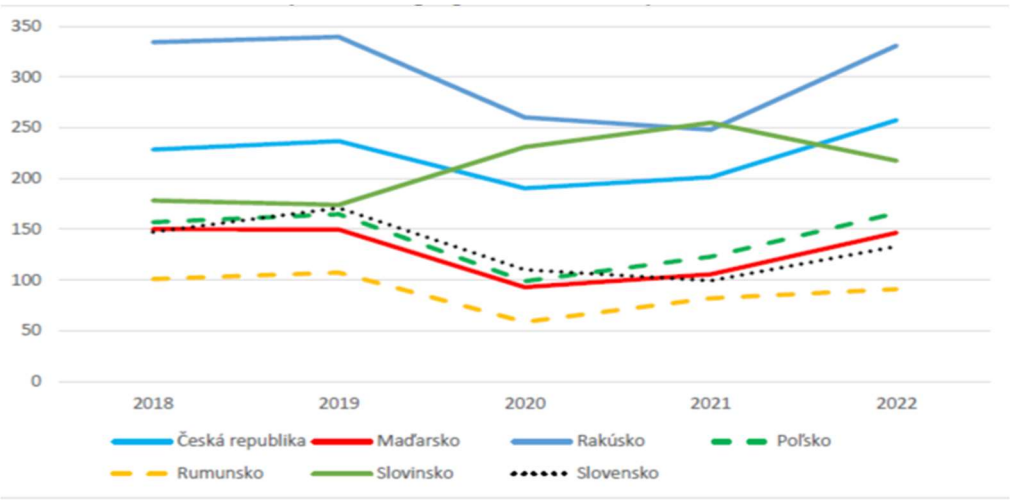
The COVID-19 pandemic has had a major impact on tourism in Slovakia, with a significant decline in visitor numbers, a change in the structure of tourists and a transformation in consumer behaviour.

In general, the impacts of the Covid-19 pandemic can be seen in the following areas:

3.1.1. Decline in visitors, overnight stays and sales

In 2020, Slovak tourism experienced a significant decline. The number of overnight stays by foreign visitors decreased by 13.8% compared to the average for 2017-2019, and by 19.5% compared to 2019.

Graph 3 Development of the number of overnight stays for 2018-2022 in 7 EU countries



Source: Eurostat. Database.[7]

Slovakia is among six EU countries where the number of overnight stays has not yet reached the average level of the last three years before the pandemic – their number is still lower by up to 7.5%, compared to the record year 2019 by up to 15.7%.

A similar development was also recorded in sales. The following results of sales were generated in the businesses we monitored, which also show their decline in 2020 and 2021 as a result of the Covid-19 pandemic:

Table 2 Development of sales in the analysed accommodation facilities

Year	Tourism Enterprises [€]				
	Large	Medium	Small	SMEs	Index [%]
2018	58 513 052	5 465 082	3 427 953	67 406 087	
2019	65 319 483	6 410 006	4 128 592	75 858 081	12,54
2020	36 910 900	4 006 683	2 612 295	43 529 878	-42,62
2021	32 866 152	3 351 813	2 102 812	38 320 777	-11,97
2022	61 765 892	5 983 713	3 885 966	71 635 571	86,94

Source: own processing

The data shows that in 2022, sales did not reach the level of 2019, when their level reached only 94.43% of 2019 with the current inflation, which fluctuated year-on-year from 2018 to 2022 at an average of 3%. The recovery of tourism after an extraordinary

[7] Eurostat. Database.

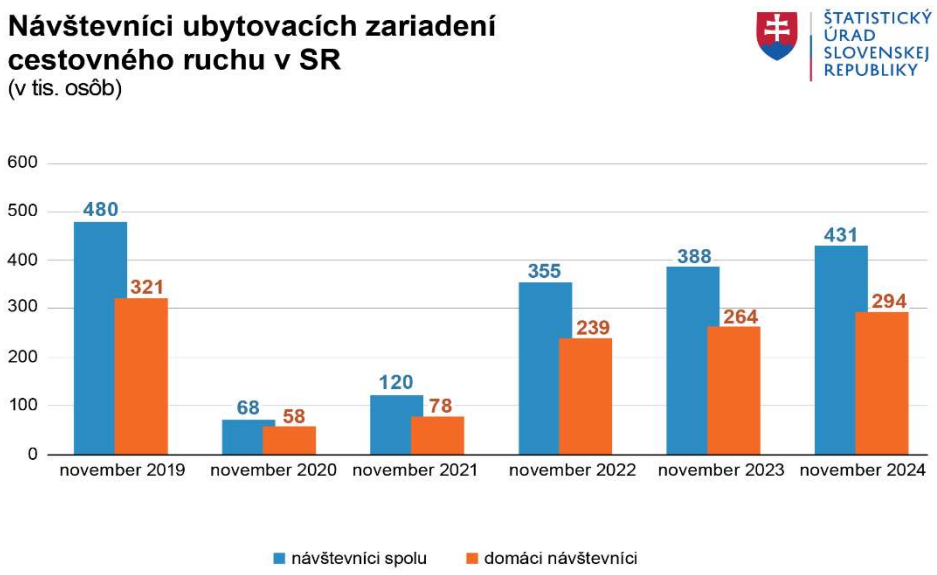
event – a global pandemic – is taking a long time, and a return to the most successful year in history in real terms can only be expected in 2025. Only after this period can economic growth be monitored.

The Covid-19 pandemic also meant the demise of many tourism businesses, especially gastronomic businesses. According to the FinStat.sk database, up to 3,680 service businesses bankrupted in 2021, most of which were part of the tourism industry.

3.1.2. Change in the structure of tourist clientele

The pandemic has caused a significant change in the structure of tourists in Slovakia. While foreign visitors made up a significant part of tourists before the pandemic, they have decreased significantly during the pandemic. On the contrary, the share of domestic tourists has increased, which indicates a shift in Slovaks' interest to domestic destinations. The increase in Slovak clientele is also due to the internal incentive of the introduction of the obligation for employers to provide a contribution for recreation in Slovakia. The development of foreign clientele in Slovakia is visible in the graph:

Graph 4 Visitors to tourism accommodation facilities in the Slovak Republic



Source: Statistical Office of the SR [domestic visitors in yellow, all visitors in blue][8]

The data shows that while in 2018 foreign visitors accounted for about 159 thousand guests, in 2020 there were only 10 thousand foreign guests, in 2021 there were 42 thousand foreign guests and by the end of 2024 there were 137 thousand foreign guests. The structure of foreign guests was also affected by another extraordinary event, with a decrease in guests recorded by guests from the Russian Federation and Ukraine. On the contrary, they were mainly replaced by guests from the Baltic states. However, tourism

[8] Statistic Office of the Slovak Republic

businesses in Slovakia have not yet managed to compensate for the loss in tourism even by the end of 2024.

3.1.3. Regional differences

The impact of the pandemic varied across Slovakia's regions. Some areas, particularly those with developed infrastructure and natural attractions, saw smaller declines in visitor numbers, while others, dependent on foreign tourists, suffered more significant losses. In 2023, tourism took off the most in northern Slovakia, with one region even breaking its pre-COVID record. [9] Northern Slovakia has the advantage of externalities, primarily because it is home to the High Tatras, Low Tatras and Slovak Paradise mountains, as well as many caves and thermal springs that are used as water parks. These are popular tourist areas.

3.1.4. The crisis in human resources management

Tourism is currently exposed not only to the challenge of renewing its activity and expanding it, but also to the challenge of employment. In gastronomy and accommodation services, according to the requirements of employers, there is currently an acute lack of quality workforce willing to work in this industry. It is important to analyse the changes that have occurred in the behaviour of employees and their approach to work in the tourism industry and find out their causes. [10]

Turnover in 2021 – 2023 increased rapidly in tourism sector. There is a shortage of professional staff as concerns persist about a recurring crisis.

Table 2 Ratio of turnover in tourism in H. Tatras and Liptov region compared to the average of the Slovak Republic (data in %)

Year	2021	2022	2023
Tourism	34,98	39,01	38,10
Average in SR	29,50	32,90	

Source: own processing

In the area of human resources, there has also been a significant change in employees' priorities. Compared to previous periods, the primary motivation for leaving the tourism sector was not the amount of earnings, but was overtaken by concerns about

[9] Hospodárske Noviny.2024. Tourism took off the most last year in northern Slovakia, one region broke the pre-Covid record.
[10] Petruščáková. 2023. A current view of the causes of the increase in turnover in the field of tourism. p. 35-41

repeated measures in the event of emergencies and dissatisfaction with the social climate at the workplace.

The change in employees' priorities signals the impact of the Covid-19 pandemic in tourism on the social environment of staff. Employers' dissatisfaction with the reduced work commitment of employees was also noted. Overall, the impact of the Covid-19 pandemic clearly demonstrates the impact on the sociological aspects that tourism in Slovakia has to deal with.[11]

3.1.5. Adaptation and new trends

Travel agencies and tour operators have begun to focus on the domestic market during the pandemic, adapting their products to Slovak clients. At the same time, new trends have emerged, such as increased interest in nature and rural tourism, individual travel and digital technologies in tourism services.[12]

3.2. The military conflict in Ukraine and its consequences for tourism in the SR

Since February 2022, a military conflict has been ongoing between Ukraine and the Russian Federation. The Slovak Republic, as a neighbouring country, has been directly affected by the consequences of this war. The conflict caused a wave of migration of Ukrainian citizens to European Union countries, including Slovakia. Accommodation facilities were temporarily turned into humanitarian centres and the state provided financial compensation for the accommodation of refugees. However, after the end of this compensation, the tourism industry lost many clients and operators had to look for new sources of income.

In addition to humanitarian challenges, accommodation facilities have also experienced a significant decline in tourism, which has been reflected mainly in the reduced number of tourists and economic losses for service providers.

3.2.1. Decrease in number of visitors and economic impacts

According to data from 2021, the number of domestic visitors decreased by more than 40%, while the number of foreign tourists decreased by up to 77%. This trend was caused by a combination of the COVID-19 pandemic and the war in Ukraine. Spa facilities were particularly affected, losing a significant part of their clientele from Russia, Belarus and Ukraine. Some spas found themselves on the verge of bankruptcy and required state support.[13]

[11] Ibid.

[12] Petrikovičová, Petrikovič, Wittlinger. 2022. Reflection of the COVID-19 pandemic on tourism and travel agencies in the Slovak Republic. p. 320

[13] STVR. 26.4.2022. online: https://spravy.stvr.sk/2022/04/pandemia-covidu-a-vojna-na-ukrajine-decimuju-cestovny-ruch-na-slovensku

The recommended structure of domestic and foreign visitors is a ratio of 60:40. In Slovakia, according to the Association of Hotels and Restaurants of the Slovak Republic, this ratio is currently at 69:31.[14]

In Slovakia, a complete decline in Ukrainian guests was recorded, who became temporarily accommodated in many tourist establishments as refugees. Their accommodation was temporarily subsidized by the state. Income from subsidies did not reach the income of ordinary accommodated tourists, but at that time they fulfilled the role of helping Ukraine. However, subsidies no longer exist and Slovakia still lacks guests from Ukraine and Russia. The decline is estimated at 20%. The replacement of foreign guests from other countries has not reached the required level and the tourism industry lacks incentives that would attract guests from other countries. This means a shortfall in the income part of tourism.

3.2.2. State response and adaptation measures

The Ministry of Transport and Construction of the Slovak Republic recognized in 2022 the need not only to repair the outages, but also to motivate domestic and foreign tourists. It considered continuing state aid to hotels, restaurants, spas and aquaparks after 2022 and the aid lasted until the first half of 2024. At the same time, there was discussion about making Slovak destinations more attractive to new markets.

The Ukrainian-Russian conflict had a significant negative impact on tourism in Slovakia. In addition to a direct decrease in visitor numbers, it also caused economic losses and the need for the tourism sector to adapt. The future of the industry will depend on the ability to attract new visitors and effectively respond to changing geopolitical conditions.

The new Ministry of Tourism and Sports of the Slovak Republic has already adopted several measures, and calls for projects are currently being issued to support tourism businesses with high state subsidies.[15] The call for projects is ongoing, so it is not yet possible to see its results.

3.3. The energy crisis – economic consequences for tourism

All these extraordinary events led to unprecedented volatility in energy markets. Slovakia, heavily reliant on energy imports, particularly from Russia, experienced significant increases in electricity and gas prices. The crisis also coincided with inflationary pressures and post-pandemic recovery, compounding its effects.

The energy crisis has increased its impact after Ukraine stopped gas supplies to Europe from January 1, 2025, with Slovakia being one of the most affected countries in terms of gas. Although it currently has sufficient gas,[16] its price is rising sharply. Slovakia, on the other hand, is self-sufficient in electricity production, which also exports. The future development is unclear, as the situation with stopped supplies is only at its beginning.

[14] Association of Hotels and Restaurants of the Slovak Republic. online: https://ahrs.sk/

[15] Ministry of Tourism and Sport of the Slovak Republic. online: https://mincrs.sk/ministerstvo-cestovneho-ruchu-a-sportu-sr-vyhlasuje-vyzvu-na-podporu-organizacii-cestovneho-ruchu-s-historicky-najvyssou-dotaciou/

[16] TASR, News Portal. 2025. online: https://www.teraz.sk/ekonomika/tok-zemneho-plynu-z-ukrajiny-na-slovens/846551-clanok.html

As stated in the technical forecast of analysts of the Ministry of Finance of the Slovak Republic,[17] compiled based on the current development of energy prices, gas prices could increase by 20% next year, and heat prices by 14%. Electricity could increase by 7%. This means that the growth in energy prices would be very similar to that in 2022 and 2023.

At the same time, from 2025, the Slovak government has introduced consolidation measures to increase the revenue part of the state budget, which means pressure on entrepreneurs. Currently, Slovak business entities have started to pay a transaction tax on banking operations and an increased value added tax, which has increased from the previous 20% to 23% on most goods and services.

3.3.1. Impact on the Tourism Sector

Energy-intensive tourism services, such as hotels, wellness centers, and winter resorts, were among the first to feel the consequences. Rising heating, lighting, and operational costs forced many businesses to limit services, shorten opening hours, or increase prices. These changes negatively impacted demand, especially from domestic tourists with reduced purchasing power.

The increase in energy prices according to current forecasts means that while energy costs in tourism businesses, especially accommodation facilities, accounted for 16.5% of total costs in 2023, this share increased to 18.5% in 2024. If prices continue to rise as forecast in 2025, tourism will face problems in its development. Rising sales prices and rising inflation will reduce interest in tourism, which will significantly slow down economic growth.

3.3.2. Regional Disparities

Tourism destinations in colder, mountainous regions such as the High Tatras were more severely affected due to higher energy requirements during winter months. Small and medium-sized enterprises (SMEs), which make up the majority of tourism businesses in Slovakia, struggled to absorb the costs without passing them on to consumers.

3.3.3. Government Responses and Measures

The Slovak government introduced temporary support measures, including energy price caps and direct subsidies. While these mitigated some of the financial burdens, delays in implementation and limited scope left many businesses vulnerable. The paper evaluates the effectiveness and sustainability of these interventions.

From mid-2025, however, the Slovak government will also reduce and end energy price subsidies for businesses by introducing consolidation measures, which means that their share of costs will mean a significant reduction in business profits. The prediction is not yet known, as Slovak businesses are trying to deal with the first consolidation measure in the form of a transaction tax on banking operations from 1 April 2025, which has already had a significant impact on them in the first few days. This may result in the closure of a large number of accommodation facilities and at the same time an undesirable return to the preference for cash payments.

[17] Ministry of Finance of the Slovak Republic. 2025. 71. Meeting of Macroeconomic Prognosis Committee.

3.3.4. Risk of Increasing Tax Gape in Tourism

Given the current situation in the tourism sector, it is possible to expect a risk that businesses will seek tax evasion to a greater extent.

When calculating the estimated tax evasion in the area of indirect taxes, we adopted the methodology for estimating and calculating the volume of the so-called grey economy in Slovakia, which is used within the European Union.

Both direct and indirect approaches are used for calculation methods, but most often model method approaches:

Direct methods are aimed at adding to GDP the production of the grey economy at a certain place and time, i.e. sample surveys or tax evasion surveys. They are detailed and accurate, but limited, as they can only quantify a sample set.

Indirect methods have a macroeconomic character and are most often monetary methods, which is also their disadvantage.

The model method approach is based on the assumption of causality between the cause and effect of the shadow economy. The most commonly used method is the MIMIC (*Multiple-Indicators and Multiple-Causes).*[18]

It can therefore be predicted that the current 13% of estimated grey income may increase by as much as 2%, which will create an increased tax gap in the state budget for both value added tax and income tax, which will be counterproductive to efforts to increase the revenue part of the state budget.

4. Discussion

We compared the conclusions on the impact of extraordinary events on tourism with the findings of other authors. In Depreter's article, we find the statement that at least 50% fewer tourists from abroad arrived in Slovakia in 2020 compared to previous years. This had an impact on the profits achieved by tourism businesses. Similarly, Blahušiaková states that 73.8% of tourism businesses in the Slovak Republic also recorded a decrease in revenue, of which 56% saw a decrease of more than 40%.

We also compared our conclusions in the area of change in human resources management. The development of employment with its decrease and subsequent increase during the pandemic and then in post-covid period has been overcome according to the SAV publication.[19] It is also shown according to the regions of Slovakia and fully correlates with our findings for the Tatras and Liptov region.

The situation is not unique to accommodation facilities in Slovakia, similar developments can be seen elsewhere in the world. Small accommodation facilities in particular are reaching negative equity values in other countries as well. As an example, we can cite the results of the analysis in the pre- and post-COVID period in Catalonia, where, according to the analysis, accommodation facilities were experiencing varying degrees of financial distress.[20]

[18] Hošová. 2019. The Shadow Economy in the Slovak Republic.
[19] Frank, Morvay. 2022. Economic development of Slovakia in 2021
[20] Saus-Sala et al. 2024. Financial analysis of rural tourism in Catalonia and Galicia pre- and post-COVID-19.

Conclusion

Extraordinary events, such as the Covid-19 pandemic, the military conflict in Ukraine, the energy crisis and the economic measures of the Slovak government, have fundamentally affected tourism in Slovakia. The future of this sector will depend on the adaptability of entrepreneurs, the ability to diversify the offer, but also on the support of the state and increasing the quality and safety of the services provided.

The COVID-19 pandemic had a profound and lasting impact on tourism in Slovakia. In addition to immediate economic losses, it also brought changes in tourist behaviour and market structure. During the period of Covid-19 restrictions, the share of tourism in GDP in Slovakia fell year-on-year from 2.76% to 1.45%. In the years before the tourism crisis, the share of tourism in gross domestic product in European Union countries was 5%.[21]

We also perceive the importance of research in the field of tourism, taking into account the fact that its share in the gross domestic product is very low compared to neighbouring countries and European Union countries with comparable conditions for building tourism.

The problem remains that companies in the field of accommodation services are able to obtain foreign sources of financing for the renewal, modernization or reconstruction of their long-term assets to a much lower extent than they would be interested in. The area has long been considered relatively risky by financial institutions and the possibility of obtaining a loan is conditioned by good long-term financial results, when equity must not only achieve positive values, but also the financial indicators used in banking must correspond to the required values.

The energy crisis has posed significant challenges for the Slovak tourism sector, revealing its vulnerability to external economic and geopolitical shocks. However, it also presents an opportunity to innovate and move toward a more resilient, sustainable tourism model. Strategic support and investment in green technologies will be key to the sector's long-term stability and competitiveness

The crisis has accelerated discussions around energy efficiency and sustainable tourism. Investments in renewable energy sources, better insulation, and energy-saving technologies are increasingly seen as essential to the sector's resilience.

Investments are needed in digitalizing services, developing eco-friendly travel, safety measures and diversifying the offer. At the same time, it is important to support domestic tourism and develop lesser-known destinations that have the potential to attract new visitors.

REFERENCES

Journals

Blahušiaková, M. 2021. Impact of the Covid-19 Crisis on Facilities in Tourism Sector on Economics and Computer Science. Vol. 19 No. 3. ISSN 1336-3514 [online]

Frank, K. Morvay, K. 2022. Economic development of Slovakia in 2021. CSČ SAV VEDA ISBN [online] 978–80–7144–328–5. Online: https://ekonom.sav.sk/uploads/journals/421_hospodarsky_vyvoj_2022.pdf

[21] Majstríková. 2015. Position of Tourism in Economy of V4 Countries.

Hošová, K. 2019. The Shadow Economy in the Slovak Republic. International Scientific Conference Economic and Social Policy: Economic and Social Challenges for European Economy. VŠ PRIGO. ISSN 2571-1776; e-ISSN 2694-796X; ISBN 978-80-87291-25-2. https://www.narodacek.cz/conference-proceedings-2019/

Majstríková, Ľ. 2015. Position of Tourism in Economy of V4 Countries. In:: Proceedings of Slovak University of Agriculture. Nitra, SR: Slovak University of Agriculture, 2015. ISSN 9788055211961. Online: http://www.slpk.sk/eldo/2015/zborniky/9788055211961/prispevok_Majstrikova.pdf .

Petrikovičová, L, Petrikovič, J., Wittlinger, L. 2022. Brno, Masaryk University:2022. Reflection on the COVID-19 pandemic on Tourism and Travel Agencies in the Slovak Republic. Brno: Masaryk University. International Colloquium on Regional Sciences. Online: https://munispace.muni.cz/library/catalog/chapter/2157/670

Petruščáková, M. 2023. A Current View of the Causes of the Increase in Turnover in the Field of Tourism. Czech Journal of Tourism. Vol. 12 No. 1-2. Brno: Masaryk University. ISSN 1805-9767 [online]

Saus-Sala,E et al. 2024. Financial Analysis of Rural Tourism in Catalonia and Galicia pre- and post-Covid-19. International Journal of Tourism Research. Vol. 24 No. 4. ISSN 1099-2340. Online: https://doi.org/10.1002/jtr.2589

Books

Gregorová, M., Neradný, M., Klaučo, M., Masný, M., Balková, N. 2015. Tourism and regional development. Banská Bystrica: University of Matej Bel in Banská Bystrica Belianum. ISBN 978-80-557- 0952-9.

Matlovičová, K., Šprochová, L., Morong, F. 2023. Economic development of the territory through tourism and market setting. Prešov: University of Prešov. European Union Human Resources Operational Programme Project. Online: azasi.gov.sk/wp-content/uploads/2023/10/AV-Ekonomicky-rozvoj-uzemia-prostrednictvom-cestovneho-ruchu-a-nastavenia-trhu-prace.pdf

Report and brochure references

Association of Hotels and Restaurants of the Slovak Republic. online: https://ahrs.sk/

European Commission. 2023. Consequences of the war in Ukraine for the EU economy. Online: https://ec.europa.eu

European Commission. 2023. Energy Market Developments in the EU. Online: https://ec.europa.eu

Eurostat Database. Online https://ec.europa.eu/eurostat

Ministry of Economy of the Slovak Republic. 2023. National Energy and Climate Plan. Online: https://www.economy.gov.sk/energetika/integrovany-narodny-energeticky-a-klimaticky-plan-na-roky-2021-2030/navrh-integrovaneho-narodneho-energetickeho-a-klimatickeho-planu

Ministry of Finance of the Slovak Republic. 2025. 71. Meeting of Macroeconomic Prognoses Committee. 02/2025. Online: https://www.mfsr.sk/sk/financie/institut-

financnej-politiky/ekonomicke-prognozy/makroekonomicke-prognozy/71-zasadnutie-vyboru-makroekonomicke-prognozy-februar-2025.html

Ministry of Travel and Construction of the Slovak Republic. 2023. Statistics of Tourism. Online: https://www.mindop.sk

Ministry of Travel and Construction of the Slovak Republic. Terminology of selected terms in tourism. Online: https://www.mindop.sk/ministerstvo-1/cestovny-ruch-7/informacie/cestovnyruch/terminologia-v-cr-pdf-183-kb

Register of Financial statements of the Slovak Republik. Online: https://www.registeruz.sk/cruz-public/domain/accountingentity/simplesearch

Slovak Tourist Board. 2023. Tourism Statistics and Sector Reports.

Statistic Office of the Slovak Republic. 2023. Development of Tourism in Slovakia. Online: https://www.statistics.sk

World & Travel and Tourism Council (WTTC): https://www3.weforum.org/docs/

/WEF_TTCR_2019.pdf

Webpages on a news web sites

Act. No. 91/2010 Coll. on the promotion of tourism

Act No. 278/2024 Coll., amending certain laws in connection with further improving the state of public finances

Act No. 369/2018 Coll. Act amending and supplementing Act No. 222/2004 Coll. on Value Added Tax, as amended.

Act No. 595/2003 Coll. on Income Tax, as amended

Depreter, M. 2021. Czech Republic, Slovak Republic, Poland and Germany: Impact of Covid-19 on individual sectors in 2020. Article: Credendo. 21.4.2021. Online: https://credendo.com/sk/knowledge-hub/ceska-republika-slovensko-polsko-nemecko-vplyv-covid-19-na-jednotlive-sektory-v-roku

Hospodárske Noviny. 2024**.** Tourism took off the most last year in northern Slovakia, one region broke the pre-Covid record. Online:

https://hnonline.sk/finweb/ekonomika/96194120-cestovny-ruch-sa-vlani-rozbehol-najviac-na-severe-slovenska-jeden-kraj-prekonal-predcovidovy-rekord

STVR. News Portal. 26.4.2022. online: https://spravy.stvr.sk/2022/04/pandemia-covidu-a-vojna-na-ukrajine-decimuju-cestovny-ruch-na-slovensku

TASR, News Portal. 2025. Online: https://www.teraz.sk/ekonomika/tok-zemneho-plynu-z-ukrajiny-na-slovens/846551-clanok.html

Transposition of the ECN+ Directive in the Candidate Country: The Case of Albania

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Abstract

Albania has gradually harmonised its domestic legislation in line with the EU acquis. The Albanian competition law, currently in force, is drafted in line with EU competition rules. The Albanian Competition Authority (ACA) has played an important role in furthering the harmonisation level by issuing directives or guidelines that transpose EU secondary competition acts or Commission soft. This paper analyses the role of the Albanian Competition Authority in transposing the ECN + Directive into the Albanian legal system and whether this approach is correct. The paper argues that transposing an EU legal act through a non-legal act is an incorrect transposition.

Keywords: EU competition law, public enforcement, ECN+ Directive, Albanian Competition Law

1. Introduction

Albania has gradually harmonised its competition legislation in line with the EU competition *acquis*. The Albanian competition law, currently in force, is drafted in line with the EU competition rules (Skara, 2022: 217-253). The Albanian Competition Authority (ACA) has played an important role in furthering the harmonisation level by issuing directives or guidelines that transpose EU secondary competition acts or Commission soft (Skara, 2022: 217-253; Skara, 2020: 198-231). To further the level of harmonisation, on June 30, 2020, the ACA adopted the Guideline on "empowering Albanian Competition law as amended for ensuring proper functioning of the internal market", which transposes the ECN + Directive into the domestic legal system (ACA Guideline 2020).

This paper analyses the ECN + Directive's transposition into the Albanian legal system. This research is based on traditional legal doctrine and comparative analysis methods. Traditional legal doctrine analyses and interprets the EU competition provisions, the ECN + Directive, and Albanian competition law. CJEU cases, non-binding soft law documents of the Commission, and secondary European antitrust legal doctrine have also been consulted. Comparative analysis methods determine how the EU Member States have transposed the ECN+ Directive. The paper argues that the ECN

+ Directive, as a legally binding act, needs to be transposed by a legally binding act in Albania and not by a guideline.

2. Enforcement of EU Competition Rules: from Regulation 17 to Regulation 1/2003

Since establishing the European Economic Community (EEC), the treaty competition rules (Arts 85 and 86 EEC) have remained basically the same, whereas the rules governing their enforcement have undergone a fundamental transformation. The EEC treaty did not provide any enforcement mechanisms of competition rules, yet it emphasised the necessity of adopting secondary legislation to enforce them (Warlouzet, 2016: 729-730).

For around 40 years, the EU competition law enforcement system was centralised in the Commission's hands. In 2003, Regulation 1/2003 abolished the centralised enforcement system and empowered national courts and national competition authorities to apply EU Treaty competition rules.

Ten years later, the Commission carried out an assessment of the functioning of Regulation 1/2003. In the covered period - from May 1, 2004 to December 31, 2013 - the Commission and NCAs have adopted about 787 enforcement decisions (Commission, 2014). These numbers lead to two conclusions: first, the enforcement of EU competition law is taking place on a level that the Commission could not have achieved with a centralised system, and, second, NCAs proved effective in enforcing EU competition law (Potocnik-Manzouri, 2021: 991). On the other hand, empirical data shows that not all Member States contributed equally to the growth of investigations and decisions, due to differences in the independence, resourcing, investigative powers and sanctioning powers of NCAs (Goggin, 2017). Founding EU member states like France, Germany, and Italy are at the top of the list. The Central and Eastern Europe countries that acceded in 2004 and Croatia that acceded in 2007 are lagging behind, due to a lack of awareness of competition culture combined with a lack of independence of NCAs from political influence and insufficient human resources and budget (ECN 2025). In this report, the Commission stated that "to enhance EU competition enforcement for the future, the institutional position of NCAs needs to be reinforced while at the same time ensuring further convergence of national procedures and sanctions applying to infringements of EU antitrust rules" (Commission, 2014: para 25). Based on this empirical evidence, the Commission concluded that the NCAs "is an essential building block for the creation of an open, competitive and innovative internal market" (Commission, 2017: 2).

Following the 2014 Communication, on 5 November 2015, the Commission launched a public consultation with different stakeholders on whether further action should be taken to boost enforcement by NCAs. Around 80 % of the respondents supported the initiative that further action should be taken to boost enforcement by NCAs (Commission, 2017: 10). Several other public consultations or meetings were held to get feedback on the initiative.

Finally, on 3 February 2019, the European Parliament and the Council adopted the ECN+ Directive, which empowers national competition authorities to be more effective enforcers and ensures the proper functioning of the internal market.

3. The ECN + Directive: Empowering the NCAs for enforcement of competition rules

The ECN + Directive aims to increase the effectiveness of NCAs' enforcement of EU competition rules. Instead of relying on the 'soft laws' as commonly used, the Commission opted for a 'hard law' instrument to harmonise public enforcement regimes in the Member States. The choice of hard law was the only way to protect undertakings of "arbitrary differences in the enforcement of Arts 101 and 102 TFEU, depending on whether their case is handled by a 'weak' or by a 'strong' authority, or whether national rules on enforcement offer loopholes or not" (Editorial, 2015: 1195). Contrary to the regulation used before (Regulation 1/2003), the Commission opted for a directive because it gives the Member States the discretion to choose appropriate means of implementing the measures in the Directive (Art 288 TFEU).

The ECN + Directive uses a dual legal basis as it pursues two independent goals: i) effective application of EU competition policy and ii) proper functioning of the internal market. The former goal falls within the ambit of Article 103 (1) TFEU. Within this goal, the ECN + Directive harmonises certain rules to ensure that national competition authorities: i) are independent and have necessary human resources; ii) be able to apply Articles 101 and 102 TFEU effectively; iii) impose fines and periodic penalties and iv) have leniency programmes (Art 1 para 1).

Article 114 TFEU is used as a legal base to approximate national rules that "have as their object the establishment and functioning of the internal market". Art 114 TFEU was chosen for the following reasons: i) to tackle national rules which prevent NCAs from being effective enforcers; ii) to ensure that the same guarantees and instruments are in place for national competition law when it is applied in parallel with the EU competition rules; iii) to put in place effective rules on mutual assistance (Commission, 2017:5).

Another characteristic of the ECN + Directive is that it entails a minimum harmonisation approach, leaving room for Member States to maintain a minimum approach. Several core sections of the ECN + Directive partake the attributes of a minimum harmonisation (Knapp and Cunha, 2023). If Member States wish to go further than the threshold established by these provisions, they may. On the other hand, some sections or provisions introduce uniform rules which should be implemented by Member States. On the other hand, Art 4 (3) introduces a uniform rule concerning not dismissing the NCAs "authorities for reasons related to the proper performance of their duties or the proper exercise of their powers for applying Articles 101 and 102 TFEU".

The ECN + Directive introduces the following novelties. First, the ECN + Directive laid out rules to guarantee the independence and necessary resources to enforce EU competition rules effectively (ECN + Directive, Rec 5). Art 4 of the ECN + Directive requires "Member States to ensure that NCAs perform their duties and exercise their powers impartially in the interest of effective and uniform application of Articles 101 and 102 TFEU". NCA staff shall be recruited or appointed based on clear and transparent procedures and shall receive no instructions from governments or public or private entities, not precluding general policy rules. Furthermore, NCAs must have the right to set their priorities for applying Articles 101 and 102 TFEU, including the right to decide which cases shall be pursued and which cases shall not be pursued further (Blažo, 2020: 119-122). The NCA shall be able, at a minimum: i) to conduct investigations to apply Articles 101 and 102 TFEU; ii) to adopt decisions applying those

provisions based on Article 5 of Regulation (EC) No 1/2003; and iii) to cooperate closely in the ECN to ensure the effective and uniform application of Articles 101 and 102 TFEU (Art 5 para 2). The ECN + Directive is very vague in relation to sufficient human resources to enforce Arts 101 and 102 TFEU effectively.

Second, the ECN + Directives introduces a minimum set of common powers that NCAs shall have to enforce EU competition rules effectively (Arts 6-12). Regulation 1/2003 obligated EU Member States to design NCAs "for the application of Articles 81 and 82 of the Treaty in such a way that the provisions of this regulation are effectively complied with" (Art 35 para 1). Regulation 1/2003 did not regulate the issue of NCAs' power. Thus, NCAs enjoyed only those powers granted by the national law. In this context, the degree of NCAs' investigative power varied from one EU Member State to another. Some countries required court decision for the dawn raids, other not. Also, exchanging information between EU member states varied from one competition authority to another. There was no common rule on exchange of information at the EU level. With the adoption of the ECN + Directive, NCAs shall have a minimum set of common investigative and decision-making power to be able to enforce EU competition rules. Accordingly, NCAs shall have the following common power: i) to inspect business premises (Art 6); ii) to inspect other premises under the condition of prior judicial authorisation (Art 7); iii) to request information from the undertakings or to summon any representative of an undertaking or association of undertakings if they possess information related to the application of the EU competition rules (Arts 8-9); iv) the right to impose behavioural as well as structural remedies to end conduct that is in breach of art. 101 or Art 102 TFEU (Art 10); v) the power to issue interim measures upon request by a complainant and on their own initiative (Art 11); and vi) the power to accept commitment decisions (Art 12). By introducing these powers, the NCAs become more effective enforcers. For instance, one NCA may ask another NCA to conduct dawn raids without a court decision. Moreover, the ECN + Directive introduces rules for the exchange of information or the summoning of any representative of an undertaking that possesses this information.

Third, the ECN + Directive empowers NCAs to impose dissuasive fines. Until the adoption of the ECN + Directive, not all NCAs had the power to impose fines or periodic fines. Article 13 of the ECN+ Directive introduces, as a minimum standard, the principle that NCAs have the right to impose "effective, proportionate and dissuasive fines on undertakings and associations of undertakings". Such fines shall be determined proportionately to the undertakings' total worldwide turnover (Art 13). When calculating the fine amount to be imposed, NCAs have to consider both the gravity and the duration of the infringement (Art 14 para 1). The fine should not exceed 10 % of the total worldwide turnover of the last business year of the decision (Art 15). Furthermore, Art 14 (2) of the ECN + Directive requires EU MS to ensure that NCAs "may consider compensation paid as a result of a consensual settlement when determining the amount of the fine to be imposed for an infringement of Article 101 or 102 TFEU, in accordance with Article 18(3) of Directive 2014/104/EU".

Fourth, the ECN + Directive introduces legally binding rules for leniency programmes, an area previously regulated by Commission soft laws. The ECN + Directive introduces rules governing leniency applications leading to total immunity from fines (Art 17) and applications that will only reduce fines (Art 18).

Finally, the ECN + Directive introduces mutual assistance rules amongst the NCAs. The general principles of cooperation are foreseen in Art 27. Also, the ECN + Directive provides several provisions governing cooperation between NCA as, for instance, the possibility for NCAs to take part in investigations in other Member States and receive, upon request, relevant information and documents from other NCAs (Arts 24-25). Furthermore, NCAs will be able to request that their decisions are imposed on other Member States (Art 26).

4. The Transposition of ECN + Directive into the Albanian Legal System

Following Albania's commitment to harmonise its domestic legislation with the EU *acquis*, furthering the harmonisation of Albanian competition law with the EU competition *acquis* has been one of the main priorities of ACA (ACA Decision 43, 2006:40-43). In this context, the ACA has been very active in further aligning domestic competition law with the EU competition *acquis*. So far, the ACA has transposed several secondary EU competition legal acts and the Commission's soft law.

On 30 June 2020, the ACA adopted a guideline that transposes the ECN + Directive into the Albanian legal system (ACA Guideline 2020). Similarly to the ECN+ Directive, the Guideline sets out certain rules to empower the ACA to be a more effective enforcer and ensure the Albanian market's proper functioning. Moreover, the Guideline stipulates rules for cooperation with other NCAs for the protection of competition and functioning of the market, which are fully in line with the ECN+ Directive.

ACA opted for a literal transposition of the ECN + Directive, with some exceptions. First, instead of the EU Competition rules [Arts 101 and 102], it refers to the national competition law, respectively to restrictive agreement (Art 4) and abuse of dominant position (Art 9). Secondly, contrary to the ECN+ Directive, which "covers the application of Articles 101 and 102 TFEU and the parallel application of national competition law to the same case" (ECN + Directive, Art 1 para 1), the Guideline applies only to Albanian competition law. This is understandable, as Albania is not yet an EU Member.

In the case of the ECN + Directive, the ACA opted out to transpose the ECN + Directive through a guideline, instead of a binding legal act. This transposition method is mistaken from both the perspective of the EU and Albanian Law. From the perspective of EU law, the directive needs to be transposed by a national legal measure. The directive is binding on the result to be achieved upon each Member State to which it is addressed (TFEU, Art 288). Contrary to the regulation, which is directly applicable, the directive must be transposed by national measures. By looking at the experience of the EU Member States that have communicated the transposition measure, it can be observed that none of them have transposed the ECN + Directive through soft law. Instead, the EU Member States have transposed the ECN + Directive into their domestic legal system through a legally binding instrument. Some EU Member States have amended the existing legislation, whereas others have introduced specific legislation (EUR-Lex 2025).

In the case of Albania, the ACA opted out through a guideline without binding effects. Like EU Member States, the correct transposition of the ECN + Directive should be done by a legally binding act, either through enacting *lex specialis* or amending the existing competition law (Skara & Hajdini, 2022).

5. Conclusion

Despite the application of EU competition rules by national courts and National Competition authorities, EU Member States still enjoyed procedural autonomy. In this regard, EU Member States' competition authorities had different degrees of independence and human, financial, and technical resources, investigative power, and enforcement priorities.

To address this degree of diversity among the NCAs, on 3 February 2019, the European Parliament and the Council adopted the ECN+ Directive. The ECN+ Directive harmonises procedural rules on: i) NCA's independence and resources; ii) NCA's power; iii) fines and periodic penalty; iv) leniency program for secret cartels; and v) mutual assistance between NCAs.

Likewise, EU Member States, even candidate countries, have the obligation to transpose the ECN + Directive into the domestic legal system. As the paper shows, transposing the ECN + Directive through a non-legally binding act does not have any legal effects. Therefore, the proper transposition should be done by amending the Law on Protection of Competition.

References

ACA Guideline to empower the Albanian Competition Authority to be more effective enforcer of the Law 9121/2003 as amended and to ensure proper functioning of the market <https://caa.gov.al/wp-content/uploads/2023/05/Udhezues_30.06.2020.pdf> accessed 20 April 2025.

Blažo, Ondrej (2020). Proper, transparent and just prioritisation policy as a challenge for national competition authorities and prioritisation of the Slovak NCA. Yearbook of Antitrust and Regulatory Studies 13, 117

Commission (2014). Ten Years of Antitrust Enforcement under Regulation 1/2003. SWD(2014) 230/2

Commission (2017). Proposal for a Directive of the European Parliament and of the Council to empower the competition authorities of the Member States to be more effective enforcers and to ensure the proper functioning of the internal market. COM(2017) 142 final

Council Regulation (EC) No 1/2003 of 16 December 2002 on the implementation of the rules on competition laid down in Articles 81 and 82 of the Treaty [2003] OJ L 1/1 (Hereafter Regulation 1/2003).

Directive (EU) 2019/1 of the European Parliament and of the Council of 11 December 2018 to empower the competition authorities of the Member States to be more effective enforcers and to ensure the proper functioning of the internal market (Text with EEA relevance) [2019] OJ L 11/3

ECN (2025). Statistics: Aggregate Figures on antitrust cases. https://competition-policy.ec.europa.eu/antitrust-and-cartels/european-competition-network/statistics_en accessed 15 April 2025.

Editorial (2015). Public Enforcement of EU Competition Law: Why the European Antitrust Family Needs a Therapy. Common Market Law Review 52, 119

EUR-Lex (2025). National transposition measures communicated by the Member States concerning: Directive (EU) 2019/1 of the European Parliament and of the Council of 11 December 2018 to empower the competition authorities of the Member States to be more

effective enforcers and to ensure the proper functioning of the internal market (Text with EEA relevance).

<https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32019L0001> Accessed 15 April 2025.

Goggin, Isolde (2017). Making Competition Authorities more Enforcers. Journal of Competition Law and Practice 8, 549.

Knapp, Magdalena and Cunha, Diogo Costa (2023). Antitrust Fines and Limitation Periods After the Implementation of Directive (EU) 2019/1 Throughout Member States: Focus on French and Polish Perspectives. IIC-International Review of Intellectual Property and Competition 54, 891-915.

Law 8417/1998 The Constitution of the Republic of Albania [1998] OJ 28 as last amended by Law 16/2022 (The Constitution of Albania)

Potocnik-Manzouri, Corinna (2021) The ECN+ Directive: An Example of Decentralised Cooperation to Enforce Competition Law. European Papers 6, 987

Skara, Gentjan (2020). Private Enforcement of Competition Law and the Directive 2014/104/EU on Action for Damages for Infringements of Competition Law Provisions: The Impact on Albanian Legal System compared with the Implementation in some selected EU-Member States. PhD Thesis. University of Ferrara

Skara, Gentjan (2022). Europeanisation of Private Enforcement of Competition Law: the Case of Albania: Springer

Skara, Gentjan & Hajdini, Bojana (2022). Transposition of the ECN+ directive in Albania: the mistaken approach. https://www.maastrichtuniversity.nl/blog/2022/05/transposition-ecn-directive-albania-mistaken-approach. Accessed 15 April 2025

Treaty on the Functioning of the European Union (TFEU Consolidated version 2016) [2016] OJ C 202/1

Warlouzet, Laurent (2016). The Centralisation of EU Competition Policy: Historical Institutionalist Dynamics from Cartel Monitoring to Merger Control (1956-1991). Journal of Common Market Studies 54, 725

An Energy Consumption Prediction Method Based on Verbal Artificial Intelliegence Classification

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Abstract

In recent years, global energy demand has risen rapidly due to economic growth, particularly in developing countries, population growth and industrialization drive consumption. Energy is a key factor in manufacturing and reflects a country's economic and social development potential. Future investments depend on demand, costs, and environmental regulations, emphasizing the need for cost-effective solutions. Insufficient energy supply could hinder economic progress. Efficient financial allocation for energy production investments relies on accurate predictions of future energy demand. Optimizing financial allocation is crucial due to budget constraints, even in developed nations. These limitations highlight the growing importance of forecasting energy demand for effective planning. To increase prediction accuracy many different methods are used. In this study, an AI based verbal prediction method is suggested, and some results are presented.

Keywords: Energy Production, Energy Consumption Prediction, AI methods.

INTRODUCTION

In recent years the energy demand increasing rapidly and steadily throughout the World as the economic growth increases. Especially in developing countries rapid population increase and industrialization increases energy demand. Energy is an essential production factor in manufacturing and is one of the fundamental indicators reflecting a country's potential for economic and social development. Energy consumption is one of the indicators of social development and economic development and welfare results in a rise in energy consumption. Consequently, planning the investments of energy production facilities becomes more important to keep up with the energy demand increase. Future planning of investment greatly depends on energy demands, energy costs, environmental restriction etc. Because of the reasons mentioned

above, cost effective energy production investment becomes important. For example, under supply of energy may become the major block for economic development. On the other hand, over supply of energy also blocks economic development because cost of investment for energy production may be transferred to other areas of economic development. Optimizing the cost of energy investment is a necessity especially for developing countries that may have limited budgets investments.

To efficiently allocate the finances for energy production investments requires good prediction future energy demands. Thus, investments can be allocated according to future necessities of the country including but not limited to energy demand. An optimized allocation of finances among the future necessities of the country becomes more important because of the budget limitations of the many countries that even include developed regions of the World. Consequently, these limitations and requirements make future energy demand more and more important.

To increase prediction accuracy many different methods are used. Some of these methods include but are not limited to metaheuristic optimization algorithms, adaptively optimal search algorithms, time series models, regression models, artificial neural networks (ANN), artificial intelligence models.

Islam et all give a wide introduction to energy demand forecasting and summarizes methods some methods used in forecasting. In their paper time series methods, regression and ANN are investigated. They also presented some metrics to measure the success of the methods (1).

Özdemir at all introduced a novel modified artificial bee colony (M-ABC) algorithm and evaluates its performance against established optimization techniques, including ant colony optimization (ACO), particle swarm optimization (PSO), and a hybrid ACO-PSO (HAP) approach. Furthermore, the study presents energy demand estimations under four distinct scenarios, utilizing various input parameters. The results demonstrate that the models developed using the proposed M-ABC algorithm exhibit superior performance in estimating energy demand compared to the alternative methods. (2)

A study by Aderibigbe at all provides a comprehensive review of the transformative impact of artificial intelligence (AI) and machine learning (ML) on energy efficiency, with a specific focus on electricity demand forecasting. The review critically analyzes various ML models, assessing their theoretical foundations, selection criteria, and performance across different scenarios. Findings indicate that ML models, particularly those leveraging deep learning and big data analytics, surpass traditional methods in accuracy and adaptability, excelling in managing complex, nonlinear relationships and large datasets. (3)

Hu reported in 2017 that grey forecasting model has attracted significant attention among researchers due to its ability to effectively characterize uncertain systems with limited data sets. The most widely used GM(1,1) model has some limitations because of its dependence on the evolution coefficient and control variable and difficulty of determining background value. In order to solve this problem, a neural network-based GM(1,1) model, NNGM(1,1), is proposed. This study has applied the NNGM(1,1) model to the field of electricity consumption forecasting and evaluated the performance of the model using sample data obtained from the Turkish Ministry of Energy and Natural Resources and the Asia-Pacific Economic Cooperation energy

database. Experimental findings reveal that the NNGM(1,1) model exhibits effective performance in electricity consumption forecasting indicating that the model can provide a more powerful and adaptable alternative to the GM(1,1) model. (4)

In the study by Wang and his colleagues, they provide a practical guide to determining appropriate techniques in three main areas, namely load forecasting, anomaly detection and demand response, by conducting a comprehensive analysis of artificial intelligence models. In the context of load forecasting, the paper presents a comprehensive framework for selecting the most effective machine learning and deep learning models, including reinforcement learning methods along with hybrid model applications and learning optimization strategies. Furthermore, by examining the advantages and limitations of different learning methods in detail, the study creates a discussion platform on optimization strategies for the imbalanced data set problem, which is frequently encountered during anomaly detection in energy systems. (5)

Çunkaş and Taşkıran examines Turkey's current electricity generation and consumption patterns while employing genetic algorithms to model future energy demand projections. The algorithmic forecasts are subsequently benchmarked against both conventional regression analysis methodologies and official projections published by the Ministry of Energy and Natural Resources. (6)

Koç at all summarized the energy situation in the World and Türkiye. They reported that global and Turkish energy resources, focusing on their reserves, production, and consumption. It examines energy production, consumption, CO_2 emissions, and electrical energy usage across different countries, comparing per capita energy and electricity consumption. Their assessment covers the non-renewable resources (oil, natural gas, coal, uranium, thorium) and renewable energy sources (hydropower, geothermal, biomass, solar, wind). Additionally, it highlights countries' renewable electrical power capacities, providing a comprehensive overview of energy trends and sustainability efforts worldwide and in Türkiye. (7)

MATERIAL AND METHODS

The data used in this study is given in Table.1

Table.1. Data used in the study (GDP in billion dollars, Export and Import in US Dollars, Electricity Consumption in TWh)

Year	Population	GDP	Export	Import	Electricity Consumption
1992	55748000	158	14714629	22871055	67
1993	56653000	180	15345067	29428370	73
1994	57564000	131	18105872	23270019	78
1995	58486000	169	21637041	35709011	86
1996	59423000	181	23224465	43626642	95
1997	60372000	190	26261072	48558721	106
1998	61329000	276	26973952	45921392	114
1999	62287000	256	26587225	40671272	118
2000	63240000	273	27774906	54502821	128
2001	64191000	200	31334216	41399083	127
2002	65143000	238	36059089	51553797	133
2003	66085000	312	47252836	69339692	141
2004	67007000	405	63167153	97539766	150
2005	67903000	501	73476408	116774151	161
2006	68763000	552	85534676	139576174	175
2007	69597000	676	107271750	170062715	190
2008	70440000	764	132027196	201963574	198
2009	71339000	645	102142613	140928421	194
2010	72326000	772	113883219	185544332	210
2011	73409000	833	134906869	240841676	230
2012	74569000	874	152461737	236545141	242
2013	75787000	951	161480915	260822803	248
2014	77030000	934	166504862	251142429	257
2015	78271000	860	150982114	213619211	266
2016	79512000	864	149246999	202189242	278
2017	80810525	859	164494619	238715128	292
2018	82003882	798	177168756	231152483	303
2019	83154997	760	180832722	210345203	302
2020	83614362	717	169637755	219516807	305
2021	84680273	807	225291385	271424473	330
2022	85279553	906	254169747	363710574	327
2023	85372377	1119	255440780	361764556	329

Data is required to train the models collected from various resources. These resources include the study of Özdemir at all (2), National Energy Plan of Türkiye 2022 prepared by Republic of Türkiye Ministry of Energy and Natural Sources (8), Electricity Distribution Sector Plan of Year 2022 prepared by Turkish Electricity Distribution

Corporation (TEDAŞ) (9) and miscellaneous related report of Turkish Statistical Institute (TUIK) (10).

The data columns used for estimation are the population, GDP, import and export values. By using the four values per year electricity consumption for the next year is estimated verbally. The values of the column of electricity consumption are classified into 3 or 4 four classes.

In the first run 4 classes are chosen. These classes are "Negative" if the increase is negative percentage, "Low" if the increase is between 0 to 5 percent, "Medium" if the increase between 5 to 10 percent and High if the increase is larger than 10 percent. Increase percentages and classes of increases are given in Table 2.

Table.2. 4 Verbal Classes used in Estimation

Year	Consumption in TWh	Increase Class	Increase Percentage
1992	67	Medium	N/A
1993	73	Medium	8.955224
1994	78	High	6.849315
1995	86	High	10.25641
1996	95	High	10.46512
1997	106	Medium	11.57895
1998	114	Low	7.54717
1999	118	Medium	3.508772
2000	128	Negative	8.474576
2001	127	Low	-0.78125
2002	133	Medium	4.724409
2003	141	Medium	6.015038
2004	150	Medium	6.382979
2005	161	Medium	7.333333
2006	175	Medium	8.695652
2007	190	Low	8.571429
2008	198	Negative	4.210526
2009	194	Medium	-2.0202
2010	210	Medium	8.247423
2011	230	Medium	9.52381
2012	242	Low	5.217391
2013	248	Low	2.479339
2014	257	Low	3.629032
2015	266	Low	3.501946
2016	278	Medium	4.511278
2017	292	Low	5.035971
2018	303	Negative	3.767123
2019	302	Low	-0.33003
2020	305	Medium	0.993377
2021	330	Negative	8.196721
2022	327	Low	-0.90909
2023	329	N/A	0.611621

In the second run 3 classes are chosen. These classes are "NONE" if the increase is less than 3 percent, "NORMAL" if the increase is between 3 to 6 percent, "HIGH" if the increase is larger than 6 percent. Increase percentages and classes of increases are given in Table 3.

Table.3. 3 Verbal Classes used in Estimation

Year	Consumption in TWh	Increase Class	Increase Percentage
1992	67	HIGH	N/A
1993	73	HIGH	8,955224
1994	78	HIGH	6,849315
1995	86	HIGH	10,25641
1996	95	HIGH	10,46512
1997	106	HIGH	11,57895
1998	114	HIGH	7,54717
1999	118	NORMAL	3,508772
2000	128	HIGH	8,474576
2001	127	NONE	-0,78125
2002	133	NORMAL	4,724409
2003	141	HIGH	6,015038
2004	150	HIGH	6,382979
2005	161	HIGH	7,333333
2006	175	HIGH	8,695652
2007	190	HIGH	8,571429
2008	198	NORMAL	4,210526
2009	194	NONE	-2,0202
2010	210	HIGH	8,247423
2011	230	HIGH	9,52381
2012	242	NORMAL	5,217391
2013	248	NONE	2,479339
2014	257	NORMAL	3,629032
2015	266	NORMAL	3,501946
2016	278	NORMAL	4,511278
2017	292	NORMAL	5,035971
2018	303	NORMAL	3,767123
2019	302	NONE	-0,33003
2020	305	NONE	0,993377
2021	330	HIGH	8,196721
2022	327	NONE	-0,90909
2023	329	N/A	0,611621

Consequently, classification tables of Table 2 and Table 3 are used to produce the year depth data. Depths from 3 years to 5 years are chosen arbitrarily. Here, the year depth means how many years are used for estimation backwards for next year's

consumption estimation. For example, if data from 3 years back is used to estimate next year's consumption estimation, the year depth is 3. To measure the performance of the classification algorithms, classification algorithms of MATLAB 2023A software is used. A Large summary of all methods used in this study can be in the work of Patlak at all (11).

RESULTS

Some classification results are presented below.

The first result is for 3-year depth, 3 class data. In Table 4, the best 5 model based on accuracy values results are chosen. In Figure1, confusion matrix, accuracy percentages and true positive results (TPR) and false negative results (FNR) of Linear SVM being the best method for 3-year depth 3 class data.

Table 4. Best Classification Methods for year depth:3 and number of classes: 3.

Ranking	Model	Sub Type	Accuracy % (Validation)	Total Cost
1	SVM	Linear	70.00	9
2	Ensemble	Sub Space Discriminant	66.67	16
3	Ensemble	Bagged Trees	63.33	16
4	SVM	Medium Gaussian	63.33	16
5	KNN	Weighted	60.00	13

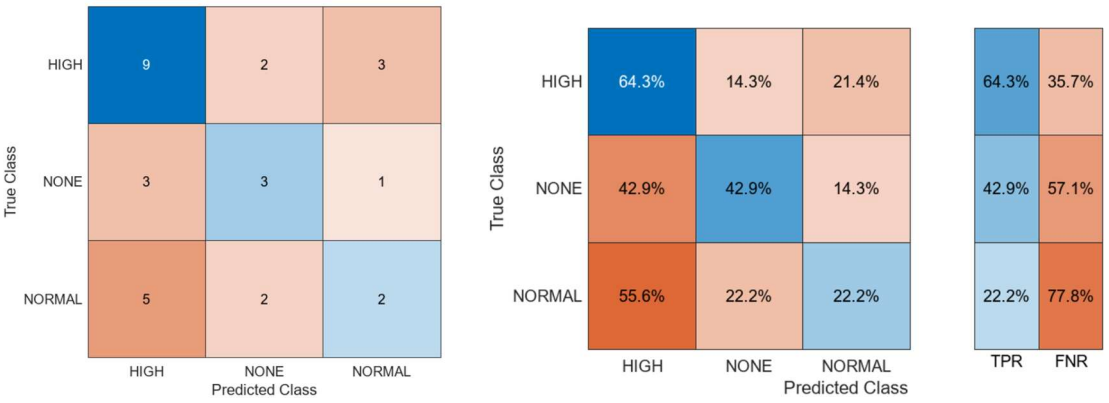


Figure 1. Linear SVM (Best Method) Confusion Matrix (left), Accuracy Percentages and True Positive and False Negative Results (right) for year depth:3 and number of classes: 3

The second result is for 5-year depth, 4 class data. In Table 5, the best 5 model based on accuracy values results are chosen. In Figure 2, confusion matrix, accuracy

percentages and true positive results (TPR) and false negative results (FNR) of Medium Sized Neural Networks being the best method for 5-year depth 4 class data.

Table 5. Best Classification Methods for year depth:5 and number of classes: 4.

Ranking	Model	Sub Type	Accuracy % (Validation)	Total Cost
1	Neural Net.	Medium Size	57.14	12
2	SVM	Linear	53.57	13
3	SVM	Fine Gaussian	53.57	13
4	Ensemble	Subspace Discriminant	53.57	13
5	Kernel	SVM	53.57	13

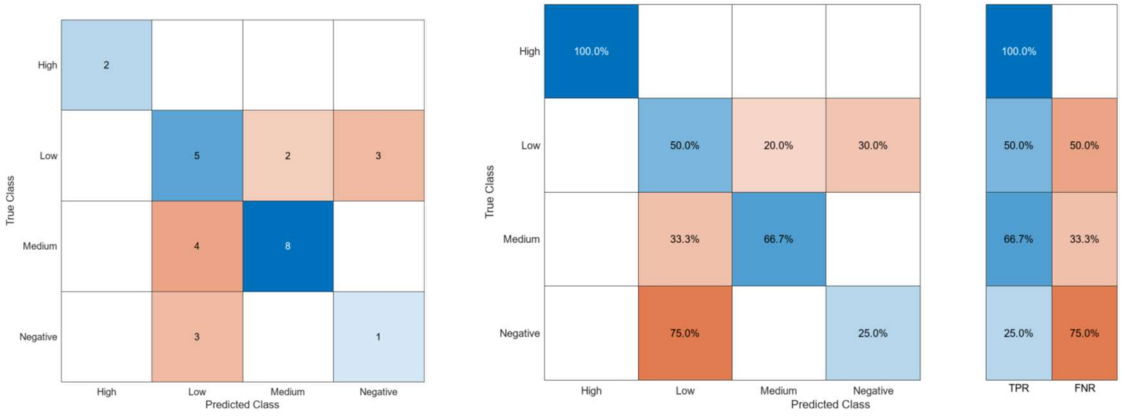


Figure 2. Medium Size Neural Network (Best Method) Confusion Matrix (left), Accuracy Percentages and True Positive and False Negative Results (right) for year depth:5 and number of classes: 4

The third result is for 4-year depth, 3 class data. In Table 6, the best 6 model based on accuracy values results are chosen. In Figure 3, confusion matrix, accuracy percentages and true positive results (TPR) and false negative results (FNR) of Bagged Tress Ensemble being the best method for 4-year depth 3 class data.

Table 6. Best Classification Methods for year depth:5 and number of classes: 4.

Ranking	Model	Sub Type	Accuracy % (Validation)	Total Cost
1	Ensemble	Bagged Trees	65.52	10
2	SVM	Linear	62.07	11
3	Ensemble	Subspace Discriminant	62.07	11
4	SVM	Cubic	58.62	12
5	KNN	Medium	58.62	12

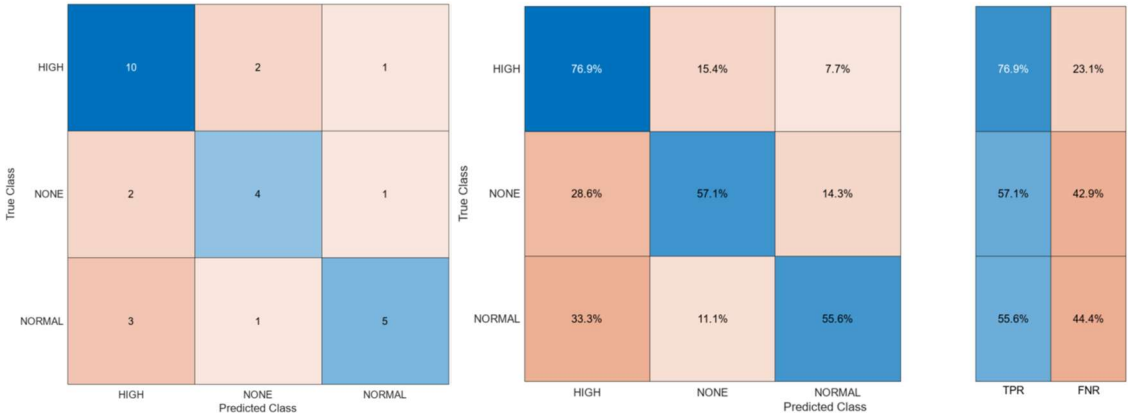


Figure 3. Medium Size Neural Network (Best Method) Confusion Matrix (left), Accuracy Percentages and True Positive and False Negative Results (right) for year depth:5 and number of classes: 4

CONCLUSION

Global energy demand is rising steadily, particularly in developing countries having rapid growth in population and industrialization. Energy is a crucial factor in manufacturing and a key indicator of a nation's economic and social development potential. Increased energy needs, making strategic planning for energy production investments essential. Cost-efficient energy production is vital. Insufficient energy supply can hinder economic growth, while excess may divert funds from other critical development areas. Optimizing energy investment costs is especially important for countries having limited budgets to ensure balanced and sustainable economic progress.

Estimating next year's energy consumption is crucial for effective short-term financial planning. Even approximate consumption forecasts enable more optimized allocation of resources. For instance, if projections indicate low or negative growth in energy demand, financial resources can be diverted to other critical sectors instead of energy investments. Conversely, medium to high projected consumption necessitates urgent funding reallocation toward energy production to prevent supply shortages.

The findings of this study establish a promising foundation for future research. Building upon this groundwork, more precise energy consumption estimations can be developed, with significant potential for methodological refinement. A key area for improvement lies in determining the optimal temporal range (year-depth) for forecasting, which would substantially enhance predictive accuracy. Furthermore, identifying the optimal predictive model among those evaluated, especially for datasets of this nature, can substantially improve forecast precision by calibrating key model parameters. This approach ensures that the selected methodology aligns with the data's inherent characteristics, thereby enhancing the robustness and reliability of energy consumption projections. Additionally, further research could focus on developing advanced numerical prediction models to improve the reliability of energy demand projections.

REFERENCES

(1) M.A. Islam. Hang Seng Che. M. Hasanuzzaman. N.A. Rahim. Chapter 5 - Energy demand forecasting. Editor(s): MD. Hasanuzzaman. Nasrudin Abd Rahim. Energy for Sustainable Development. Academic Press. 2020. Pages 105-123. ISBN 9780128146453. https://doi.org/10.1016/B978-0-12-814645-3.00005-5.

(2) Özdemir. D.. Dörterler. S. & Aydın. D. A new modified artificial bee colony algorithm for energy demand forecasting problem. Neural Comput & Applic 34. 17455–17471 (2022). https://doi.org/10.1007/s00521-022-07675-7

(3) Aderibigbe. Adebayo & Ani. Emmanuel & Ohenhen. Peter & Ohalete. Nzubechukwu & Daraojimba. Donald. (2023). ENHANCING ENERGY EFFICIENCY WITH AI: A REVIEW OF MACHINE LEARNING MODELS IN ELECTRICITY DEMAND FORECASTING. Engineering Science & Technology Journal. 4. 341-356. 10.51594/estj.v4i6.636.

(4) Hu. YC. Electricity consumption prediction using a neural-network-based grey forecasting approach. J Oper Res Soc 68. 1259–1264 (2017). https://doi.org/10.1057/s41274-016-0150-y

(5) Wang. X.. Wang. H.. Bhandari. B. et al. AI-Empowered Methods for Smart Energy Consumption: A Review of Load Forecasting. Anomaly Detection and Demand Response. Int. J. of Precis. Eng. and Manuf.-Green Tech. 11. 963–993 (2024). https://doi.org/10.1007/s40684-023-00537-0

(6) Çunkaş, M., & Taşkiran, U. (2011). Turkey's Electricity Consumption Forecasting Using Genetic Programming. *Energy Sources, Part B: Economics, Planning, and Policy*, *6*(4), 406–416. https://doi.org/10.1080/15567240903047558

(7) Koç. A.. Yağlı. H.. Koç. Y.. Uğurlu. İ. (2018). Dünyada ve Türkiye'de Enerji Görünümünün Genel Değerlendirilmesi. Mühendis Ve Makina. 59(692). 86-114

(8) Türkiye Ulusal Enerji Planı. Republic of Türkiye, Ministry of Energy and Natural Resources. https://enerji.gov.tr/Media/Dizin/EIGM/tr/Raporlar/TUEP/T%C3%BCrkiye_Ulusal_Enerji_Plan%C4%B1.pdf

(9) Türkiye Elektrik Dağıtım A.Ş. Genel Müdürlüğü 2022 Yılı Türkiye Elektrik Dağıtımı Sektör Raporu. https://www.tedas.gov.tr/FileUpload/MediaFolder/f1bb5ed3-88d0-4502-966b-4ecaab4c1270.pdf

(10) Turkish Statistical Institute. https://www.tuik.gov.tr/

(11) Patlak, M., Çunkaş, M. & Taskiran, U. The Innovative Approach to Real-Time Detection of Fuel Types Based on Ultrasonic Sensor and Machine Learning. Arab J Sci Eng 49, 16571–16591 (2024). https://doi.org/10.1007/s13369-024-09092-5

On ⊕-g-Supplemented Lattices

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Abstract

In this work, every lattice is a complete modular lattice. An element b of a lattice L is called a complement of a in L if $a\wedge b=0$ and $a\vee b=1$, this case we denote $1=a\oplus b$ (a and b also are called direct summands of L). Let L be a lattice and $k\in L$. If $t=0$ for every $t\in L$ with $k\wedge t=0$, then k is called an essential element of L and denoted by $k(L$. Let L be a lattice and $a\in L$. If $x=1$ for every $x(L$ such that $a\vee x=1$, then a is called a g-small (or g-superfluous) element of L and denoted by $a\ll_g L$. The meet of all essential maximal ($\neq 1$) elements of L is called the g-radical of L and denoted by $r_g(L)$. If L have no essential maximal ($\neq 1$) elements, then we call $r_g(L)=1$. Let L be a lattice and $a,b\in L$. a is said to be a g-supplement of b in L if $1=b\vee a$ and $b\wedge a\ll_g a/0$. A lattice L is called a g-supplemented lattice if every element of L has a g-supplement in L. L is called ⊕-g-supplemented if every element of L has a g-supplement that is a direct summand in L.

Key Words: Lattice, g-Radical, g-Small Element, Supplemented Lattice

1. INTRODUCTION

In this work, each lattice is a complete modular lattice with the smallest element 0 and the greatest element 1. Let L be a lattice, $a,b\in L$ and $a\leq b$. A sublattice $\{x\in L \mid a\leq x\leq b\}$ is called a *quotient sublattice*, denoted by b/a. An element a' of a lattice L is called a *complement* of a in L if $a\wedge a'=0$ and $a\vee a'=1$, this case we denote $1=a\bigoplus a'$ (a and a' also are called *direct summands* of L). L is called a *complemented* lattice if every element of L has at least one complement in L. Let L be a lattice and $k\in L$. If $t=0$ for every $t\in L$ with $k\wedge t=0$, then k is called an *essential* element of L and denoted by $k(L$. An element a of a lattice L is called a *small* (or *superfluous*) element of L and denoted by $a\ll L$ if $b=1$ for every element b of L such that $a\vee b=1$. Let L be a lattice and $a\in L$. a is called a *g-small* (or *g-*

superfluous) element of L and denoted by $a \ll_g L$ if $t=1$ for every $t(L$ such that $a \vee t=1$. The meet of all maximal ($\neq 1$) elements of a lattice L is called the *radical* of L and denoted by $r(L)$. If L have no maximal ($\neq 1$) elements, then we call $r(L)=1$. Let L be a lattice and t be a maximal ($\neq 1$) element of L. If $t(L$, then t is called a *g-maximal* element of L. The meet of all g-maximal elements of a lattice L is called the *g-radical* of L and denoted by $r_g(L)$. If L have no g-maximal elements, then we call $r_g(L)=1$. An element b of a lattice L is called a *supplement* of a in L if it is minimal for $a \vee b=1$. b is a supplement of a in a lattice L if and only if $a \vee b=1$ and $a \wedge b \ll b/0$. A lattice L is called a *supplemented* lattice if every element of L has a supplement in L. Let L be a lattice. L is said to be $\oplus$-*supplemented* if every element of L has a supplement that is a direct summand in L. An element b of a lattice L is called a *g-supplement* of a in L if $a \vee b=1$ and $a \vee t=1$ with $t(b/0$ implies that $t=b$. a is a g-supplement of b in a lattice L if and only if $a \vee b=1$ and $a \wedge b \ll_g a/0$. A lattice L is said to be *g-supplemented* if every element of L has a g-supplement in L. A lattice L is said to be *hollow* if every element ($\neq 1$) is superfluous in L, and L is said to be *local* if L has the greatest element ($\neq 1$). L is said to be *g-hollow* if every element of L with distinct from 1 is g-small in L. An element a of a lattice L is called a *weak supplement* of b in L if $a \vee b=1$ and $a \wedge b \ll L$. A lattice L is said to be *weakly supplemented* if every element of L has a weak supplement in L. An element a of a lattice L is called a *weak g-supplement* of b in L if $a \vee b=1$ and $a \wedge b \ll_g L$. A lattice L is said to be *weakly g-supplemented* if every element of L has a weak g-supplement in L. An element a of a lattice L has *ample supplements* in L if for every $b \in L$ with $a \vee b=1$, a has a supplement b' in L with $b' \leq b$. L is said to be *amply supplemented* if every element of L has ample supplements in L. It is clear that every supplemented lattice is weakly supplemented and every amply supplemented lattice is supplemented. An element a of a lattice L has *ample g-supplements* in L if for every $b \in L$ with $a \vee b=1$, a has a g-supplement b' in L with $b' \leq b$. L is said to be *amply g-supplemented* if every element of L has ample g-supplements in L. It is clear that every g-supplemented lattice is weakly g-supplemented and every amply g-supplemented lattice is g-supplemented. A lattice L is said to be *distributive* if $a \wedge (b \vee c)=(a \wedge b) \vee (a \wedge c)$ for every $a,b,c \in L$.

2. ⊕-g-SUPPLEMENTED LATTICES

Definition 2.1. Let L be a lattice. If every element of L has a g-supplement that is a direct summand of L, then L is called a $\oplus$-*g*-supplemented lattice. (See also (Baradaran and Nebiyev, 2024))

Proposition 2.2. Every ⊕-g-supplemented lattice is weakly g-supplemented.

Proof. Let L be a ⊕-g-supplemented lattice. Since L is ⊕-g-supplemented, L is g-supplemented. Since every g-supplemented lattice is weakly g-supplemented, L is weakly g-supplemented, as desired.

Proposition 2.3. Let L be a lattice and $a,b \in L$. If $a \vee b$ has a g-supplement in L and $b/0$ is ⊕-g-supplemented, then a has a weak g-supplement in L.

Proof. Since $b/0$ is ⊕-g-supplemented, by Proposition 2.2, $b/0$ is g-supplemented. Then by (Ökten, 2021) Corollary 3, a has a g-supplement x in L. Here $1=a \vee x$ and $a \wedge x \ll_g x/0$. Since $a \wedge x \ll_g x/0$, $a \wedge x \ll_g L$. Hence x is a weak g-supplement of a in L.

Proposition 2.4. Let L be a lattice, $a,b\in L$ and $a\vee b=1$. If $a/0$ and $b/0$ are $\oplus$-g-supplemented, then L is weakly g-supplemented.

Proof. Since $a/0$ and $b/0$ are $\oplus$-g-supplemented, they are g-supplemented. Then by (Ökten, 2021) Lemma 4, L is g-supplemented. Since L is g-supplemented, L is weakly g-supplemented, as desired.

Proposition 2.5. Let L be a lattice and $a_1\vee a_2\vee\ldots\vee a_n=1$ with $a_i\in L$ $(1\leq i\leq n)$. If $a_i/0$ is $\oplus$-g-supplemented for every $i=1, 2, \ldots, n$, then L is weakly g-supplemented.

Proof. Clear from Proposition 2.4.

Proposition 2.6. Let L be a $\oplus$-g-supplemented lattice. Then $1/a$ is weakly g-supplemented for every $a\in L$.

Proof. Since L is $\oplus$-g-supplemented, L is g-supplemented. Then by (Ökten, 2021) Corollary 5, $1/a$ is g-supplemented for every $a\in L$. Hence $1/a$ is weakly g-supplemented for every $a\in L$.

Proposition 2.7. Let L be a lattice. If L is $\oplus$-g-supplemented and every nonzero element of L is essential in L, then L is $\oplus$-supplemented.

Proof. Since every nonzero element of L is essential in L, every g-small element in $x/0$ is small in $x/0$ for every $x\in L$. Hence every g-supplement element in L is a supplement element in L. Thus L is $\oplus$-supplemented.

3. CONCLUSIONS

$\oplus$-g-supplemented lattices are the special parts of weakly g-supplemented lattices.

REFERENCES

Alizade R, Toksoy S. E. (2009). Cofinitely weak supplemented lattices. Indian Journal of Pure and Applied Mathematics 40(5), 337-346.

Alizade R, Toksoy S. E. (2011). Cofinitely supplemented modular lattices. Arabian Journal for Science and Engineering 36, 919-923.

Baradaran M, Nebiyev C. (2024). $\oplus$-g-supplemented lattices. Presented in '1th International Üsküdar Scientific Research and Innovation Congress', Istanbul-Turkey.

Biçer Ç, Nebiyev C. (2019). $\oplus$-supplemented lattices. Miskolc Mathematical Notes 20(2), 773-780.

Călugăreanu G. (2000). Lattice concepts of module theory. Kluwer Academic Publisher, Dordrecht, Boston, London.

Clark J, Lomp C, Vanaja N, Wisbauer R. (2006). Lifting modules: supplements and projectivity in module theory. Frontiers in Mathematics, Birkhauser, Basel.

Harmancı A, Keskin D, Smith P. F. (1999). On $\oplus$-supplemented modules. Acta Mathematica Hungarica 83(1-2), 161-169.

Koşar B, Nebiyev C, Sökmez N. (2015). g-supplemented modules. Ukrainian Mathematical Journal 67(6), 861-864.

Koşar B, Nebiyev C, Pekin A. (2019). A generalization of g-supplemented modules. Miskolc Mathematical Notes 20(1), 345-352.

Nebiyev C, Ökten H. H. (2022). Weakly g-supplemented lattices. Presented in 6th International Conference on Mathematics "An Istanbul Meeting for World Mathematicians" (ICOM-2022), Istanbul-Turkey.

Nebiyev C, Ökten H. H. (2022). On amply g-supplemented lattices. Palestine Journal of Mathematics 11(Special Issue II), 37-40.

Nebiyev C, Ökten H. H. (2023). Some properties of $\oplus$-g-supplemented modules. Miskolc Mathematical Notes 24(1), 335-341.

Ökten H. H. (2021). g-supplemented lattices. Miskolc Mathematical Notes 22(1), 435-441.

Wisbauer R. (1991). Foundations of module and ring theory. Gordon and Breach, Philadelphia.

Strongly ⊕-g-Supplemented Lattices

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Abstract

In this work, every lattice is a complete modular lattice with the smallest element 0 and the greatest element 1. An element b of a lattice L is called a complement of a in L if $a\wedge b=0$ and $a\vee b=1$, this case we denote $1=a\oplus b$ (a and b also are called direct summands of L). Let L be a lattice and $a,b\in L$. If $a\vee b=1$ and $a\wedge b\ll_g b/0$, then b is called a g-supplement of a in L. A lattice L is said to be g-supplemented if every element of L has a g-supplement in L. L is said to be ⊕-g-supplemented if every element of L has a g-supplement that is a direct summand in L. Let L be a g-supplemented lattice. If every g-supplement element of L is a direct summand of L, then L is called a strongly ⊕-g-supplemented lattice. In this work, some properties of strongly ⊕-g-supplemented lattices are investigated. It is clear that every strongly ⊕-g-supplemented lattice is ⊕-g-supplemented.

Keywords: Lattice, g-Small Element, g-Supplemented Lattice, ⊕-Supplemented Lattice

1. INTRODUCTION

In this work, all lattices are complete modular lattices with the smallest element 0 and the greatest element 1. Let L be a lattice, $a,b\in L$ and $a\leq b$. A *quotient sublattice* is defined by $\{x\in L\,|\,a\leq x\leq b\}$ and denoted by b/a. An element b of a lattice L is called a *complement* of c in L if $b\wedge c=0$ and $b\vee c=1$, this case we denote $1=b\bigoplus c$ (b and c also are called *direct summands* of L). If every element of L has a complement in L, then L is

called a *complemented* lattice. Let L be a lattice and $k\in L$. If $t=0$ for every $t\in L$ with $k\wedge t=0$, then k is called an *essential* element of L and denoted by $k\subset L$. An element b of a lattice L is said to be *small* (or *superfluous*) in L and denoted by $b\ll L$ if $c=1$ for every element c of L such that $b\vee c=1$. Let L be a lattice and $b\in L$. b is said to be *g-small* (or *g-superfluous*) in L and denoted by $b\ll_g L$ if $c=1$ for every $c\subset L$ such that $b\vee c=1$. The radical of a lattice L is defined by the meet of all maximal ($\neq 1$) elements of L and denoted by $r(L)$. If L have no maximal ($\neq 1$) elements, then the radical of L is defined by $r(L)=1$. Let L be a lattice and t be a maximal ($\neq 1$) element of L. If $t\subset L$, then t is called a *g-maximal* element of L. The *g-radical* of a lattice L is defined by the meet of all g-maximal elements of L and denoted by $r_g(L)$. If L have no g-maximal elements, then the g-radical of L is defined by $r_g(L)=1$. An element b of a lattice L is called a *supplement* of a in L if it is minimal for $a\vee b=1$. b is a supplement of a in a lattice L if and only if $a\vee b=1$ and $a\wedge b\ll b/0$. A lattice L is said to be *supplemented* if every element of L has a supplement in L. Let L be a lattice. If every element of L has a supplement that is a direct summand of L, then L is called a $\oplus$-*supplemented* lattice. If $a/0$ is $\oplus$-supplemented for every direct summand a of L, then L is called a *completely* $\oplus$-*supplemented* lattice. Let L be a supplemented lattice. If every supplement element in L is a direct summand of L, then L is called a *strongly* $\oplus$-*supplemented* lattice. An element b of a lattice L is called a g-supplement of a in L if $a\vee b=1$ and $a\vee t=1$ with $t\subset b/0$ implies that $t=b$. b is a g-supplement of a in a lattice L if and only if $a\vee b=1$ and $a\wedge b\ll_g b/0$. A lattice L is said to be *g-supplemented* if every element of L has a g-supplement in L. L is said to be $\oplus$-*g-supplemented* if every element of L has a g-supplement that is a direct summand in L. L is said to be *hollow* if every element ($\neq 1$) is superfluous in L, and L is said to be *local* if L has the greatest element ($\neq 1$). L is said to be *g-hollow* if every element of L with distinct from 1 is g-small in L. An element a of a lattice L is called a *weak supplement* of b in L if $a\vee b=1$ and $a\wedge b\ll L$. A lattice L is said to be *weakly supplemented* if every element of L has a weak supplement in L. An element a of a lattice L is called a *weak g-supplement* of b in L if $a\vee b=1$ and $a\wedge b\ll_g L$. A lattice L is called a *weakly g-supplemented* lattice if every element of L has a weak g-supplement in L. We say that an element a of a lattice L has *ample supplements* in L if for every $b\in L$ with $a\vee b=1$, a has a supplement c in L with $c\leq b$. L is said to be *amply supplemented* if every element of L has ample supplements in L. We say that an element a of a lattice L has *ample g-supplements* in L if for every $b\in L$ with $a\vee b=1$, a has a g-supplement c in L with $c\leq b$. L is said to be *amply g-supplemented* if every element of L has ample g-supplements in L. Let L be a lattice. If $a\wedge(b\vee c)=(a\wedge b)\vee(a\wedge c)$ for every $a,b,c\in L$, then L is called a *distributive* lattice.

2. STRONGLY ⊕-g-SUPPLEMENTED LATTICES

Definition 2.1. Let L be a g-supplemented lattice. If every g-supplement element of L is a direct summand of L, then L is called a strongly ⊕-g-supplemented lattice.

Proposition 2.2. Every strongly ⊕-g-supplemented lattice is ⊕-g-supplemented.

Proof. Clear from definitions.

Proposition 2.3. Every strongly ⊕-g-supplemented lattice is g-supplemented.

Proof. Clear from definition.

Proposition 2.4. Let L be a lattice and $a,b\in L$. If $a\vee b$ has a g-supplement in L and $b/0$ is strongly $\oplus$-g-supplemented, then a has a g-supplement in L.

Proof. Since $b/0$ is strongly $\oplus$-g-supplemented, by Proposition 2.3, $b/0$ is g-supplemented. Then by (Ökten, 2021) Corollary 3, a has a g-supplement in L.

Proposition 2.5. Let L be a lattice, $a,b\in L$ and $a\vee b=1$. If $a/0$ and $b/0$ are strongly $\oplus$-g-supplemented, then L is g-supplemented.

Proof. Since $a/0$ and $b/0$ are strongly $\oplus$-g-supplemented, by Proposition 2.3, they are g-supplemented. Then by (Ökten, 2021) Lemma 4, L is g-supplemented, as required.

Proposition 2.6. Let L be a lattice and $a_1\vee a_2\vee\ldots\vee a_n=1$ with $a_i\in L$ $(1\leq i\leq n)$. If $a_i/0$ is strongly $\oplus$-g-supplemented for every $i=1, 2, \ldots, n$, then L is g-supplemented.

Proof. Clear from Proposition 2.5.

Proposition 2.7. Let L be a strongly $\oplus$-g-supplemented lattice. Then $1/a$ is g-supplemented for every $a\in L$.

Proof. Since L is strongly $\oplus$-g-supplemented, by Proposition 2.3, L is g-supplemented. Then by (Ökten, 2021) Corollary 5, $1/a$ is g-supplemented for every $a\in L$, as required.

Proposition 2.8. Let L be a lattice. If L is strongly $\oplus$-g-supplemented, then $1/r_g(L)$ is complemented.

Proof. Since L is strongly $\oplus$-g-supplemented, by Proposition 2.3, L is g-supplemented. Then by (Ökten, 2021) Lemma 8, $1/r_g(L)$ is complemented, as required.

Proposition 2.9. Let L be a lattice. If L is strongly $\oplus$-g-supplemented and every nonzero element of L is essential in L, then L is strongly $\oplus$-supplemented.

Proof. Since every nonzero element of L is essential in L, every g-small element in $x/0$ is small in $x/0$ for every $x\in L$. Hence every g-supplement element in L is a supplement element in L. Thus L is strongly $\oplus$-supplemented.

3. CONCLUSIONS

Strongly $\oplus$-g-supplemented lattices are the special parts of $\oplus$-g-supplemented lattices.

REFERENCES

Alizade R, Toksoy S. E. (2009). Cofinitely weak supplemented lattices. Indian Journal of Pure and Applied Mathematics 40(5), 337-346.

Alizade R, Toksoy S. E. (2011). Cofinitely supplemented modular lattices. Arabian Journal for Science and Engineering 36, 919-923.

Baradaran M, Nebiyev C. (2024). $\oplus$-g-supplemented lattices. Presented in '1th International Üsküdar Scientific Research and Innovation Congress', Istanbul-Turkey.

Biçer Ç, Nebiyev C. (2019). ⊕-supplemented lattices. Miskolc Mathematical Notes 20(2), 773-780.

Călugăreanu G. (2000). Lattice concepts of module theory. Kluwer Academic Publisher, Dordrecht, Boston, London.

Harmancı A, Keskin D, Smith P. F. (1999). On ⊕-supplemented modules. Acta Mathematica Hungarica 83(1-2), 161-169.

Koşar B, Nebiyev C, Sökmez N. (2015). g-supplemented modules. Ukrainian Mathematical Journal 67(6), 861-864.

Koşar B, Nebiyev C, Pekin A. (2019). A generalization of g-supplemented modules. Miskolc Mathematical Notes 20(1), 345-352.

Koşar B, Nebiyev C, Ökten H. H. Some properties of weakly g-supplemented lattices. Miskolc Mathematical Notes (Accepted).

Nebiyev C. (2019). On supplement elements in lattices. Miskolc Mathematical Notes 20(1), 441-449.

Nebiyev C, Ökten H. H. (2022). On amply g-supplemented lattices. Palestine Journal of Mathematics 11(Special Issue II), 37-40.

Nebiyev C, Ökten H. H. (2023). Some properties of ⊕-g-supplemented modules. Miskolc Mathematical Notes 24(1), 335-341.

Ökten H. H. (2021). g-supplemented lattices. Miskolc Mathematical Notes 22(1), 435-441.

Wisbauer R. (1991). Foundations of module and ring theory. Gordon and Breach, Philadelphia.

The Effect of Organic Salts $NaCH_3COO$, $Zn(CH_3COO)_2$, and $C_6H_5Na_3O_7$ on the Phase Diagram of the Peg-Dextran-Water Biphasic System

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Abstract

The present study is dedicated to the investigation, development, and analysis of aqueous two-phase polymer systems with properties tailored for specific applications. In this context, the effects of certain organic salts ($NaCH_3COO$, $Zn(CH_3COO)_2$, and $C_6H_5Na_3O$) on the properties of the PEG-dextran-water biphasic system and on the parameters characterizing these properties were examined. The research findings indicate that the addition of these salts shifts the binodal curve closer to the origin of coordinates, expands the area of the heterogeneous region, and increases the immiscibility between PEG and dextran. This behavior suggests that the investigated salts exhibit a structure-breaking effect on water.

Keywords: Aqueous two-phase system, PEG, dextran, salts, binodal curve

Özet

Sunulan çalışma, belirli uygulama alanlarına uygun özelliklere sahip ikifazlı su-polimer sistemlerinin araştırılması, elde edilmesi ve incelenmesine adanmıştır. Bu bağlamda, bazı organik tuzların ($NaCH_3COO$, $Zn(CH_3COO)_2$ ve $C_6H_5Na_3O$) PEG-dekstran-su ikifazlı sisteminin özelliklerine ve bu özellikleri karakterize eden parametrelere etkisi araştırılmıştır. Araştırma sonuçları göstermektedir ki, bu tuzların sisteme ilavesiyle binodal eğrisi koordinat başlangıcına yaklaşmakta, heterojen bölgenin alanı genişlemekte ve PEG ile dekstran arasındaki suda çözünmezlik artmaktadır. Bu durum, incelenen tuzların suyun yapısına bozucu (yani yapıyı parçalayıcı) bir etki gösterdiğini ortaya koymaktadır.

Anahtar Kelimeler: İkifazlı sistem, PEG, dekstran, tuzlar, binodal eğrisi

Biolojik aktiv parçacıklar karışımının terkip hisselerine ayrılması, temizlenmesi ve araştırılması Tıp ve Moleküler Biofiziğin önemli problemlerindendir. Sözkonusu alanlarda yapılan araştırmalar biyolojik moleküllerin fonksiyonel özelliklerinin açıklanması açısından özel önem teşkil etmektedir. Bizzat bu nedenden dolayı bazi kimyasal ve biyolojik yöntemler işlenilmişdir. Kimyasal yöntem uygulandığında söz konusu ayrılması gereken moleküller bu veya diğer nedenlerden dolayı denaturasyona uğradığından dolayı söz konusu bu metot(yöntem) kullanıma yaramır. Biyolojik metotlar(yöntemler) ise ekonomik açıdan önemsiz olmakla yanısıra ciddi zorunluklarla karşı-karşıya gelmektedir.

P.A.Albertsson [1] biyolojik obyektlerin ayrılması və temizlenmesi için çok önemli yeni bir yöntem işlemişdir. Sözkonusu bu yöntem, pratik kullanım açısından çok önemlidir - ekonomik açıdan elverişlidir, basittir, yan etkileri yok, fazla avadanlıklara gerek yok. Sözkonusu yöntem maddelerin ikifazlı su-polimer sistemlerde eşit olmayan dağılımına esaslanmaktadır. Burada kimyasal özellikleri farklı olan iki polimer molekülünün sulu çözeltisinde komponentlerin konsentrasyonlarının belli bir değerinden büyük olduğunda iki faz oluşur. Böyle ikifazlı sisteme biyolojik parçacıklar (protein, virüs, hücre ve s.) ekledikte onlar fazların birinde daha fazla, diğerinde ise daha düşük dağılır [2]. Bu türlü eşit olmayan dağılım ise bizzat komponentlerin özellikleri ve dağılım ortamı (polimer moleküllerinin özellikleri, konsentrasyonu, eklenen katkıların özellikleri ve sair) ilgilidir. Sözkonusu ikifazlı su-polimer sisteminin en önemli özelliyi şunlardan ibaretdir: bu sistemde rastgele hassas biyolojik materiallar sistemde dağıldıqda zedelenmiyor, biyolojik aktivitelerini kayb etmiyorlar. Bu ve diger önemli özelliklerinden dolayı sözkonusu yöntemin uygulama alanları genişdir. Bizzat bu nedenden dolayı belirli uygulama alanının taleplerine cevab veren ikifazlı su-polimer sistemlerinin elde edilmesine ihtiyac duyulmaktadır [3]. Değişik uygulama alanlarına uyğun ikifazlı su-polimer sisteminin elde olunması ve onların güdümlü özelliklere sahip olmaları için en optimal üsul değişik kiçikmoleküllü bileşenlerin (tuzların, şekerler, spirtler ve sair) sözkonusu sisteme eklenmeleridir. Halen sisteme eklenen katkılar içerisinde en fazla kullanılan orqanik ve qayri-orqanik tuzlardır.

Sözkonusu takdim olunan çalışmada $NaCH_3COO$, $Zn(CH_3COO)_2$ və $C_6H_5Na_3O_7$ qayri-orqanik tuzların PEQ-dekstran-su ikifazalı sistemlerin faz diaqramına etkileri araştırılmıştır. $NaCH_3COO$, $Zn(CH_3COO)_2$ və $C_6H_5Na_3O_7$ tuzlarının 5,10,15%-li çeki konsentrasyonları kullanılmıştır. Her üç tuzun etkisi sonucu binodal eğrinin koordinat başlanğıcına taraf yerdeğişdiyi, heterogen bölge alanının büyümesi saptanmışdır. Lakin, $NaCH_3COO$ tuzunun su-polimer ikifazlı sistemin faz diaqramının binodal əyrisinə nisbeten zayıf, $Zn(CH_3COO)_2$ tuzu mükayisede nisbeten küçük miktarda çox, $C_6H_5Na_3O_7$ tuzu isə daha önemli derecede etkilemektedir. Böyle değişik sonuçların nedeni asetat aniyonunun iyonik gücünün düşük olması və suyu strukturlaştırma yeteneyinin zayıf olmasıdır. Zinko asetatda isə Zn^{2+} iyonları suda güclü hidratlaşıyor (yüksək yük yoğunluğundan dolayı) ve bu nedenden dolayı natrium asetatla mükayisede suyu nisbeten güclü strukturlaşdırır. Trinatrium sitratın eklenmesi sonucunda su-polimer ikifazlı sistemin heterogen bölgesi önemli derecede genlenir, su

strukturlaşdırıcı sitrat iyonları polimerleri hidrat sudan daha fazla çıkarıyor. Genel olaraq söyleye bilerik ki, her üç tuzun etkisi sonucu polimerlerin karşılıklı suda uyumsuzlukları artır. Elde olunan sonuçlardan göründüyü gibi, her üç tuz suyu strukturlaştırmaktadır, tuzların etkisile fazlara ayrılma kolaylaşmaktadır ve bizzat bu nedenlerden dolayı polimerlerin düşük konsentrasyonlarından faydalanmak önemlidir.

Kaynakça

1. P. A. Albertsson,PartitionofCellParticlesandMacromolecules, 3rded. Wiley,New York, 1986.

2. J. A. Asenjo, B.A. Andrews, Aqueous two-phase systems for protein separation: phase separation and applications, J. Chromatogr. A 1238 (2012) 1–10.

3. Yao, T., Feng, C. & Yan, H. (2024). Current developments and applications of smart polymers based aqueous two-phase systems. Microchemical Journal, 204.

Stability or Instability of a Static Meniscus Appearing in Ribbon Single Crystal Growth from Melt using E.F.G. Method

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Abstract

This study presents necessary conditions for the existence and sufficient conditions for the stability or instability of the static meniscus (liquid bridge) appearing in the ribbon single crystal growth from the melt, of predetermined sizes, by using the edge-defined-film- fed (EFG) growth method. The cases when the contact angle and the growth angle verify the inequality $0 < \alpha_c < \frac{\pi}{2} - \alpha_g$ or $\frac{\pi}{2} > \alpha_c > \frac{\pi}{2} - \alpha_g$ are treated separately. Experimentally, only static meniscus (liquid bridges) which verifies the necessary condition of existence and the sufficient conditions of stability can be created; static meniscus (liquid bridges) which does not verify both of these conditions, exist only in theory because in reality they collapses. The results of this study is significant for thin ribbon single crystal growth from melt, with prior given macroscopic dimensions, using

prior given specific equipment. That is because the obtained inequalities represent limits for what can and cannot be achieved experimentally.

Keywords: static stability, meniscus, ribbon growth, edge-defined-film-fed-growth.

MSC: 34.B.15.

1. Introduction. The basic growth methods available for crystal growth are broadly; growth from the melt, growth from vapor, and growth from solution. Modern engineering does not only need single crystals of arbitrary shapes but also plates-, rod-,and tube-shaped single crystals, i.e. single crystals of shapes that allow one to use them as final products without additional machining. This problem appears to be solved by profiled- container crystallization as in the case of casting. However, this solution is not always acceptable. Container material needs to satisfy a certain set of requirements: should be neither react with the melt nor be wetted by it, it should be of high-temperature and aggressive-medium resistant, etc. Even if all these requirements are satisfied perfect –single crystal growth is not secured and growing very thin plate-shaped single crystals, to say nothing of shapes that are more complicated, excludes container application completely. The Springer Handbook of Crystal Growth [1] present on 1816 pages the state of the art in crystal growth until the years 2010. In Chapter 40 pg. 1379-1402 of this book the authors Th. George, St. Balint, L. Braescu presents several mathematical models describing processes, which take place in case of crystal growth from the melt by Bridgman-Stockbarger (BC) and by Edge-Defined-Film-Fed –Growth (EFG) method. For BC growth of cylindrical bar see Fig1 for ribbon (thin plate) growth by EFG method see Figures 2,3.

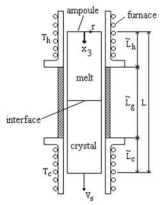


Fig.1.1Cylindrical bar

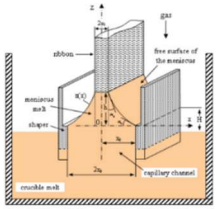


Fig. 1.2 Ribbon , $0 < \alpha_c \leq \frac{\pi}{2} - \alpha_g$.

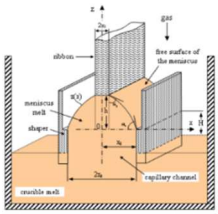


Fig.1.3 Ribbon , $\frac{\pi}{2} > \alpha_c > \frac{\pi}{2} - \alpha_g$.

In case of the BS method, the melt is encapsulated in a crucible and the crystallization of the melt takes place in conditions of permanent contact between the melt and the crystal with the

inner wall of the crucible. A significant advantage of the EFG method in comparison with respect to the BS method is that the crystal is grown without interaction with the crucible, which considerably improves the structural quality of the material: less residual stresses, dislocations, spurious nucleation or twins. In case of EFG method, there is a liquid bridge between the crystal and the shaper (die), called meniscus.. The melt is in a crucible, from which it flows through a capillary tube onto the surface of the shaper Fig.2.Fig.3.Hear a liquid bridge is formed between the shaper surface and the crystal. The crystallization takes place on the so "called crystallization front" which is the border line between the upper part of the liquid bridge and the bottom of the crystal. In the second section of this paper a short mathematical description of the real problem is given. Along with the equations, boundary conditions, and initial values defining the model are presented. In the third section in the framework of the mathematical model, predictions are made concerning the stability and instability of convex meniscus. In the fourth section in the framework of the same mathematical model, predictions are made concerning the stability and instability of concave meniscus. These predictions are made analyzing the static stability or instability of meniscus with theoretical tools presented in [2]. In the fifth section we discuss the problem what is wanted and wat can be done.

2. **Mathematical description of meniscus free surface.** The free surface of the static meniscus, in single crystal growth by EFG method, in hydrostatic approximation is described by the Young- Laplace capillary equation [3], [4]:

$$\gamma \times \left(\frac{1}{R_1}+\frac{1}{R_2}\right) = P_a - P_m \qquad (2.1)$$

Here: γ is the melt surface tension; $\frac{1}{R_1}$, $\frac{1}{R_2}$ denote the main normal curvatures of the free surface at an arbitrary point M of the meniscus ; P_a is the pressure above the free surface, equal to the pressure of the gas flow introduced in the furnace for release the heat and thereafter is denoted by p_g ($P_a = p_g$).The pressure P_m under the free surface is the sum of the hydrodynamic pressure p_m in the meniscus melt (due to the thermal convection) and the hydrostatic pressure of the melt column equal to $-\rho \times g \times (z + H)$ (see Fig.1. 2,Fig.1.3). Here: ρ denotes the melt density; g is the gravity acceleration; z is the coordinate of M with respect to the Oz axis, directed vertically upwards; H denotes the melt column height between the horizontal crucible melt level and the shaper top level. H is positive when the crucible melt level is under the shaper top level and it is negative when the shaper top level is under the crucible melt level.

The pressure difference $P_a - P_m$ across the free surface is $P_a - P_m = p_g - p_m + \rho \times g \times (z + H) = \rho \times g \times z - \left(p_m - p_g - \rho \times g \times H\right) = \rho \times g \times z - p$

where $p=\left(p_m - p_g - \rho \times g \times H\right)$ .In hydrodynamic equilibrium $p_m = 0$ and $p=\left(-p_g - \rho \times g \times H\right)$ .This pressure difference p is constant and it is called the controllable part of the pressure difference $P_a - P_m$.

In hydrostatic approximation the Young -Laplace capillary surface equation can be written as :

$$\gamma \times \left(\frac{1}{R_1}+\frac{1}{R_2}\right) = \rho \times g \times z - p \qquad (2.2)$$

Where $$p = -p_g - \rho \times g \times H \qquad (2.3)$$

To calculate the meniscus surface shape and size in hydrostatic approximation is convenient to employ the Young–Laplace equation (2.2) in its differential form:

$$\left[1+\left(\frac{\partial z}{\partial y}\right)^2\right] \times \frac{\partial^2 z}{\partial x \partial x} - 2 \times \frac{\partial z}{\partial x} \times \frac{\partial z}{\partial y} \times \frac{\partial^2 z}{\partial x \partial y} + \left[1+\left(\frac{\partial z}{\partial x}\right)^2\right] \times \frac{\partial^2 z}{\partial y \partial y} = \frac{\rho \times g \times z - p}{\gamma} \times \left[1 + \left(\frac{\partial z}{\partial x}\right)^2 + \left(\frac{\partial z}{\partial y}\right)^2\right]^{\frac{3}{2}}$$

(2.4)

With respect to the Oxyz, reference frame.(see Figs.1.2,1.3.)

For an Oyz plan symmetric meniscus $\frac{\partial z}{\partial y} = 0$ equation (2.4) become

$$z'' = \frac{\rho \times g \times z - p}{\gamma} \times \sqrt{[1+z'^2]^3} \qquad \text{for } x_1 \leq x \leq x_0 \qquad (2.5)$$

where : $x_1 > 0$ is the single crystal ribbon half-thickness and x_0 $(x_0 > x_1)$ is the shaper half-thickness.

Equation (2.5) is the Euler equation for the free energy functional $I(z)$ of the melt column

$$I(z) = \int_{x_1}^{x_0} \{\gamma \times [1+\sqrt{1+(z')^2} - \frac{1}{2} \times \rho \times g \times z^2 - p \times z\} dx \;\; z(x_1) = h \,,\; z(x_0) = 0 \quad (2.6)$$

The Euler equation is the first order necessary condition of minimum of the functional (2.6). Namely

$$\frac{d}{dx}\left(\frac{\partial F}{\partial z'}\right) - \left(\frac{\partial F}{\partial z}\right) = 0 \,,\; F(x,z,z') = \{\gamma \times [1+\sqrt{1+(z')^2} + \frac{1}{2} \times \rho \times g \times z^2 - p \times z\} \quad (2.7)$$

As the Young- Laplace equation in hydrostatic approximation (2.5) is a second order differential equation formulation of boundary conditions requires assignment of two boundary conditions; one of the melt crystal interface, the second one on the melt and shaper interface. These conditions are: solution $z = z(x)$ of the Eq. (2.5) satisfy the following boundary conditions:

$z'(x_1) = -\tan(\frac{\pi}{2} - \alpha_g)$, $z'(x_0) - \tan(\alpha_c)$, $z(x_0) = 0$ and

$z(x) is\ strictly\ decreasing\ on\ [x_1, x_0]$ (2.8)

Where α_g is the growth angle, α_c is the contact angle between the meniscus free surface and the edge of the shaper top .

3. Stability or instability of a convex meniscus. A meniscus is convex if $z''(x) > 0 \ for \ \ x_1 \leq x \leq x_0$

Remark first that in case of a convex meniscus the function $z'(x)$ is increasing. This means that the angle between the tangent line to meniscus in every point , and the OX axis $\alpha(x) = -arctanz'(x)$ is decreasing. In particular, it follows that $\alpha(x_1) > \alpha(x_0)$.Since $\alpha(x_1) = \frac{\pi}{2} - \alpha_g$ and $\alpha(x_0) = \alpha_c$ we obtain inequality $\frac{\pi}{2} - \alpha_g > \alpha_c$ >0.(see Fig.2.)

It should be noted that, the convex meniscus stability (the static one) should be distinguished from the dynamic stability of the crystallization process .For statically stable convex meniscus, not only indispensable (necessary) first order but also second order sufficient conditions of functional (2.6) should be satisfied. These second order sufficient conditions for the minimum of functional (2.6) are the Legendre condition and the Jacobi condition [5].

The Legendre condition is

$$\frac{\partial^2 F}{\partial z\prime \partial z\prime} > 0 \qquad (3.1)$$

Computing $\frac{\partial^2 F}{\partial z\prime \partial z\prime}$ we find $\frac{\partial^2 F}{\partial z\prime \partial z} = \frac{\gamma}{(1+(z\prime)^2)^{\frac{3}{2}}} > 0$ .Therefore the Legendre condition is satisfied.

The Jacoby condition concern the so-called Jacoby equation:

$$\left[\frac{\partial^2 F}{\partial z \partial z} - \frac{d}{dx}\left(\frac{\partial^2 F}{\partial z \partial z'}\right)\right] \times \eta - \frac{d}{dx}\left[\frac{\partial^2 F}{\partial z' \partial z'} \times \eta'\right] = 0 \qquad (3.2)$$

for which a Sturm type upper bound has to be find.[5]

In case of the functional (2.6) equation (3.2) become:

$$\frac{d}{dx}\left[\frac{\gamma}{(1+(z\prime)^2)^{\frac{3}{2}}} \times \eta'\right] - g \times \rho \times \eta = 0 \qquad (3.3)$$

Remark that for the coefficients of (3.3) the following inequalities hold:

$$\frac{\gamma}{(1+(z\prime)^2)^{\frac{3}{2}}} > \gamma \times (sin\alpha_g)^3 \quad \text{and} \quad -g \times \rho < 0 \qquad (3.4)$$

Hence

$$(\eta' \times \gamma \times (sin\alpha_g)^3)' = 0 \quad \text{or} \quad \eta'' = 0 \qquad (3.5)$$

is a Sturm –type upper bound for (3.3)

Since every non zero solution of the equation $\eta'' = 0$ vanishes at most once on the interval $x_1 \leq x \leq x_0$ the solution $\eta(x)$ of the initial value problem

$$\frac{d}{dx}\left[\frac{\gamma}{(1+(z')^2)^{\frac{3}{2}}} \times \eta'\right] - g \times \rho \times \eta = 0 \qquad \eta(x_1) = 0\,, \quad \eta'(x_1) = 1 \qquad (3.6)$$

has only one zero on the interval $x_1 \leq x \leq x_0$. Hence the stability condition of Jacobi is verified.

This result can be surprising and create the impression that a convex meniscus is stable. In fact, the result is that if a convex meniscus exist, then it is stable. For this reason in the following, we will establish necessary conditions for the existence of convex meniscus (see Fig.1.2.).

Starting from equations (2.3) and (2.5) it is easy to see that in hydrostatic approximation the pressure difference p verify equalities:

$$p = -p_g - \rho \times g \times H = \gamma \times \alpha' \times cos \propto + \rho \times g \times z \qquad (3.7)$$

Using $p = \gamma \times \alpha' \times cos \propto + \rho \times g \times z$,the boundary conditions $\alpha(x_1) = \frac{\pi}{2} - \alpha_g$, $\alpha(x_0) = \alpha_c$,with the Lagrange mean value theorem we obtain that there exists x' in the interval $[x_1, x_2]$

such that

$$p = -\gamma \times \frac{\frac{\pi}{2} - (\alpha_c + \alpha_g)}{x_0 - x_1} \times cos\alpha(x') + \rho \times g \times z(x') \qquad (3.8)$$

Since $\alpha(x)$ is strictly decreasing on the interval $[x_1, x_2]$ the following inequalities hold:

$$\alpha_c \leq \alpha(x') \leq \frac{\pi}{2} - \alpha_g \qquad (3.9)$$

$$\sin(\alpha_g) \leq \cos(\alpha(x')) \leq \cos(\alpha_c) \qquad (3.10)$$

$$-\rho \times g \times h \leq \rho \times g \times z(x') \leq \rho \times g \times h \qquad (3.11)$$

Using equality (3.8) and inequalities (3.9)-(3.11) in hydrostatic approximation, in case of the existence of s convex static meniscus, for the pressure difference $p = -p_g - \rho \times g \times H$ the following inequalities hold:

$$-\gamma \times \frac{\frac{\pi}{2} - (\alpha_c + \alpha_g)}{x_0 - x_1} \times \cos(\alpha_c) - \rho \times g \times h \leq -p_g - \rho \times g \times H \leq -\gamma \times \frac{\frac{\pi}{2} - (\alpha_c + \alpha_g)}{x_0 - x_1} \times \sin(\alpha_g) + \rho \times g \times h \qquad (3.12)$$

Therefore in case of convex meniscus the values of the pressure difference $p = -p_g - \rho \times g \times H$ has to be researched in the interval $[L_{left}, L_{right}]$ where :

$$L_{left} = -\gamma \times \frac{\frac{\pi}{2}-(\alpha_c+\alpha_g)}{x_0-x_1} \times \cos(\alpha_c) - \rho \times g \times h \quad \text{and} \quad L_{right} = -\gamma \times \frac{\frac{\pi}{2}-(\alpha_c+\alpha_g)}{x_0-x_1} \times \sin(\alpha_g) + \rho \times g \times h \quad (3.13)$$

For

$$p < -\gamma \times \frac{\frac{\pi}{2}-(\alpha_c+\alpha_g)}{x_0-x_1} \times \cos(\alpha_c) - \rho \times g \times h \quad \text{and for} \quad p > -\gamma \times \frac{\frac{\pi}{2}-(\alpha_c+\alpha_g)}{x_0-x_1} \times \sin(\alpha_g) + \rho \times g \times h \quad (3.14)$$

convex meniscus like in Fig.1.2 does not exit. These regions of the pressure difference are regions of static instability .A meniscus obtained with p in this region collapse. For p satisfying one of the inequalities (3.14) it is impossible to create experimentally a convex meniscus like in Fig.1.2

Retain that the pressure difference $p = -p_g - \rho \times g \times H$ can be controlled by the gas pressure p_g and the parameter H.

In the following we will illustrate first the existence of convex static meniscus in case of Ge assuming that $h = 0.00019[m]$, $x_1 = 0.0001[m], x_0 = 0.0002[m]$

In case of Ge $L_{left} = -2302.11249$[Pa] and $L_{right} = -686.52187[Pa]$ and a convex meniscus is obtained for $p = -1525[Pa]$ .This meniscus is obtained by integrating the initial value problem :

$$z'(x) = -\tan(\alpha(x)) \;\; \alpha'(x) = \frac{p-\rho\times g\times x}{\gamma} \times \frac{1}{\cos(\alpha(x))} \;; \quad z(x_1) = h = 0.00019 \; and \; \alpha(x_1) = 1.361796327. \quad (3.15)$$

The numerical values of ρ, g, γ are:, $\rho = 5600[\frac{kg}{m^3}]$, $g = 9.82[\frac{m}{s^2}]$, $\gamma = 0.620\ [\frac{N}{m}]$, $\alpha(x_1) = \frac{\pi}{2} - \alpha_g = \frac{\pi}{2} - 0.209 = 1.361796327$[rad],

$\alpha_g = 0.209[rad] is\ the\ growth\ angle\ in\ case\ of\ Ge\ growth$.The pressure $p = -1525[Pa]$ was found by trial solving (3.15) for different values of p in the range $[-2302, -686][Pa\}$

The obtained results concerning the meniscus shap $z(x)$ and the variation of $\alpha(x)$ are presented in the next figures:

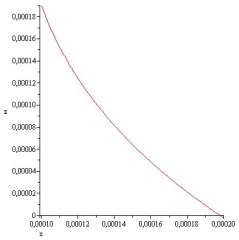


Fig.3.1.Ge convex meniscus shape for $p = -1525[Pa]$

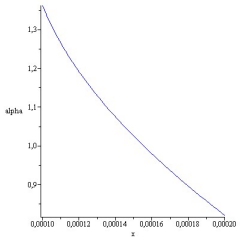


Fig. 3.2. $\alpha\ vrsuse\ x$

Fig. 3.2. $\alpha\ vrsuse\ x$

For $x = 0.00020000000000000$ we have $\alpha(x) = 0.82070727652608210$ and $z(x) = -0.000002148369277296419$:

According to the above results concerning stability of the static meniscus that of obtained here numerically is stable. Can be realized experimentally!

We continue analyzing what happens numerically if $p < -2302.11249[Pa]$ or $> -686.521879[Pa]$.

First we solve (3.15) for $p = -10000[Pa]$ .The obtained result is presented on Fig.3.3 and Fig 3.4

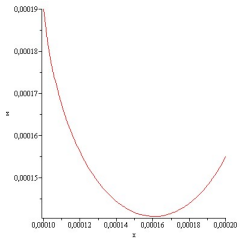


Fig.3.3.Ge meniscus shape for $p = -10000[Pa]$

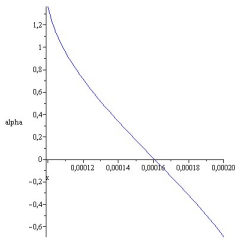


Fig.3.4.α *versus* x *in case of* Ge meniscus

This computation shows that for $p = -10000[Pa]$ the meniscus shape is not convex. The purpose to create a convex meniscus, as in Fig.2 is not realizable experimentally!

Now we solve (3.15) for $p = 100[Pa]$ .The obtained result is presented on Fig.3.5 and Fig 3.6

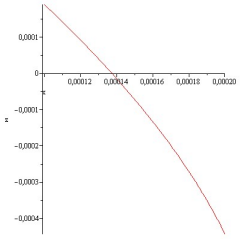


Fig.3.5.Ge meniscus shape for $p = 100[Pa]$

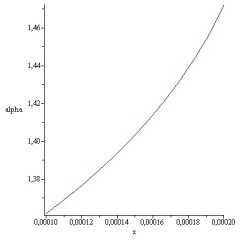


Fig.3.6.α *versus* x *in case of* Ge meniscus

This computation shows that for $p = 100[Pa]$ the meniscus shape is not convex. The purpose to create a convex meniscus, as in Fig.1.2 is not realizable experimentally!

Remember that in hydrostatic approximation $p = -p_g - \rho \times g \times H$ .This relation can be used for the control of p via p_g and H.

For example if $p = -1525[Pa]$ then $-1525[Pa] = -p_g - \rho \times g \times H$ and for a given gas pressure p_g we can find, namely $H = \frac{1525 - p_g}{\rho \times g}$.For instance if $p_g = 200[Pa]$ we have $H = \frac{1325}{\rho \times g}$=

0.02411897481[m].This means that the crucible melt level is under the shaper top level with 0.02411897481[m].

If $p = -10000[Pa]$ and $p_g = 200[Pa]$ then $H = \frac{10000 \quad g}{\rho \times g} = \frac{9980}{\rho \times g} = 0.1816659385[m]$ .This means that the crucible melt level is under the shaper top level with 0.1816659385 [m].

If $p = 100[Pa]$ and $p_g = 200[Pa]$ then $H = \frac{100 - p_g}{\rho \times g} = \frac{-100}{\rho \times g} = -0.00182029998[m]$ .This means that the shaper top level is under the crucible melt level with $0.00182029998[m]$.

4. Stability or instability of concave meniscus. A meniscus is concave if $z''(x) < 0 \ for \ \ x_1 \leq x \leq x_0$

Remark that in case of a concave meniscus the function $z'(x)$ is decreasing. Therefore, the angle between the tangent line to meniscus in every point, and the OX axis $\alpha(x) = -arctanz'(x)$ is increasing. In particular, it follows that $\alpha(x_1) < \alpha(x_0)$. Since $\alpha(x_1) = \frac{\pi}{2} - \alpha_g$ and $\alpha(x_0) = \alpha_c$ we obtain inequality $0 < \frac{\pi}{2} - \alpha_g < \alpha_c$.(see Fig.3.)

It should be noted that, the concave meniscus stability (the static one) should be distinguished from the dynamic stability of the crystallization process .For statically stable concave meniscus, not only indispensable (necessary) first order but also second order sufficient conditions of functional (2.6) should be satisfied. These second order sufficient conditions for the minimum of functional (2.6) are the Legendre condition and the Jacobi condition [5]. Since the functional is the same as in convex meniscus case the Legendre condition and the Jacobi condition are the same as in the case of convex meniscus i.e.

$$\frac{\partial^2 F}{\partial z' \partial z} = \frac{\gamma}{(1+(z')^2)^{\frac{3}{2}}} > 0 \qquad (4.1)$$

$$\frac{d}{dx}\left[\frac{\gamma}{(1+(z')^2)^{\frac{3}{2}}} \times \eta'\right] - g \times \rho \times \eta = 0 \qquad (4.2)$$

Only the evaluation of coefficients of the equation (4.2) change, and in concave case is given by:

$$\frac{\gamma}{(1+(z')^2)^{\frac{3}{2}}} > \gamma \times (cos\alpha_c)^3 \text{ and } -g \times \rho < 0. \qquad (4.3)$$

Hence

$$(\eta' \times \gamma \times (cos\alpha_c)^3)' = 0 \quad \text{or} \quad \eta'' = 0 \qquad (4.4)$$

is a Sturm –type upper bound for (4.2)

Since every non zero solution of the equation $\eta'' = 0$ vanishes at most once on the interval $x_1 \leq x \leq x_0$ the solution $\eta(x)$ of the initial value problem

$$\frac{d}{dx}\left[\frac{\gamma}{(1+(z\prime)^2)^{\frac{3}{2}}}\times\eta'\right]-g\times\rho\times\eta=0 \qquad \eta(x_1)=0\,,\quad \eta'(x_1)=1 \qquad (4.5)$$

has only one zero on the interval $x_1 \leq\ x \leq x_0$. Hence the stability condition of Jacobi is verified.

This result can be surprising and create the impression that a convex meniscus is stable. In fact, the result is that if a concave meniscus exist, then it is stable. For this reason in the following, we will establish necessary conditions for the existence of concave meniscus (see Fig.1.3.)

Starting from equations (2.3) and (2.5) it is easy to see that in hydrostatic approximation the pressure difference p verify equalities:

$$p=-p_g-\rho\times g\times H=\gamma\times\alpha'\times cos\propto+\rho\times g\times z \qquad (4.6)$$

Using $p=\gamma\times\alpha'\times cos\propto+\rho\times g\times z$,the boundary conditions $\alpha(x_1)=\frac{\pi}{2}-\alpha_g$, $\alpha(x_0)=\alpha_c$,with the Lagrange mean value theorem we obtain that there exists x' in the interval $[x_1,x_2]$

such that

$$p=-\gamma\times\frac{\frac{\pi}{2}-(\alpha_c+\alpha_g)}{x_0-x_1}\times cos\alpha(x')+\rho\times g\times z(x') \qquad (4.7)$$

Since $\alpha(x)$ is strictly increasing on the interval $[x_1,x_2]$ the following inequalities hold:

$$\frac{\pi}{2}-\alpha_g\leq\alpha(x')\leq\alpha_c \qquad (4.8)$$

$$\cos(\alpha_c)\leq\cos(\alpha(x'))\leq\sin(\alpha_g) \qquad (4.9)$$

$$-\rho\times g\times h\leq\rho\times g\times z(x')\leq\rho\times g\times h \qquad (4.10)$$

Using equality (4.7) and inequalities (4.8)-(4.10) in hydrostatic approximation, in case of the existence of concave static meniscus, for the pressure difference $p=-p_g-\rho\times g\times H$ the following inequalities hold:

$$-\gamma\times\frac{\frac{\pi}{2}-(\alpha_c+\alpha_g)}{x_0-x_1}\times\cos(\alpha_c)-\rho\times g\times h\leq-p_g-\rho\times g\times H\leq-\gamma\times\frac{\frac{\pi}{2}-(\alpha_c+\alpha_g)}{x_0-x_1}\times\sin(\alpha_g)+\rho\times g\times h$$

(4.11)

Therefore in case of concave meniscus the values of the pressure difference $p=-p_g-\rho\times g\times H$ has to be researched in the interval $[L_{left},L_{right}]$ where:

$$L_{left}=-\gamma\times\frac{\frac{\pi}{2}-(\alpha_c+\alpha_g)}{x_0-x_1}\times\cos(\alpha_c)-\rho\times g\times h,\ L_{right}=-\gamma\times\frac{\frac{\pi}{2}-(\alpha_c+\alpha_g)}{x_0-x_1}\times\sin(\alpha_g)+\rho\times g\times h$$

(4.12)

For $p<-\gamma\times\frac{\frac{\pi}{2}-(\alpha_c+\alpha_g)}{x_0-x_1}\times\cos(\alpha_c)-\rho\times g\times h$ and for $p>-\gamma\times\frac{\frac{\pi}{2}-(\alpha_c+\alpha_g)}{x_0-x_1}\times\sin(\alpha_g)+$

$\rho\times g\times h$ (4.13)

concave meniscus like in Fig.1.3 does not exit. These regions of the pressure difference are regions of static instability .A meniscus obtained with p in this region collapse. For p satisfying one of the inequalities (4.13) it is impossible to create experimentally a concave meniscus like in Fig.1.3.

Retain that the pressure difference $p = -p_g - \rho \times g \times H$ can be controlled by the gas pressure p_g and the parameter H.

In the following we will illustrate first, the existence of concave static meniscus in case of Ge assuming that $h = 0.00019[m]$, $x_1 = 0.0001[m], x_0 = 0.0002[m]$ and $\alpha_c = 1.4[rad]$.This value of α_c can be realized by choosing an appropriate material for shaper.

In case of Germanium $L_{left} = 29.821049[Pa]$ and $L_{right} = 59.582547\ [Pa]$ .It turns that integrating the initial value problem :

$z'(x) = -\tan(\alpha(x))\ \ \alpha'(x) = \frac{p-\rho\times g\times x}{\gamma} \times \frac{1}{\cos(\alpha(x))}\ ;\quad z(x_1) = h = 0.00019\ and\ \alpha(x_1) = 1.361796327$ (4.14)

for different values of $p \in [$ 29.821049,59.582547] $there\ is\ no\ value\ of\ p\ for\ which\ concave\ meniscus\ exist$. A typical solution of (4.14) for

$p \in [$ 29.821049,59.582547] is represented in the next figures,

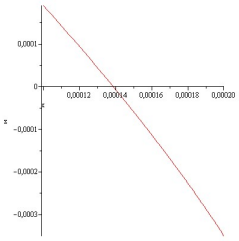


Fig.4.1. $z(x)$ for $p = 59[Pa], h = 0.00019$

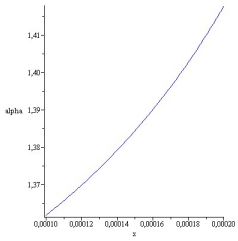


Fig.4.2. $\alpha(x)$ for $p = 59[Pa], h = 0.00019$

The computed figures show that none of the conditions $z(x_0)$=0[m], $\alpha(x_0) = 1.4[Pa]$ is fulfilled. Therefore for $p \in [$ 29.821049,59.582547][Pa] with the prior giving data a concave meniscus like on Fig.1.3. can not be created.Since for $p < 29.821049$ and $p > 59.582547$ concave meniscus like in Fig.1.3.does not exist (see (4.13) it follows that for the above prior given data concave meniscus can not be created experimentally.

In the same time Fig.4.1.and Fig.4.2. suggest that increasing the level of the crystallization front h creation of a concave meniscus like in Fig.1.3. wood be possible.In order to verify the true

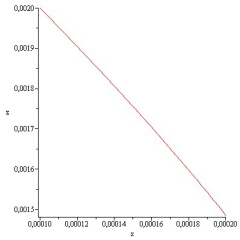
value of this impression we assume that $h = 2 \times 10^{-3}[m]$ and we compute the corresponding range $[L_{left}, L_{right}]$ We find

$[L_{left}, L_{right}]$ =[-69.613111,159.016207][Pa].This range is larger than that obtained for $h = 0.00019[m]$. Integrating the initial value problem :

$z'(x) = -\tan(\alpha(x))$, $\alpha'(x) = \frac{p-\rho \times g \times x}{\gamma} \times \frac{1}{\cos(\alpha(x))}$; $z(x_1) = h = 2 \times 10^{-3}[m]$ and $\alpha(x_1) = 1.361796327[rad]$ (4.15)

for $p \in$[-69.613111,159.016207]Pa] the following result is found:there exist a concave meniscus for $p = 141[Pa]$.

The meniscus $z(x)$ and the angle $\alpha(x)$ are represented in the next figures:



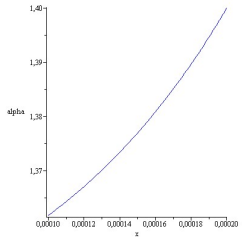
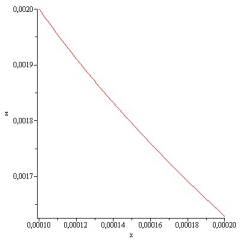


Fig.4.3 $z(x)$ for $p = 141[Pa], h = 2 \times 10^{-3}[m]$ Fig.4.4. $\alpha(x)$ for , $h = 2 \times 10^{-3}[m]$

This meniscus exist, it is stable and can be created experimentally.

For $p < -69.613111$[Pa] and $p > 159.016207$[Pa] concave static menisc does not exit.Therefore can not be created experimentally.

A meniscus $z(x)$ and $\alpha(x)$ obtained for $p = -71[Pa]$ are presented in the next figures:



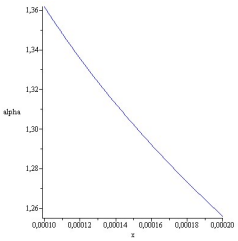


Fig.4.5.$z(x)$ for $p = -71[Pa], h = 2 \times 10^{-3}[m]$ Fig.4.6. $\alpha(x)$ for , $h = 2 \times 10^{-3}[m]$

A meniscus shape $z(x)$ and $\alpha(x)$ obtained for $p = 161[Pa]$ and $h = 2 \times 10^{-3}[m]$are represented in the next figures:

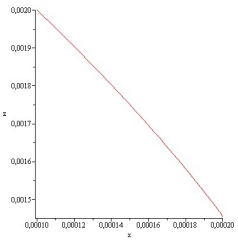


Fig.4.7 $z(x)$ for $p = 161[Pa], h = 2 \times 10^{-3}[m]$

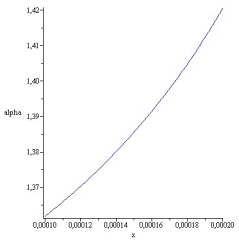


Fig.4.8. $\alpha(x)$ for , $h = 2 \times 10^{-3}[m]$

Note that experimentally the increase of the crystallization front h from $h = 0.00019[m]$ to $h = 2 \times 10^{-3}[m]$ imply modification of the thermal field.

Remember that in hydrostatic approximation $p = -p_g - \rho \times g \times H$ .This relation can be used for the control of p via p_g and H.

For example if $p = 141[Pa]$ then $141[Pa] = -p_g - \rho \times g \times H$ and for a given gas pressure p_g we can find H, namely $H = \frac{141 - p_g}{\rho \times g}$.For instance if $p_g = 100[Pa]$ we have $H = \frac{41}{\rho \times g}$= 0.0007463229940[m].This means that the crucible melt level is under the shaper top level with 0.0007463229940[m].

If $p = -71[Pa]$ and $p_g = 200[Pa]$ then $H = \frac{-271}{\rho \times g} = -0.00493301295[m]$

This means that the shaper top level is under the crucible melt level with -0.00493301295[m].

If $p = 161[Pa]$ and $p_g = 200[Pa]$ then $H = \frac{161-2}{\rho \times g} = \frac{-3}{\rho \times g} = -0.000709916994[m]$ .This means that the shaper top level is under the crucible melt level with -0.000709916994[m].

5.Results. Necessary conditions for the existence and sufficient conditions for the stability or instability of the static meniscus (liquid bridge) appearing in the ribbon single crystal growth from the melt, of predetermined sizes, by using the edge-defined-film- fed (EFG) growth method, are presented. Theoretical results are illustrated numerically in case of Germanium ribbon growth.

6. Comments and Conclusions. The main novelty in this article consists in the obtained inequalities. These represent limits for what can and cannot be achieved. Experimentally, only stable static liquid bridges can be created if they exist theoretically. Unstable static liquid bridges could exist just in theory; in reality, they collapse; therefore, they are not appropriate for crystal growth.

Authors contribution. The authors contributed equally to the realization of this work. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: The original contributions presented in the study are included in the article; further inquiries can be directed to the corresponding author**.**

Conflicts of Interest: The authors declare no conflicts of interest.

References

[1] Springer Handbook of Crystal Growth; ISBN:978-3-540-74761-1; DOI 10.1007/978-3-570-74761-1;2010.

[2] Cojocaru, A.V.; Balint, S. Stability or Instability of a Static Liquid Bridge Appearing in Shaped Crystal Growth from Melt via the Pulling-Down Method. Fluids **2024**, 9,176.https://doi.org/10.3390/

[3] R. Finn, Equilibrium Capillary Surfaces, vol. 284 of Grundlehren der Mathematischen Wissenschaften, Springer, New York, NY, USA, 1986.

[4] V. A. Tatarchenko Shaped Crystal Growth, Kluwer Academic Publishers, Dordrecht, The Netherlands, 1993.

[5] P.Hartman, Ordinary Differential Equations, John Wiley & Sons, New York, NY, USA, 1964.

[6] S.Balint,A.M.Balint,R Szabo; Nonlinear boundary value problem for concave capillary surfaces occurring in single crystal ribbon growth from the melt, Nonlinear Studies Nonlinear Studies Vol. 17, No. 1, pp. 65-76, 2010

[7]. S. Balint and A. M. Balint. Nonlinear Boundary Value Problem for Concave Capillary Surfaces Occurring in Single Crystal Rod Growth from the Melt. Hindawi Publishing Corporation, Volume 200

8, Article ID 310924, 13 pages doi:10.1155/2008/310924

r-Supplemented Lattices

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Abstract

In this work, every lattice is a complete modular lattice. Let L be a lattice and $a\in L$. If $x=1$ for every $x\in L$ such that $a\vee x=1$, then a is called a small (or superfluous) element of L and denoted by $a\ll L$. The meet of all maximal ($\neq 1$) elements of L is called the radical of L and denoted by $r(L)$. If L have no maximal ($\neq 1$) elements, then we call $r(L)=1$. If $a\ll L$ for $a\in L$, then $a\leq r(L)$. Let L be a lattice and $a,b\in L$. a is said to be a supplement of b in L if a is minimal for $1=b\vee a$. a is a supplement of b in a lattice L if and only if $1=b\vee a$ and $b\wedge a\ll a/0$. A lattice L is called a supplemented lattice if every element of L has a supplement in L. Let L be a lattice, $a\in L$ and $a\leq r(L)$. If $a\ll r(L)/0$, then a is called an r-small or (r-superfluous) element of L and denoted by $a\ll_r L$. Let L be a lattice and $a,b\in L$. If $a\vee b=1$ and $a\wedge b\ll_r b/0$, then b is called an r-supplement of a in L. If every element of L has an r-supplement in L, then L is called an r-supplemented lattice.

Keywords: Lattice, Radical, r-Small Element, Supplemented Lattice

1. INTRODUCTION

In this paper, all lattices are complete modular lattices with the greatest element 1 and the smallest element 0. Let L be a lattice and $a,b\in L$ with $a\leq b$. A *quotient sublattice* is defined by $\{x\in L \mid a\leq x\leq b\}$ and denoted by b/a. Let L be a lattice and $a,b\in L$. a is called a *complement* of b in L and denoted by $1=a\oplus b$ if $a\vee b=1$ and $a\wedge b=0$ (here we also call that a and b are *direct summands* of L). If every element of L has a complement in L, then L is called a *complemented* lattice. Let L be a lattice and $a\in L$. If every subset X of L with $a\leq\vee X$ there exists a finite subset F of X such that $c\leq\vee F$, then a is called a *compact* element of L. L is called a *compact* lattice if 1 is compact in L. L is called a *compactly generated* lattice if every element of L is a join of compact elements in L. Let L be a lattice and $a\in L$. If $b=1$

for every $b\in L$ with $a\vee b=1$, then a is called a *small* or (*superfluous*) element of L and denoted by $a\ll L$. The meet of all maximal ($\neq 1$) elements of a lattice L is called the *radical* of L and denoted by $r(L)$. If L have no maximal ($\neq 1$) elements, then the radical of L is defined by $r(L)=1$. Let L be a lattice and $a,b\in L$. a is said to be a *supplement* of b in L if a is minimal for $1=b\vee a$. a is a supplement of b in a lattice L if and only if $1=b\vee a$ and $b\wedge a\ll a/0$. A lattice L is called a *supplemented* lattice if every element of L has a supplement in L. L is called a *hollow* lattice if every element with distinct from 1 is small in L, and L is called a *local* lattice if L has the greatest element ($\neq 1$). We say that an element a of a lattice L has *ample supplements* in L if for every $b\in L$ with $a\vee b=1$, a has a supplement x in L with $x\leq b$. L is called an *amply supplemented* lattice if every element of L has ample supplements in L. We say that an element y of a lattice L lies above an element x in L if $x\leq y$ and $y\ll 1/x$. Let L be a lattice and $a,b\in L$. If $a\vee b=1$ and $a\wedge b\leq r(b/0)$, then b is called a *generalized* (*radical*) *supplement* (briefly, *Rad-supplement*) of a in L. If every element of L has a Rad-supplement in L, then L is called a *generalized* (*radical*) *supplemented* (briefly, *Rad-supplemented*) lattice. Let L be a lattice, $a\in L$ and $a\leq r(L)$. If $a\ll r(L)/0$, then a is called an r-small (or *r-superfluous*) element of L and denoted by $a\ll_r L$.

Lemma 1.1. Let L be a lattice. The following statements hold.

(i) Let $a,b,c\in L$ and $c\leq a$. If b is a supplement of a in L and $c\vee b=1$, then b is a supplement of c in L.

(ii) Let $a,b,c\in L$ and $c\ll L$. If b is a supplement of a in L, then b is a supplement of $a\vee c$ in L.

(iii) Let $a,b\in L$. If $a\vee b$ has a supplement in L and $b/0$ is supplemented, then a has a supplement in L.

(iv) Let $a,b\in L$ and $a\vee b=1$. If $a/0$ and $b/0$ are supplemented, then L is also supplemented.

(v) Let $a_1,a_2,\ldots,a_n\in L$ and $a_1\vee a_2\vee\ldots\vee a_n=1$. If $a_i/0$ is supplemented for every $i=1,2,\ldots,n$, then L is also supplemented.

(vi) If L is supplemented, then $1/r(L)$ is complemented.

Proof. See (Călugăreanu, 2000).

2. r-SUPPLEMENTED LATTICES

Definition 2.1. Let L be a lattice and $a,b\in L$. If $a\vee b=1$ and $a\wedge b\ll_r b/0$, then b is called an r-supplement of a in L. If every element of L has an r-supplement in L, then L is called an r-supplemented lattice.

Proposition 2.2. Let L be a lattice, $a\in L$ and $a\ll_r L$. Then $a\ll L$.

Proof. Since $a\ll_r L$, $a\ll r(L)/0$. Then $a\ll L$, as desired.

Proposition 2.3. Let L be a lattice and $a,b\in L$. If b is an r-supplement of a in L, then b is a supplement of a in L.

Proof. Since b is an r-supplement of a in L, $1=a\vee b$ and $a\wedge b\ll_r b/0$. Since $a\wedge b\ll_r b/0$, by Proposition 2.2, $a\wedge b\ll b/0$. Hence b is a supplement of a in L.

Proposition 2.4. Let L be an r-supplemented lattice. Then L is supplemented.

Proof. Let $a\in L$. Since L is r-supplemented, a has an r-supplement b in L. By Proposition 2.3, b is a supplement of a in L. Hence L is r-supplemented.

Proposition 2.5. Let L be a lattice, $a,b,c\in L$ and $c\leq a$. If b is an r-supplement of a in L and $c\vee b=1$, then b is a supplement of c in L.

Proof. Since b is an r-supplement of a in L, by Proposition 2.3, b is a supplement of a in L. Since $c\leq a$ and $c\vee b=1$, by Lemma 1.1, b is a supplement of c in L, as desired.

Proposition 2.6. Let L be a lattice, $a,b,c\in L$ and $c\ll_r L$. If b is a supplement of a in L, then b is a supplement of $a\vee c$ in L.

Proof. Since $c\ll_r L$, by Proposition 2.2, $c\ll L$. Then by Lemma 1.1, b is a supplement of $a\vee c$ in L, as desired.

Proposition 2.7. Let L be a lattice, $a,b,c\in L$ and $c\ll L$. If b is an r-supplement of a in L, then b is a supplement of $a\vee c$ in L.

Proof. Since b is an r-supplement of a in L, by Proposition 2.3, b is a supplement of a in L. Then by Lemma 1.1, b is a supplement of $a\vee c$ in L, as desired.

Proposition 2.8. Let L be a lattice, $a,b,c\in L$ and $c\ll_r L$. If b is an r-supplement of a in L, then b is a supplement of $a\vee c$ in L.

Proof. Since $c\ll_r L$, by Proposition 2.2, $c\ll L$. Since b is an r-supplement of a in L, by Proposition 2.3, b is a supplement of a in L. Then by Lemma 1.1, b is a supplement of $a\vee c$ in L, as desired.

Proposition 2.9. Let L be a lattice and $a,b\in L$. If $a\vee b$ has an r-supplement in L and $b/0$ is supplemented, then a has a supplement in L.

Proof. Since $a\vee b$ has an r-supplement in L, by Proposition 2.3, $a\vee b$ has a supplement in L. Then by Lemma 1.1, a has a supplement in L.

Proposition 2.10. Let L be a lattice and $a,b\in L$. If $a\vee b$ has a supplement in L and $b/0$ is r-supplemented, then a has a supplement in L.

Proof. Since $b/0$ is r-supplemented, by Proposition 2.4, $b/0$ is supplemented. Then by Lemma 1.1, a has a supplement in L.

3. CONCLUSIONS

r-supplemented lattices are the special parts of supplemented lattices.

4. REFERENCES

Alizade R, Toksoy S. E. (2011). Cofinitely supplemented modular lattices. Arabian Journal for Science and Engineering 36, 919-923.

Bayat N, Nebiyev C. (2024). r-small elements in lattices. Presented in 'MAS 19th International European Conference on Mathematics, Engineering, Natural and Medical Sciences', Mingachevir State University, Mingachevir-Azerbaijan.

Biçer Ç, Nebiyev C, Pancar A. (2018). Generalized supplemented lattices. Miskolc Mathematical Notes 19(1), 141-147.

Călugăreanu G. (2000). Lattice concepts of module theory. Kluwer Academic Publisher, Dordrecht, Boston, London.

Clark J, Lomp C, Vanaja N, Wisbauer R. (2006). Lifting modules: supplements and projectivity in module theory. Frontiers in Mathematics, Birkhauser, Basel.

Nebiyev C. (2019). On supplement elements in lattices. Miskolc Mathematical Notes 20(1), 441-449.

Nebiyev C, Ökten H. H. (2022). Some properties of r-small submodules. Erzincan University Journal of Science and Technology 15(3), 996-1001.

Nebiyev C, Pancar A. (2013). On supplement submodules. Ukrainian Mathematical Journal 65(7), 1071-1078.

Nebiyev C, Sökmez N. (2024). Some properties of r-supplemented modules. Miskolc Mathematical Notes 25(2), 933-938.

Wisbauer R. (1991). Foundations of module and ring theory. Gordon and Breach, Philadelphia.

On r-Small Elements in Lattices

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Abstract

In this work, all lattices are complete modular lattices. Let L be a lattice. We denote the smallest element of L by 0 and the greatest element of L by 1. The meet of all maximal ($\neq 1$) elements of L is called the radical of L and denoted by $r(L)$. If L have no maximal ($\neq 1$) elements, then we call $r(L)=1$. Let L be a lattice and $t\in L$. If $k=0$ for every $k\in L$ with $t\wedge k=0$, then t is called an essential element of L and denoted by $t(L$. The meet of all essential maximal ($\neq 1$) elements of L is called the g-radical of L and denoted by $r_g(L)$. If L have no essential maximal ($\neq 1$) elements, then we call $r_g(L)=1$. Here $r(L)\leq r_g(L)$. Let L be a lattice and $a\in L$. If $x=1$ for every $x\in L$ such that $a\vee x=1$, then a is called a small (or superfluous) element of L and denoted by $a\ll L$. If $a\ll L$, then $a\leq r(L)\leq r_g(L)$. Let L be a lattice, $a\in L$ and $a\leq r(L)$. If $a\ll r(L)/0$, then a is called an r-small (or r-superfluous) element of L and denoted by $a\ll_r L$. If $a\ll_r L$, then $a\ll r_g(L)/0$.

Keywords: Essential Element, Superfluous Element, g-Radical, Supplemented Lattice

1. INTRODUCTION

In this paper, every lattice is a complete modular lattice with the greatest element 1 and the smallest element 0. Let L be a lattice and $a,b\in L$ with $a\leq b$. A sublattice $\{x\in L \mid a\leq x\leq b\}$ is called a *quotient sublattice* and denoted by b/a. Let L be a lattice and $a,b\in L$. If $a\vee b=1$ and $a\wedge b=0$, then a is called a *complement* of b in L and denoted by $1=a\oplus b$ (here we also call a and b are *direct summands* of L). L is said to be *complemented* if each element of L has a complement in L. Let L be a lattice and $a\in L$. a is called a *compact*

element of L if every subset X of L with $a\leq\vee X$ there exists a finite subset F of X such that $c\leq\vee F$. L is called a *compact* lattice if 1 is compact in L. L is called a *compactly generated* lattice if every element of L is a join of compact elements in L. Let L be a lattice and $a\in L$. a is called a *small* (or *superfluous*) element of L and denoted by $a\ll L$ if $b=1$ for every $b\in L$ with $a\vee b=1$. The meet of all maximal ($\neq 1$) elements of a lattice L is called the *radical* of L and denoted by $r(L)$. If L have no maximal ($\neq 1$) elements, then the radical of L is defined by $r(L)=1$. Let L be a lattice and $a,b\in L$. If a is minimal for $1=b\vee a$, then a is called a *supplement* of b in L. a is a supplement of b in a lattice L if and only if $1=b\vee a$ and $b\wedge a\ll a/0$. A lattice L is said to be *supplemented* if every element of L has a supplement in L. L is called a *hollow* lattice if every element with distinct from 1 is superfluous in L, and L is called a *local* lattice if L has the greatest element ($\neq 1$). We say that an element y of a lattice L *lies above* an element x of L if $x\leq y$ and $y\ll 1/x$. Let L be a lattice and $k\in L$. If $t=0$ for every $t\in L$ with $k\wedge t=0$, then k is called an *essential* element of L and denoted by $k(L$. Let L be a lattice and $a\in L$. a is called a *g-small* (or *g-superfluous*) element of L and denoted by $a\ll_g L$ if $t=1$ for every $t(L$ such that $a\vee t=1$. Let L be a lattice and t be a maximal ($\neq 1$) element of L. If $t(L$, then t is called a *g-maximal* element of L. The meet of all g-maximal elements of a lattice L is called the *g-radical* of L and denoted by $r_g(L)$. If L have no g-maximal elements, then we call $r_g(L)=1$. An element b of a lattice L is called a *g-supplement* of a in L if $a\vee b=1$ and $a\vee t=1$ with $t(b/0$ implies that $t=b$. a is a g-supplement of b in a lattice L if and only if $a\vee b=1$ and $a\wedge b\ll_g a/0$. A lattice L is said to be *g-supplemented* if every element of L has a g-supplement in L.

2. r-SMALL ELEMENTS IN LATTICES

Definition 2.1. Let L be a lattice, $a\in L$ and $a\leq r(L)$. If $a\ll r(L)/0$, then a is called an r-small (or r-superfluous) element of L and denoted by $a\ll_r L$. (See also (Bayat and Nebiyev, 2024))

Proposition 2.2. Let L be a lattice, $a\in L$ and $a\ll L$. Then $a\ll_g L$.

Proof. See (Ökten,2021).

Proposition 2.3. Let L be a lattice. Then $r(L)\leq r_g(L)$.

Proof. See (Ökten, 2021) Corollary 6.

Proposition 2.4. Let L be a lattice and $a\in L$. If $a\ll_r L$, then $a\ll r_g(L)/0$.

Proof. Since $a\ll_r L$, by definition, $a\ll r(L)/0$. By Proposition 2.3, $r(L)\leq r_g(L)$. Hence $a\ll r_g(L)/0$, as desired.

Proposition 2.5. Let L be a lattice and $a\in L$. If $a\ll_r L$, then $a\ll_g L$.

Proof. Since $a\ll_r L$, $a\ll L$. Then by Proposition 2.2, $a\ll_g L$, as desired.

Proposition 2.6. Let L be a lattice, $a,b\in L$ and $a\leq b$. If $b\ll_r L$, then $a\ll_g L$.

Proof. Since $b\ll_r L$, by Proposition 2.5, $b\ll_g L$. Since $a\leq b$ and $b\ll_g L$, by (Ökten, 2021) Lemma 1(i), $a\ll_g L$, as desired.

Proposition 2.7. Let L be a lattice, $a,b\in L$ and $a\leq b$. If $a\ll_r b/0$, then $a\ll_g t/0$ for every $t\in L$ with $b\leq t$.

Proof. Since $a\ll_r b/0$, by Proposition 2.5, $a\ll_g b/0$. Then by (Ökten, 2021) Lemma 1(ii), $a\ll_g t/0$ for every $t\in L$ with $b\leq t$.

Proposition 2.8. Let L be a lattice, $a,b,c\in L$ and $a\leq b$. If $a\ll_r b/0$, then $a\vee c\ll_g (b\vee c)/c$.

Proof. Since $a\ll_r b/0$, by Proposition 2.5, $a\ll_g b/0$. Then by (Ökten, 2021) Lemma 1(iii), $a\vee c\ll_g (b\vee c)/c$, as desired.

Proposition 2.9. Let L be a lattice and $a,b\in L$. If $a\ll_r L$, then $a\vee b\ll_g 1/b$.

Proof. Since $a\ll_r L$, by Proposition 2.5, $a\ll_g L$. Then by (Ökten, 2021) Lemma 1(iii), $a\vee b\ll_g 1/b$, as desired.

Proposition 2.10. Let L be a lattice and $a,b,c,d\in L$. If $a\ll_r b/0$ and $c\ll_r d/0$, then $a\vee c\ll_g (b\vee d)/0$.

Proof. Since $a\ll_r b/0$ and $c\ll_r d/0$, by Proposition 2.5, $a\ll_g b/0$ and $c\ll_g d/0$. Then by (Ökten, 2021) Lemma 1(iv), $a\vee c\ll_g (b\vee d)/0$, as desired.

3. CONCLUSIONS

r-small elements are the special parts of g-small elements in lattices.

4. REFERENCES

Alizade R, Toksoy S. E. (2011). Cofinitely supplemented modular lattices. Arabian Journal for Science and Engineering 36, 919-923.

Bayat N, Nebiyev C. (2024). r-small elements in lattices. Presented in 'MAS 19th International European Conference on Mathematics, Engineering, Natural and Medical Sciences', Mingachevir State University, Mingachevir-Azerbaijan.

Călugăreanu G. (2000). Lattice concepts of module theory. Kluwer Academic Publisher, Dordrecht, Boston, London.

Clark J, Lomp C, Vanaja N, Wisbauer R. (2006). Lifting modules: supplements and projectivity in module theory. Frontiers in Mathematics, Birkhauser, Basel.

Koşar B, Nebiyev C, Sökmez N. (2015). g-supplemented modules. Ukrainian Mathematical Journal 67(6), 861-864.

Koşar B, Nebiyev C, Pekin A. (2019). A generalization of g-supplemented modules. Miskolc Mathematical Notes 20(1), 345-352.

Nebiyev C, Ökten H. H. (2022). Some properties of r-small submodules. Erzincan University Journal of Science and Technology 15(3), 996-1001.

Nebiyev C, Ökten H. H. (2022). On amply g-supplemented lattices. Palestine Journal of Mathematics 11(Special Issue II), 37-40.

Nebiyev C, Sökmez N. (2024). Some properties of r-supplemented modules. Miskolc Mathematical Notes 25(2), 933-938.

Ökten H. H. (2021). g-supplemented lattices. Miskolc Mathematical Notes 22(1), 435-441.

Wisbauer R. (1991). Foundations of module and ring theory. Gordon and Breach, Philadelphia.

Comparative Analysis of Selected Facial Emotion Recognition Methods as Potential Tool for Emotional Disorders Automated Assessment in Terms of Remote Work Application

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Abstract

In recent years, the growing prevalence of mental health issues and emotional disorders—partly associated with remote work and social isolation—has led to increased interest in Facial Emotion Recognition (FER) methods as tools for the early detection of affective disturbances. Assessing the effectiveness of these methods may support the development of solutions aimed at identifying reduced psychological well-being among employees, allowing for timely intervention and professional support.

This publication provides a review of the most frequently used FER techniques based on visible-spectrum imaging systems. The selected methods were implemented and empirically compared using the publicly available FER-2013 dataset. The analysis emphasizes key performance parameters and metrological aspects, with particular attention to their potential applications in psychological, medical, and research settings. Laboratory tests allowed for the identification of practical strengths and limitations of each method, offering a basis for considering their integration into mental health assessment tools and suggesting directions for future research.

Keywords: affective processing, machine vision, emotion recognition, image processing

Introduction

We live in an era where technological advancement often outpaces our adaptive capacities, and automation is permeating increasingly intimate aspects of human experience — including emotions. More and more frequently, we are asking not only whether it is possible, but whether it is appropriate to technologically measure something as elusive as human emotional states. When emotions become data and facial expressions are reduced to clusters of pixels analyzed by algorithms, a deeper reflection on the boundaries of technological intervention in psychological well-being becomes essential. One of the most recent and rapidly evolving areas within this domain is Facial Emotion Recognition, which combines elements of computer science, psychology, and artificial intelligence. FER has applications in medicine, education, and the workplace — especially in contexts where direct human contact is limited, as is often the case in remote work models. In such settings, technology begins to act as an intermediary — not only

recording, but also potentially interpreting emotional states. The use of FER as a tool to support the assessment of remote employees' psychological well-being seems particularly relevant in light of increasing reports about the emotional consequences of professional isolation. The key question, however, is not only whether FER works, but how it works — and whether it works well enough to be trusted in the sensitive area of mental health.

The aim of this article is to compare selected FER methods — both classical approaches based on handcrafted feature extraction and modern deep learning techniques — in terms of their potential usefulness for monitoring emotions in remote work environments. For this purpose, selected models were analyzed using the publicly available FER-2013 dataset, which serves as a standard benchmark in emotion recognition research. This study seeks not only to evaluate the effectiveness of specific technological approaches but also to reflect on their potential applications in psychological and organizational practice. By comparing the performance of classical and deep learning-based FER methods, we examine not only their classification accuracy but also their robustness to noise, implementation feasibility, operational transparency, and ethical implications. The following sections present a theoretical overview of psychological well-being in the context of remote work, a detailed review of FER methods, a description of the materials and methodology, results of the comparative analysis, and a critical discussion of the opportunities and limitations of using such tools to assess employees' emotional functioning. Special attention is given to the ethical dimensions of emotional automation — including concerns related to privacy, surveillance, and cultural diversity.

Psychological Well-Being in the Context of Remote Work

In recent years, there has been a sharp increase in interest in the mental health of employees, largely driven by the widespread adoption of remote work and the accompanying social isolation. The COVID-19 pandemic led to a mass transition to remote work, which, although initially perceived as a temporary solution, has taken on a long-term character in many organizations. However, numerous studies indicate that this mode of work can significantly affect individual psychological well-being. A study conducted among healthcare workers found that feelings of loneliness and professional isolation correlate with decreased mental well-being, even in the presence of social support (O'Hare, 2024: 4). Similarly, Brown and Leite emphasized that the lack of daily interactions in the professional environment exacerbates stress levels and decreases employee engagement (Brown & Leite, 2023: 144). Becker et al. demonstrated that a key risk factor for the psychological well-being of remote workers is low control over tasks, which contributes to a sense of loneliness (Becker et al., 2022: 453). In light of these challenges, there is a growing need to implement technological tools that support the early detection of symptoms related to declining mental well-being and enable timely preventive and intervention measures.

In order to understand the concept of well-being, it is essential to recognize that it is a psychological construct rooted in the tradition of positive psychology, which developed at the turn of the 20th and 21st centuries. Its theoretical grounding in this perspective implies that it is not limited to the absence of suffering or neutral functioning, but rather encompasses a qualitative dimension of life experience— centered on meaning, engagement, interpersonal relationships, and opportunities for growth. In contrast to the notion of happiness, which is often associated with hedonistic

pleasure and a transient emotional state, psychological well-being refers to a relatively stable and multidimensional form of human functioning that integrates both emotional and existential components (Baes, Speagle & Haslam, 2022: 1–2). The psychological literature offers numerous models describing well-being, highlighting its complexity and multidimensional nature. One of the most significant and influential frameworks is the PERMA model, developed by Martin Seligman, the founder of positive psychology. This model identifies five core components of well-being: Positive emotions, Engagement, Relationships, Meaning, and Accomplishment. Each of these elements can independently affect an individual's quality of life, and the development of each contributes to sustained well-being (Seligman, 2011: 47–49). Another notable approach is Carol Ryff's six-dimensional model, which adopts a more eudaimonic perspective on psychological well-being. According to Ryff, well-being is grounded in aspects such as autonomy, self-acceptance, personal growth, purpose in life, environmental mastery, and positive relations with others. This model integrates psychological maturity, life meaning, and relational quality as essential pillars of mental health (Ryff, 1989: 1072–1075). In the Polish context, a particularly compelling concept is Janusz Czapiński's *onion theory of happiness,* which—despite its reference to *happiness*—in essence, describes well-being. Czapiński distinguishes three layers: a deep (core) layer based on the biological will to live, a middle layer involving emotional reactions to everyday experiences, and an outer layer comprising evaluations of satisfaction with various life domains (Czapiński, 2004: 19–22). Each of these models offers a unique perspective on the understanding of well-being, allowing for recognition of its diverse sources and underlying mechanisms.

An increasing body of research confirms that the well-being of remote workers constitutes a significant challenge in the modern world of work. By utilizing reliable diagnostic tools, such as the PERMA Profiler and Carol Ryff's model of psychological well-being, researchers are increasingly identifying decreased levels of well-being among individuals working outside traditional office environments. A study conducted among lecturers at private universities revealed a marked decline in the quality of interpersonal relationships, sense of meaning, and autonomy in those operating exclusively online (Leong, 2022: 19). Similar conclusions were drawn in a study of employees from various industries, where a comparative analysis of the pre-pandemic and pandemic periods revealed declines in PERMA components such as positive emotions, relationships, and accomplishments (Pataki-Bittó & Kun, 2022: 331). These findings were further confirmed in research on teachers working remotely, who reported lower well-being scores as measured by the PERMA Profiler, particularly in the relational and social domains (Berry, 2023: 70). Importantly, this issue is also present in both technological and industrial sectors. For instance, remote workers in the Finnish IT sector reported a decrease in engagement and sense of meaning (Lampinen, 2024: 39), while in South African mining operations, significant deficiencies in relationships and positive emotions were identified (Kau & Flotman, 2025: 9). Even in more specific contexts such as the architecture sector, women working remotely reported lower levels of accomplishment and social connection, both key components of the PERMA model (Rodríguez-Leudo & Navarro-Astor, 2024: 7). Similar patterns were observed in multinational corporate environments, where women experienced a diminished sense of belonging while working remotely (Nozari & Seyedsalehi, 2024: 23).

Studies on well-being also include managerial staff, indicating a strong correlation between the mode of work and the quality of psychological functioning. The

highest levels of well-being were observed among individuals working in a hybrid model, and the lowest among those working fully remotely. Particularly adverse outcomes were noted among remote leaders in the non-profit sector (Zimnoch, 2024: 53–59), which may be attributed to the combination of factors such as limited organizational support, high responsibility with scarce resources, and difficulties in maintaining social relationships. Given that work modality impacts well-being even at the managerial level, its influence on lower-level employees—with less autonomy and control over working conditions—may be even more profound. The breadth of industries examined, the consistency of findings, and the use of standardized research tools all support the conclusion that diminished well-being among remote workers is not an isolated phenomenon but a serious systemic issue.

With the growing prevalence of remote work, the importance of supporting employee well-being—including for those without daily contact with colleagues or supervisors—has become increasingly evident. Since monitoring well-being in such conditions can be challenging, there is a growing interest in new tools that can accurately and rapidly detect early signs of psychological decline—particularly in the context of preventing burnout, reduced engagement, or emotional disturbances. One increasingly popular direction involves the use of emotion recognition technologies, including Facial Emotion Recognition, as a potential means of assessing the psychological well-being of remote workers.

Automatic Emotion Recognition (AER) technologies, particularly those based on FER, are gaining traction in psychological contexts, especially in the fields of mental health and patient care. As demonstrated in a systematic review of studies from 2013 to 2023, real-time emotion recognition can significantly enhance diagnostic processes, emotional state monitoring, and therapeutic interventions—both in clinical and home-based environments (Guo et al., 2024: 5–6). Particularly promising are multimodal approaches—combining facial analysis, speech, and physiological signals—which move beyond subjective self-report methods toward more objective and dynamic measurement tools (Guo et al., 2024: 2–4). In a similar vein, systems employing deep learning to analyze facial expressions during remote psychological consultations are being developed to support therapists in making more accurate clinical decisions, thanks to access to real-time emotional feedback (Hadjar & Hemmje, 2025: 2–3). In the context of work and organizational psychology, however, the application of FER also raises important ethical concerns, prompting reflection on the boundaries of emotional surveillance in the workplace and the need to safeguard employees' rights (Hajric et al., 2024: 3–4).

Facial Emotion Recognition: From Classical Approaches to Deep Learning

Facial Emotion Recognition has been at the center of scientific attention since the 1970s, bringing together researchers in nonverbal communication, psychology, and artificial intelligence. As technology evolved, so too did the methods used to identify emotions — shifting from classical image analysis techniques based on manually defined rules and handcrafted features (Aslam & Hussian, 2021: 2–5) to modern deep learning approaches capable of autonomously learning emotional patterns from large datasets (Rajan, Chenniappan, & Devaraj, 2020: 1373-1374). This transition has not only improved recognition accuracy but has also opened new possibilities in areas such as remote

psychological support, education, healthcare, and well-being monitoring (Hans & Rao, 2021: 11–12). The earliest attempts to automate emotion recognition relied on manual feature extraction, where experts selected facial elements considered relevant to emotion expression (Wegrzyn, Vogt, Kireclioglu, & Schneider, 2017: 5). Two dominant strategies emerged: the geometric approach, which analyzed the positions of key facial landmarks (e.g., the distance between eyebrows), and the appearance-based approach, which focused on textures, gradients, and local patterns (Kas, Ruichek, & Messoussi, 2021: 10).

One of the most well-known systems was the Facial Action Coding System (FACS) developed by Ekman, which decomposed facial expressions into Action Units (AUs), each corresponding to specific muscle movements. While FACS proved accurate and useful in psychological research, it required significant resources — including time, training, and resilience to individual and environmental variability (Kas, Ruichek, & Messoussi, 2021: 11). Several classical FER methods also had technical implementations. Haar-like features, introduced by Viola and Jones, analyzed brightness differences between regions of the image in real time (Viola, 2001: 512). Histograms of Oriented Gradients (HOG) enabled the detection of edges and shapes in images regardless of lighting or noise — a breakthrough in object detection (Dalal, 2005: 887-888). Another important stream involved ensemble methods, such as Bagging and Boosting, which combined the outputs of multiple classifiers. This approach reduced individual model errors and improved classification performance (Dietterich, 2000: 1–4). Despite their many advantages, classical approaches proved difficult to scale. They required expert knowledge, performed poorly on diverse datasets, and were prone to errors in dynamic environments.

The development of deep learning (DL) has radically transformed how emotions are analyzed today. Rather than manually defining where to *look for emotions,* neural networks learn these patterns independently — analyzing thousands or even millions of images. As a result, systems have become more robust to changes in lighting, facial orientation, and individual appearance. The key to this transformation was the introduction of Convolutional Neural Networks (CNNs), which analyze images in layers — from simple patterns to complex emotional configurations (Palaniswamy, 2019: 2). Models such as VGGNet (a deep, symmetrical network with small filters), ResNet (a residual network that learns the *differences* between layers, allowing for deeper architectures), and Inception (a complex structure that analyzes data at multiple scales simultaneously) have become FER standards (He, et al. 2016: 770). In scenarios where emotions evolve over time — such as during video calls — Recurrent Neural Networks (RNNs) and their advanced form, Long Short-Term Memory (LSTM) networks, are used. These models can "remember" key information while ignoring irrelevant details (Hochreiter & Schmidhuber, 1997: 1743).

In recent years, hybrid approaches have gained popularity — combining CNNs with LSTM networks or attention mechanisms, allowing for the capture of both visual structure and temporal context. Transfer learning has also become significant — leveraging pre-trained models (e.g., on the ImageNet dataset) and fine-tuning them for specific tasks, reducing training time and improving performance (Yen & Li, 2022: 4). Thanks to frameworks such as TensorFlow, PyTorch, and Keras, creating, training, and deploying DL models has become accessible not only to scientists but also to practitioners in psychology, medicine, and education (Ismail et al., 2024: 11).

So why are classical methods still in use if deep learning seems superior? The answer is context. Classical approaches are faster, cheaper, and easier to implement. In controlled or educational environments, where high flexibility is not required, they may be entirely sufficient. Deep learning, on the other hand, is better suited to complex, dynamic datasets that require high precision — such as psychological diagnostics, employee well-being assessment, or crisis intervention systems (table 1).

Table 1. *Comparison of Classical and Deep Learning Approaches in Facial Emotion Recognition*

Criterion	Classical FER Methods	Deep Learning Approaches
Feature extraction	Manual, expert-driven	Automated, learned by the network
Data requirements	Low	High – requires large datasets
Noise resistance	Low	High
Result interpretability	High	Low ("black box")
Computational efficiency	Low	High – needs GPU/cloud
Model preparation time	Short	Long (training required)
Applications	Education, offline analysis	Clinical use, remote work, mobile apps, well-being monitoring
Example techniques	FACS, Haar, HOG, Boosting	CNN, ResNet, LSTM, Attention, Transfer Learning

Note. Comparison of classical and deep learning approaches to facial emotion recognition, based on the authors' comparative analysis.

Understanding the differences between classical and modern FER methods enables not only a more precise and context-appropriate selection of analytical tools, but also a more reflective evaluation of their practical applicability, technical limitations, and underlying assumptions. As technological capabilities continue to evolve, researchers and practitioners are increasingly faced with the need to align methodological choices with the specific demands of their domain. This includes considerations such as data availability, computational resources, interpretability requirements, and time constraints. Ultimately, the effectiveness of facial emotion recognition depends not solely on the sophistication of the algorithm, but also on the clarity of its intended use, the conditions under which it operates, and the ethical standards guiding its implementation.

Materials and Methods

This study evaluated the effectiveness of selected machine learning and deep learning models in the context of automatic Facial Emotion Recognition. The FER-2013 dataset was chosen for the experiments, as it is one of the most widely used and broadly recognized datasets in the scientific community—particularly in studies involving deep learning-based emotion recognition. Due to its diversity in terms of facial expressions and image quality, FER-2013 is considered one of the most frequently used benchmarks in this field (Goodfellow, 2013: 62). The FER-2013 dataset played a key role in the ICML 2013 Challenge, which contributed to its standardization in the evaluation of novel algorithms (Mollahosseini, 2016: 1). Additionally, it offers a variety of realistic, "in-the-wild" facial images, making it highly representative and useful for developing systems intended for real-world applications (Mollahosseini, 2016: 2; Minaee et al., 2021: 5). In

numerous literature reviews, FER-2013 has been cited as a benchmark standard in emotion recognition research due to its widespread use and well-established structure (Li & Deng, 2022: 1195). Its popularity and accessibility make it a natural choice for testing the effectiveness of modern emotion recognition models.

To compare different approaches to FER, a set of models was selected to represent both classical and modern deep learning techniques. The models applied in this study included CNNs (LeCun, et al, 1998: 2283), RNNs (Elman, 1990: 7), their advanced variant LSTM networks (Hochreiter, 1997: 9), as well as state-of-the-art deep architectures such as ResNet (He, 2016: 770) and VGGNet (Simonyan, 2015: 2). Additionally, ensemble methods were included, combining the outputs of multiple classifiers to enhance prediction accuracy (Dietterich, 2000: 1). Within the scope of classical emotion recognition methods, feature extraction techniques based on Haar-like features (Viola & Jones, 2001: 512) and Histograms of Oriented Gradients (Dalal & Triggs, 2005: 887-888) were applied. Haar-like features enable the rapid detection of local brightness differences in an image, making them useful for analyzing simple facial patterns with low computational complexity. This technique employs rectangular masks that slide across the image, analyzing contrast between selected regions and capturing typical lighting configurations associated with specific emotional expressions (Viola & Jones, 2001: 512). HOG, on the other hand, allows for precise analysis of local edges and contours by computing gradient directions in small segments of the image and converting them into gradient histograms (Dalal & Triggs, 2005: 888). This method is known for its robustness to lighting variations, which enhances its applicability in visually diverse environments.

The study also incorporated ensemble methods as an extension of classical approaches by combining the outputs of multiple independent classifiers. Techniques such as Bagging and Boosting (Dietterich, 2000: 1–5) improve prediction stability and accuracy by reducing variance and increasing model diversity. Through mechanisms such as voting or weighted prediction averaging, ensemble methods help build more resilient classification systems, particularly in contexts involving incomplete or heterogeneous training data.

In the domain of deep learning methods, Convolutional Neural Networks were applied. These networks consist of convolutional layers, pooling layers, activation functions (ReLU), and fully connected layers (LeCun et al., 1998: 2283). Each module of the network plays a critical role in extracting and classifying facial patterns — convolutional layers process the image locally by filtering features such as edges and textures, while pooling layers reduce dimensionality and increase the model's robustness to spatial distortions. The learning process relies on backpropagation and weight updates to minimize the loss function. The study also included advanced deep learning architectures such as VGGNet and ResNet. VGGNet, with its consistent structure of multiple convolutional layers using small filters (3×3), enables efficient extraction of complex features while maintaining computational stability and limiting the number of parameters (Simonyan, 2015: 2–3). Regularization techniques such as dropout and L2 were implemented to reduce overfitting — a critical factor when working with limited training datasets. ResNet, in contrast to conventional CNNs, introduces residual connections that allow information to bypass certain layers without degradation of the gradient, thereby facilitating the training of very deep networks (He et al., 2016: 771–773). In addition to spatial analysis, sequential architectures were also

applied — specifically RNNs and their extended form, LSTM networks. RNNs are capable of modeling temporally ordered data, which is particularly useful for analyzing sequences of facial images where changes in emotion over time are key (Elman, 1990: 186). LSTM networks, through the use of memory cells with input, output, and forget gates, can selectively retain or discard information, enabling the modeling of long-term dependencies and reducing the vanishing gradient problem (Hochreiter & Schmidhuber, 1997: 1744).

The selection of methods was based on their documented effectiveness and compatibility with the FER-2013 dataset. All models were implemented and validated under consistent conditions, ensuring reliable and comparable results. A comparative analysis was conducted on six models representing both classical feature-based and modern deep learning approaches to facial emotion recognition.

Table 2. *Summary Comparison of All Evaluated FER Method*

Model	Approach type	Computational requirements	Noise resistance	Applications	Advantages	Limitations
VGG16	Deep learning	High (GPU)	High	Psychology, healthcare, research	Well-documented and effective	Large size, needs transfer learning
ResNet	Deep learning	High (GPU)	Very high	Psychology, adaptive systems	High accuracy with deep structures	Complex and GPU-demanding
LSTM	Deep learning (sequential)	Medium–high (GPU)	Medium	Video calls, temporal emotion analysis	Long-term dependency modeling	Challenging to fine-tune
RNN	Deep learning (sequential)	Medium (GPU optional)	Medium	Dynamic emotion modeling	Simplified sequence processing	Lower accuracy than LSTM
HOG	Classical feature extraction	Low	Medium	Fast offline classification	Transparency, light-insensitive	No automatic feature learning
Haar-like features	Classical feature extraction	Very low	Low	Embedded systems, education	Fast processing, simplicity	Low effectiveness and flexibility

Note. Overview of key characteristics, strengths, and limitations of selected FER models, developed by the authors.

These models differ not only in architectural complexity but also in their data requirements, robustness to noise, and interpretability. The following comparison includes key technical and metrological aspects, allowing for an informed assessment of each model's applicability in psychological, educational, and organizational contexts. The table (table 2) presents the most relevant configuration parameters, distinguishing features, and potential applications of all the methods analyzed.

One of the analyzed models was a modified VGG16 architecture, based on the concept presented by Simonyan and Zisserman (Simonyan, 2015: 1), but adapted to the practical requirements of experiments using the FER-2013 dataset. The introduced simplifications were aimed at increasing computational efficiency and reducing training time while preserving the method's functionality in the context of emotion analysis

under remote work conditions. The model utilized a transfer learning strategy—freezing all convolutional layers responsible for feature extraction, while modifying the final classification layer to match the seven emotion classes present in the FER-2013 dataset.

Table 3. *Configuration of the Simplified VGG16 Model Used for FER Tasks*

Configuration Element	Description
Architecture	VGG16 (based on Simonyan & Zisserman, 2015), with modifications
Approach	Transfer learning
Frozen layers	Yes (convolutional layers)
Modified final layer	Yes – 7 outputs (FER2013 emotion classes)
Input image size	224 × 224 px
Data normalization	RGB means and standard deviations from ImageNet
Data split	Training: 80%, Validation: 20%
Number of epochs	10
Batch size	32
Optimizer	Adam
Learning rate (lr)	0.0001
Regularization (dropout/L2)	Not applied
Loss function	CrossEntropyLoss
Evaluation metrics	Accuracy, Precision, Recall, F1-score, Confusion Matrix

Note. Configuration details of the simplified VGG16 architecture tailored for FER, as implemented in this study.

All images were rescaled to a resolution of 224×224 pixels. The data were standardized based on the mean and standard deviation values of the RGB channels used during the original ImageNet training. The dataset was split into a training set (80%) and a validation set (20%), maintaining class balance. The model was trained for 10 epochs using the Adam optimizer (learning rate of 0.0001) and the CrossEntropyLoss function. A batch size of 32 was applied. Adam optimizer is an adaptive learning rate optimization algorithm designed for training deep neural networks. It combines the advantages of two other popular methods: AdaGrad and RMSProp, by estimating both the first and second moments of the gradients (Yi, Ahn, & Ji, 2020: 2).No regularization techniques such as dropout or L2 were used, and no learning rate scheduling was implemented. These decisions were made to simplify the process and allow for efficient experimentation under resource constraints. During each epoch, classification accuracy was monitored on both the training and validation sets. After training was completed, the model's performance was evaluated using metrics such as precision, recall, and the harmonic mean (F1-score). A confusion matrix was also generated to analyze the most frequent classification errors (table 3).

The second analyzed model was the ResNet architecture (He et al., 2016: 771), originally designed to address the vanishing gradient problem in very deep neural networks. In this study, the ResNet-18 version was selected as a compromise between

network depth and computational efficiency, while maintaining the ability to effectively extract features from complex facial expressions.

Table 4. *Configuration of the Simplified ResNet-18 Model Used for FER Tasks*

Configuration Element	Description
Architecture	ResNet-18 (based on He et al., 2016), adapted for FER tasks
Approach	Transfer learning
Frozen layers	Yes (convolutional layers)
Modified final layer	Yes – 7 outputs (FER2013 emotion classes)
Input image size	224 × 224 px
Data normalization	RGB means and standard deviations from ImageNet
Data split	Training: 80%, Validation: 20%
Number of epochs	10
Batch size	32
Optimizer	Adam
Learning rate (lr)	0.0001
Regularization (dropout/L2)	Not applied
Loss function	CrossEntropyLoss
Evaluation metrics	Accuracy, Precision, Recall, F1-score, Confusion Matrix

Note. Experimental setup of the ResNet-18 model adapted to the FER-2013 dataset.

The model was initialized using pre-trained weights from ImageNet and then adapted to the specifics of the FER-2013 dataset by freezing all convolutional layers and replacing the final classification layer with a new fully connected layer featuring seven outputs corresponding to the FER-2013 emotion classes. The data preparation process was identical to that used with the VGG16 model: images were resized to 224×224 pixels and normalized using the RGB means and standard deviations from ImageNet. The dataset was split into training (80%) and validation (20%) subsets. ResNet was trained for 10 epochs using the Adam optimizer (learning rate: 0.0001), without additional regularization. A batch size of 32 was applied. The training strategy prioritized simplicity and consistency with the VGG16 configuration, enabling a reliable comparative analysis. During each epoch, classification accuracy was monitored on both the training and validation sets. After training, the model's performance was evaluated based on accuracy, precision, recall, and F1-score, and a confusion matrix was generated. The results (table 4) allowed for an assessment of ResNet's effectiveness in recognizing facial emotions under conditions of limited data and resources.

The next model analyzed was the Long Short-Term Memory network, an extension of classical Recurrent Neural Networks, designed to retain long-term temporal dependencies in sequential data (Hochreiter & Schmidhuber, 1997: 1744). In the context of emotion recognition, this model enables the analysis of image sequences (e.g., video recordings), allowing for the capture of emotional expression dynamics — a key factor in psychological diagnostics and the analysis of online interactions. The LSTM network was combined with a convolutional feature extraction network (e.g., CNN), where the

CNN served as the feature extractor. The extracted vector representations of each frame (typically from the final convolutional layers) were then processed by the LSTM layers to identify temporal emotional changes. A single-layer LSTM structure was used, consisting of 128 units and a dropout rate of 0.3. A fully connected output layer followed, producing seven outputs corresponding to the emotion classes. Instead of using individual static images, the data were transformed into short sequences of images (e.g., five consecutive frames). Each frame was normalized according to ImageNet RGB means and standard deviations and resized to 224×224 pixels. The sequences were class-balanced across emotion categories. The model was trained for 15 epochs using the Adam optimizer (learning rate = 0.0001), the CrossEntropyLoss function, and a batch size of 16. Validation accuracy was monitored during training, and a full evaluation of classification quality was conducted upon completion. The LSTM model enabled the capture of the sequential nature of emotions, which is particularly valuable in the analysis of video recordings, online conversations, and therapeutic observations (table 5). This model allowed for the identification of subtle changes in facial expressions that might be missed by traditional convolutional models.

Table 5. *Configuration of the LSTM-Based Model for Temporal Facial Emotion Recognition*

Configuration Element	Description
Architecture	Long Short-Term Memory (LSTM)
Integration with CNN	Yes – CNN as feature extractor
Number of LSTM layers	1
Number of LSTM units	128
Dropout	0.3
Final output layer	Fully connected (7 emotion classes)
Input data type	Image sequences (e.g., from video)
Input frame size	224 × 224 px
Number of frames per sequence	5
Batch size	16
Number of epochs	15
Optimizer	Adam
Learning rate	0.0001
Loss function	CrossEntropyLoss
Evaluation metrics	Accuracy, Precision, Recall, F1-score, Confusion Matrix

Note. Design of the LSTM-based model used for analyzing temporal dynamics of facial emotions.

RNNs are among the oldest yet most foundational architectures for sequence processing in the field of machine learning. In this study, a basic version of an RNN was applied to analyze sequences of facial images for the purpose of emotion recognition. Despite its limitations, this model is capable of capturing basic temporal dependencies in sequential image data, which may be useful in analyzing short-term emotional dynamics. The RNN model received as input a sequence of feature vectors extracted from the output of a CNN feature extractor (e.g., convolutional layers). Unlike LSTM,

classical RNNs lack gating mechanisms to regulate information flow, making them more susceptible to the vanishing gradient problem but also less resource-intensive and faster to train. A single-layer RNN with 64 units was implemented, followed by a fully connected output layer with seven outputs corresponding to the emotion classes. The input data consisted of five consecutive frames from image sequences (e.g., extracted from video recordings). Each frame was resized to 224×224 pixels and normalized according to ImageNet standards. The model was trained for 10 epochs using the Adam optimizer (learning rate = 0.0001), the CrossEntropyLoss function, and a batch size of 16. During training, classification accuracy and validation loss were monitored (table 6). Although RNNs are less advanced than LSTM networks, they enabled a preliminary analysis of emotional changes over time. This makes them suitable for projects requiring basic sequence analysis or for use in resource-constrained environments such as mobile devices or educational systems.

Table 6. *Configuration of the RNN-Based Model for Sequential Facial Emotion Recognition*

Configuration Element	Description
Architecture	Recurrent Neural Network (RNN)
Integration with CNN	Yes – CNN as feature extractor
Number of RNN layers	1
Number of RNN units	64
Final output layer	Fully connected (7 emotion classes)
Input data type	Image sequences (e.g., from video)
Input frame size	224 × 224 px
Number of frames per sequence	5
Batch size	16
Number of epochs	10
Optimizer	Adam
Learning rate	0.0001
Loss function	CrossEntropyLoss
Evaluation metrics	Accuracy, Precision, Recall, F1-score, Confusion Matrix

Note. Structure and training setup of the RNN model applied to sequential facial emotion data.

The Histogram of Oriented Gradients is a classical feature extraction technique that was widely used in image analysis prior to the deep learning era. In the context of facial emotion recognition, HOG allows for the capture of local edges, contours, and structural patterns of the face that may be characteristic of specific emotional expressions. The HOG method divides the image into small, regular cells (e.g., 8×8 pixels), within which a histogram of gradient orientations — i.e., brightness changes — is computed. These histograms are then normalized across larger blocks (e.g., 2×2 cells), improving robustness to lighting variations. The result is a feature vector that represents the structure of the image in a form suitable for classification. In this study, a standard HOG configuration was used: 8×8 cells, 2×2 blocks, and 9 histogram bins. Feature extraction was performed using the **scikit-image** library. The resulting feature vectors

were classified using a Support Vector Machine (SVM) classifier with a radial basis function (RBF) kernel. Images from the FER-2013 dataset were rescaled to 64×64 pixels (due to SVM classifier constraints) and processed using HOG. The data were split into training and test sets in an 80/20 ratio. The SVM classifier was trained using default parameters: C=1.0, gamma='scale', with the RBF kernel. After training, classification performance was evaluated using standard metrics: accuracy, precision, recall, F1-score, and a confusion matrix (table 7). Although HOG is an older technique compared to deep learning models, it offers high interpretability and can be implemented on devices with limited computational power. Its main limitations include low tolerance to data variability (e.g., different face orientations) and the lack of self-learning capability. Nevertheless, in controlled or educational environments, it may provide a fast and efficient solution for basic emotion analysis.

Table 7. *Configuration of the HOG-Based Method for Classical Facial Emotion Recognition*

Configuration Element	Description
Method Type	Histogram of Oriented Gradients (HOG)
Cell size	8 × 8 pixels
Block size	2 × 2 cells
Number of histogram bins	9
Histogram normalization	L2-Hys
Input image size	64 × 64 px
Feature extraction	scikit-image library
Classifier	Support Vector Machine (SVM)
SVM parameters	C=1.0, gamma='scale', RBF kernel
Data split	80% training, 20% test
Evaluation metrics	Accuracy, Precision, Recall, F1-score, Confusion Matrix

Note. Description of the HOG-based feature extraction method combined with SVM, used in the authors' experiments.

The Haar-like features method is one of the earliest and simplest techniques used in image analysis, based on intensity differences between adjacent regions. Popularized by the Viola-Jones face detector, it remains a fast and efficient way to detect structural features, including facial patterns. Haar features use rectangular masks to compare brightness areas, such as contrasting the forehead with the eyebrows. Their computational efficiency results from integral images, enabling rapid pixel sum calculations. In this study, several hundred Haar features were generated using OpenCV, and classification was performed using the AdaBoost algorithm — an ensemble method that improves accuracy by combining weak learners. Images from the FER-2013 dataset were resized to 48×48 pixels and processed into integral images. Feature vectors were classified after 50 AdaBoost iterations. Evaluation included accuracy, precision, recall, and F1-score metrics (Table 8).

Although considered outdated compared to CNN or HOG methods, Haar-like features offer advantages in highly resource-constrained environments, such as embedded systems or mobile applications. Their main strength lies in speed, with limitations in robustness to data variability and complex pattern recognition.

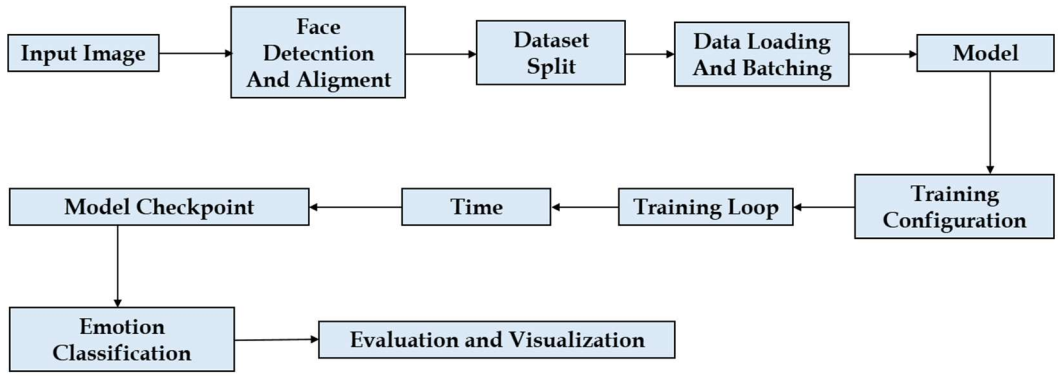
Table 8. *Configuration of the Haar-Like Features Method for Classical Facial Emotion Recognition*

Configuration Element	Description
Method Type	Haar-like features
Operating principle	Analysis of brightness differences between rectangular regions
Feature extractor	OpenCV Haar cascades
Input resolution	48 × 48 px
Image representation	Integral image
Number of features	Several hundred automatically generated features
Classifier	AdaBoost (ensemble method)
AdaBoost parameters	50 iterations, default loss function
Data split	80% training, 20% test
Evaluation metrics	Accuracy, Precision, Recall, F1-score

Note. Implementation of the Haar-like features approach with AdaBoost classifier in the context of classical FER.

All experiments were conducted on a single-workstation rig equipped with an AMD Ryzen 9 9900X CPU, 32 GB DDR5-6000 RAM, and an NVIDIA GeForce RTX 3090 GPU (24 GB GDDR6X). The host operating system was Windows 11 Pro (23H2), and the main software stack included Python 3.13, PyTorch 2.7.0, TorchVision 0.21, and CUDA 12.6. During the training and evaluation procedures, the system consistently operated under 14 GB of VRAM usage and did not exceed 320 W of board power. The entire facial emotion recognition process — from image input to final evaluation — followed a structured and repeatable workflow, ensuring methodological consistency. This workflow is illustrated in Scheme 1.

Scheme 1. *Workflow for Facial Emotion Recognition Model Training and Evaluation.*



Note. Scheme created by the authors based on the experimental setup.

Results

The evaluation of the facial emotion recognition models was conducted using several complementary metrics: accuracy, precision, recall, F1-score, and training time. These measures offer different perspectives on model performance, capturing not only overall correctness but also sensitivity to positive instances and the balance between precision and recall. In machine learning, an epoch refers to a complete cycle in which the model processes the entire training dataset. After each epoch, the model updates its internal parameters (weights) and, if more epochs are set, begins a new cycle with updated weights (Das & Das, 2023). Table 9 presents the models' overall accuracy, weighted averages of precision, recall, F1-score, and the time required to complete training. Precision in this context reflects how many of the predicted positive cases were correct; it is calculated by dividing true positives (TP) by the sum of true positives and false positives (FP) (Hersh, 2005). Recall indicates how many actual positive cases were correctly identified by the model, calculated by dividing TP by the sum of TP and false negatives (FN) (Hersh, 2005). The F1-score, which is the harmonic mean of precision and recall, provides a single measure balancing these two aspects, and gives insight into the model's ability to identify emotions accurately and consistently (Hersh, 2005).

Table 9. *General Performance Metrics of FER Models*

Model	Accuracy	Weighted Avg Precision	Weighted Avg Recall	Weighted Avg F1-Score	Time (s)
ResNet	0.44	0.42	0.44	0.40	680
VGG-16	0.60	0.60	0.56	0.59	648
HOG	0.44	0.43	0.44	0.43	155
RNN	0.37	0.30	0.29	0.27	465
LSTM	0.44	0.43	0.44	0.42	494
Haar	0.56	0.55	0.56	0.55	300

Note. Summary of model classification performance based on weighted averages and computational time.

Among the evaluated models, VGG-16 achieved the highest overall accuracy (0.60) and weighted F1-score (0.59), indicating a strong balance between precision and recall. Haar-based detection also yielded robust results (accuracy: 0.56), with notably lower training times (300 seconds), which highlights its efficiency in resource-constrained environments. In contrast, the RNN model demonstrated the weakest performance across all metrics, achieving the lowest weighted F1-score (0.27) and accuracy (0.37), suggesting limitations in recognizing facial emotions effectively. Additionally, the LSTM model, although showing better performance than the RNN, exhibited only moderate improvements, indicating that sequential architectures might require further tuning for optimal FER performance.

A more detailed analysis focusing on recognition performance for specific emotions is presented in Table 10. This table identifies the emotion best recognized (based on precision and recall) and the least effectively detected emotion (based on recall) for each model, providing further insight into their individual strengths and weaknesses across emotional categories.

Table 10. *Summary of Facial Emotion Recognition (FER) Model Performance*

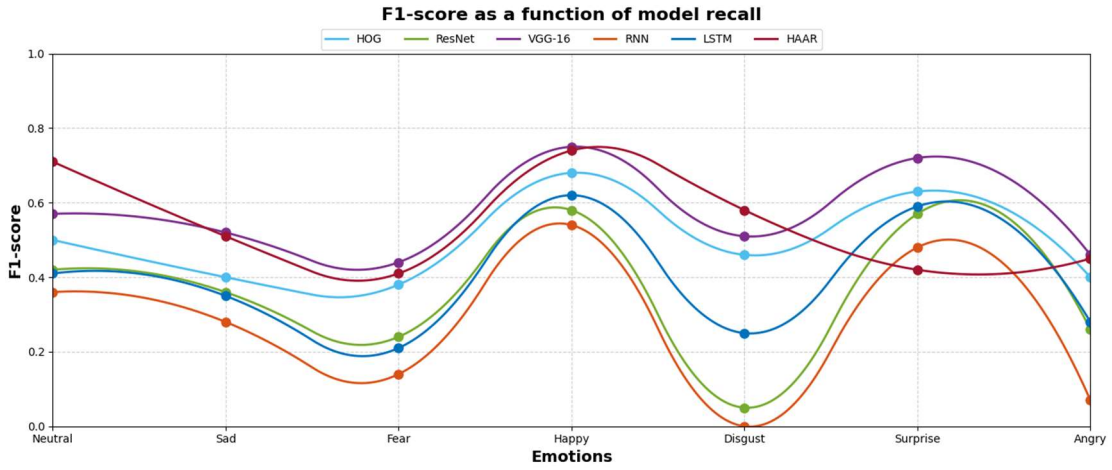
Model	Overall Accuracy	Best Precision (Emotion)	Best Recall (Emotion)	Worst-Recognized Emotion (Recall)
ResNet	0.44	surprise (0.72)	happiness (0.71)	disgust (0.03)
VGG16	0.6	disgust (0.79)	happiness (0.88)	fear (0.34)
HOG	0.44	happiness (0.57)	happiness (0.72)	disgust (0.2)
RNN	0.37	surprise (0.52)	happiness (0.72)	fear (0)
LSTM	0.44	surprise (0.62)	happiness (0.73)	fear (0.16)
Haar	0.56	neutral (0.76)	happiness (0.78)	fear (0.37)

Note. Summary of classification performance across all tested models, based on the results obtained in the present study.

Among the tested models, VGG-16 again stood out, achieving the highest precision (0.79 for disgust) and recall (0.88 for happiness), confirming its capacity to recognize distinct emotional patterns effectively. Haar cascades performed well for neutral and happiness emotions, balancing speed and classification performance. The ResNet model demonstrated good precision for surprise (0.72) and recall for happiness (0.71), but struggled considerably with disgust (recall: 0.03), indicating challenges in capturing more subtle expressions. Classical feature-based methods, such as HOG, achieved stable but modest results, while RNN and LSTM models displayed weaker recognition rates, particularly for fear, with RNN failing to recognize it at all (recall: 0.00).

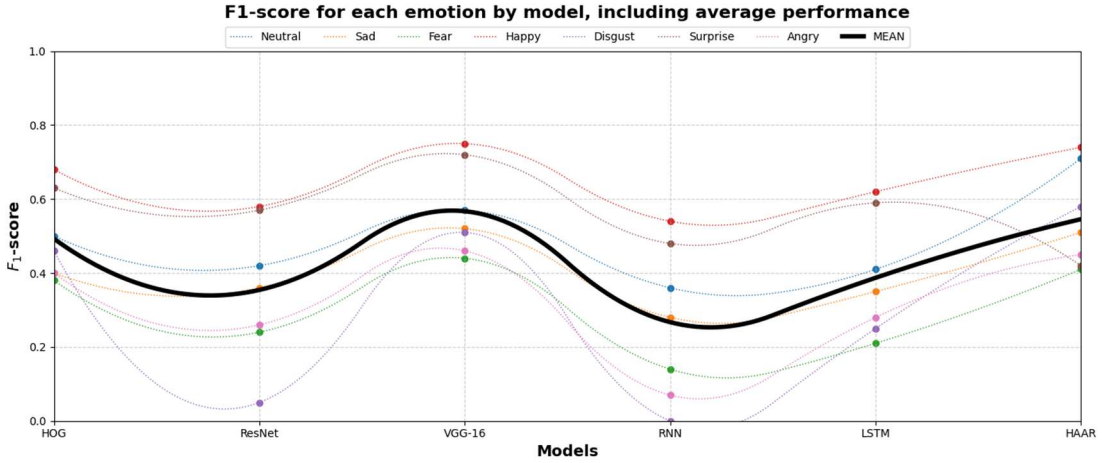
To further explore model performance, three additional visual analyses were conducted.

Figure 1. *F1-score across FER models by emotion category*



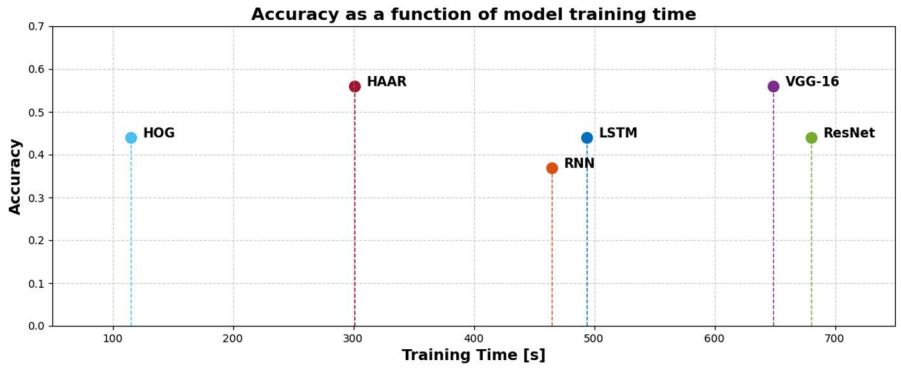
Note. Figure created by the authors based on the current study results.

Figure 2. *F1-score for each emotion by model, including average performance*



Note. Figure created by the authors to compare average and emotion-specific scores.

Figure 3. *Model accuracy as a function of training time*



Note. Figure created by the authors to show the trade-off between accuracy and time.

Figure 1 presents F1-scores across emotional categories for each model, highlighting that happiness and surprise were generally easier to recognize, whereas fear and disgust remained more difficult for all architectures. Figure 2 aggregates F1-scores across models, with the bold curve representing mean performance. VGG-16 and LSTM consistently showed higher overall recognition abilities compared to the other models. Figure 3 illustrates the trade-off between model accuracy and training time, showing that while VGG-16 and Haar achieved better classification results, their training times were significantly longer compared to lightweight methods like HOG.

Discussion

The comparative analysis revealed that certain emotions, such as happiness and surprise, were generally recognized with higher accuracy across models, while others, including fear, disgust, and anger, remained significantly more difficult to classify. These patterns, also observable in Figures 1 and 2, reflect the inherent ambiguity and lower facial distinctiveness of some emotional expressions. Notably, even advanced deep learning models struggled to detect these more nuanced emotions consistently. Moreover, as highlighted in Figure 3, achieving high accuracy often came at the cost of extensive training time, raising important questions about the practical feasibility of deploying complex FER systems in low-resource environments. These observations underscore the need to match model complexity with the intended application context—balancing performance, efficiency, and ethical considerations.

Facial Emotion Recognition systems are gaining increasing significance across a variety of domains, from education and healthcare to smart home technologies. In education, FER can be used to monitor students' emotions in real time—allowing teachers to assess whether a student is frustrated, bored, or engaged and tailor their teaching methods accordingly (Khalfallah & Ben Hadj Slama,, 2015: 276). One example includes a JavaScript-based system that tracks facial landmarks and assesses emotional responses during remote laboratory sessions (Khalfallah, 2015: 279). In the workplace, FER helps monitor employees' moods, supporting psychological well-being and productivity. For instance, Raspberry Pi-based systems can recognize real-time emotions such as joy, sadness, or anger (Rathour et al., 2021: 4). In smart home environments, FER is used to automate surroundings—e.g., by changing a television channel or lowering the volume upon detecting user frustration (Hossain & Muhammad, 2017: 2283). In healthcare, FER is applied in the diagnosis and monitoring of mood disorders such as depression, including in home settings. This technology may facilitate early detection of relapses and assessment of treatment effectiveness (Guo et al., 2024: 6). Recent advancements also include the development of contactless FER systems, which utilize radar sensors, thermal cameras, or Wi-Fi wave analysis instead of RGB cameras. These allow for emotion detection even without direct facial visibility (Khan et al., 2024: 13).

The results obtained in this study suggest that FER systems can significantly support remote work—provided that the technology is appropriately matched to the organization's needs and team structure. The choice of model should not be based solely on classification accuracy but also on computational requirements, robustness to environmental noise, and real-time performance capabilities. For example, the stable VGG16 architecture proves effective in educational settings where teachers conduct online classes and need to monitor student engagement without relying on high-

performance hardware. Due to its predictable structure and consistent results, VGG16 also performs well in organizations that conduct remote training or professional development sessions—especially where capturing clear emotional states such as frustration, joy, or boredom is essential.

The more complex ResNet architecture, with its use of residual connections, proved effective in capturing subtle facial variations. It may be successfully applied in large corporate environments where real-time emotion analysis supports not only mental well-being but also the early detection of burnout or work overload. Such systems may also be valuable for UX and AI research departments, where users' emotional reactions to new digital products are evaluated. Although ResNet requires significant computational resources, it enables deep emotion analysis in visually and culturally diverse settings.

For organizations relying on intensive synchronous communication—such as therapeutic teams, consultants, coaches, or customer service units—the LSTM model may be more appropriate. It enables temporal analysis of emotions, capturing mood changes throughout the course of an interaction. This makes it possible not only to detect emotions at a given moment but also to identify critical turning points—such as when a client begins to experience irritation or anxiety. LSTM is particularly valuable in analyzing continuous interactions, such as video calls, psychological support sessions, or online coaching.

Organizations without access to advanced technological infrastructure, but with a need for speed and interpretability, may benefit from classical methods like Histogram of Oriented Gradients. Due to their relatively low computational requirements, such methods are ideal for small businesses, NGOs, or educational institutions in developing countries, especially when emotion analysis is conducted on recorded material rather than in real time. HOG can also be used in basic feedback systems after remote meetings, aimed at assessing the general emotional tone of participant responses.

In cases where maximum responsiveness and minimal resource consumption are essential—such as in smart homes or mobile devices—techniques like Haar-like features combined with AdaBoost classifiers may be employed. These systems can respond instantly to the user's emotions, e.g., by adjusting lighting or music based on mood. While their performance does not match that of deep learning models, their simplicity and efficiency make them viable for implementation where other methods may be impractical.

Recurrent Neural Networks (RNNs), although less advanced than LSTMs, may be suitable for projects requiring basic emotion analysis over time—particularly in mobile applications, chatbots, or educational systems, where limited resources and fast processing are critical. Their simplicity may be an advantage for rapid prototyping or deploying "good enough" solutions that work effectively in the moment. The diversity of FER methods not only demonstrates the technological potential for emotion analysis but also underscores the importance of a cautious, context-aware implementation strategy. The choice of model should always be preceded by an assessment of technical constraints, organizational goals, and the specific nature of remote work in a given team. When applied thoughtfully, FER systems can support emotional diagnostics and contribute to building healthier, more balanced, and human-centered work environments.

Despite the promising results and the broad range of methods applied, this study has several important limitations that should be considered when interpreting the findings or attempting to generalize them. First, the FER-2013 dataset—although widely recognized as a benchmark in emotion recognition research—has structural and content-related limitations. Its grayscale images are standardized to a low resolution (48×48 pixels), which reduces the ability to capture subtle facial nuances—especially for more complex or less distinct emotions such as surprise or disgust. Moreover, the dataset lacks ethnic diversity; most facial images are of white individuals, which may result in models learning emotion patterns that are typical for this demographic while marginalizing facial expressions from other populations. This raises concerns about the generalizability of results to demographically diverse educational or workplace settings.

A second limitation of the study was the simplified experimental configuration, driven by the need to conduct research under constrained technical conditions. All models were trained for a relatively short time—only 10 to 15 epochs—without applying performance-enhancing techniques such as data augmentation, fine-tuning, dynamic learning rate adjustments, or advanced regularization strategies. While this approach allowed for the efficient comparison of multiple architectures under unified conditions, it may have limited the models' actual potential. This is particularly relevant for more complex architectures, such as ResNet or LSTM, which typically require longer training periods and precise hyperparameter calibration to achieve optimal performance.

Another important constraint was the computational limitation, which necessitated the exclusion of more advanced architectures such as ResNet50, EfficientNet, or deeper LSTM variants. The study was conducted using locally available hardware, which limited both the experimentation with larger models and their testing in production-like environments—e.g., real-time emotion recognition using full video datasets. As a result, the study assumed more of a comparative testing character, similar to educational or prototyping settings, rather than a full-scale industrial validation.

All of these limitations should be taken into account when interpreting the results. The project's goal was not to achieve the highest possible classification accuracy, but rather to explore the practical viability of various approaches in conditions similar to those faced by research, therapeutic, or educational teams without access to advanced computational resources. Although the results are promising, they serve as a starting point for further research—particularly studies involving more diverse datasets, extended training, and models tailored to specific cultural and technological contexts.

Despite the increasing accuracy and availability of facial emotion recognition (FER) systems, their application raises significant ethical concerns—especially in contexts where decisions based on emotion recognition may have real consequences for individuals. Even when such technologies are deployed with good intentions, they may infringe upon fundamental values such as privacy, autonomy, equality, and human dignity.

One of the most frequently cited issues is the violation of emotional privacy. Emotions are inherently personal, and their recognition—especially when done without a person's awareness or consent—can constitute a form of surveillance. Cavoukian emphasizes that privacy is not about hiding information but about having control over what is shared and with whom. FER systems deployed in workplaces, educational

platforms, or public spaces—without the informed consent of users—may undermine this right, contributing to a sense of continuous monitoring (Cavoukian, 2019: 5).

Another serious concern involves system errors and algorithmic bias. Research has shown that FER systems are more likely to misclassify the emotions of individuals with darker skin tones—for instance, labeling neutral expressions as negative emotions such as anger (Buolamwini & Gebru, 2018: 4). This occurs in part because the training datasets used to build neural networks are predominantly composed of images of white individuals. Consequently, these systems may perpetuate stereotypes and lead to unjust outcomes in workplaces, educational institutions, or even legal proceedings trajectory (Boyd & Andalibi, 2023: 5).

Even high-performing systems are not without significant challenges. Emotion recognition is a probabilistic process, and the notion that an algorithm can "know the truth" about a person's emotional state is heavily contested in scientific literature (Barrett, 2017: 12). Studies show that emotions are deeply dependent on cultural, social, and psychological contexts—dimensions that algorithms are fundamentally incapable of fully capturing (Barrett, 2017: 18). Moreover, the illusion of objectivity may lead to FER results being treated as infallible, thereby marginalizing human voice and limiting opportunities for appeal (Keyes, 2019: 14). FER technologies also carry the risk of function creep—the gradual broadening of a system's use beyond its original intent. Systems initially designed to monitor employee well-being may later be used to assess productivity, diagnose mental illnesses, or—in the most controversial scenarios—predict criminal tendencies (Mohammad, 2022: 244). Such applications not only oversimplify the complexity of human behavior but also risk pathologizing natural emotional responses and relinquishing control over how and by whom results are interpreted (Keyes, 2019: 15). FER can also distort power dynamics in professional relationships. Employees subjected to continuous emotional monitoring may experience increased stress, pressure to conform emotionally, and uncertainty about how results may impact their career trajectory (Boyd & Andalibi, 2023: 5) In such contexts, the notion of "voluntary consent" becomes questionable, as the realistic possibility of refusal is often non-existent (Buolamwini & Gebru, 2018: 5).

Ultimately, the advancement of FER raises the question of whether every domain of life should be automated. Emotions are profoundly human phenomena—shaped by history, experience, and socio-cultural relationships. Automating their recognition invites not only technical questions but also philosophical ones: Can a machine truly understand a human being? Should it? As Mohammad (2022: 246) points out, the key issue is not whether we can, but whether we should. Ethical implementation of FER requires more than technical safeguards. It demands participatory design principles, system transparency, acknowledgment of cultural and social diversity, and—most importantly—humility in the face of technological limitations and human complexity (Mohammad, 2022: 247).

Future research should prioritize the use of more diverse datasets—those that include color images in higher resolution and feature individuals from a wide range of cultural and ethnic backgrounds. Additionally, the scope of analysis should be expanded to include multimodal data—combining facial expressions with vocal tone, gestures, or physiological signals—to enhance emotion recognition accuracy in complex, real-world communicative situations. A compelling direction would also be to investigate the

behavioral effects of FER interfaces themselves—for example, whether awareness of being monitored alters the way people express emotions.

Conclusion

This analysis has demonstrated that facial emotion recognition (FER) technologies can serve as a valuable complement to diagnostic tools in the context of remote work and psychological well-being. While classical methods offer fast and cost-effective implementation despite certain limitations, deep learning approaches provide significantly higher accuracy and flexibility in dynamic conditions. However, despite growing technological accessibility, further research is necessary to assess these systems' effectiveness in real-world environments and to ensure their ethical implementation. Future directions should consider integrating FER models into multimodal systems and developing tools that support mental well-being across various organizational levels.

Both our study and the review of existing literature point to a clear potential for applying FER as a technology supporting remote work environments. Most importantly, such systems can systematically and more objectively identify early symptoms of declining mental well-being. This enables the implementation of preventive actions—such as recommending breaks, adjusting work rhythms, facilitating communication with the team or supervisor, or, in more advanced scenarios, signaling the need for psychological consultation. Potential benefits also include adapting the work environment to a user's current emotional state, which may improve concentration, reduce stress, and even enhance efficiency and job satisfaction.

Nevertheless, it is critical to recognize that FER technology touches upon one of the most intimate aspects of the human experience—emotion. Introducing such systems into the workplace carries the risk of both technological and social abuses. The most serious of these is the potential instrumentalization of emotion—treating it as another productivity metric rather than an authentic expression of an individual's mental state. Particularly concerning are potential abuses of power, where emotional data is used without the employee's informed consent or beyond the original purpose for which it was collected. Examples include using FER to evaluate *loyalty*, monitor *motivation* in real time, or even select candidates during recruitment based on their emotional responses.

Several other concerns also emerge: technical ones—related to classification accuracy and potential errors; psychological ones—concerning the impact of constant monitoring on well-being and the authenticity of emotional expression; and social ones—such as cultural differences in emotional expression, which may lead to algorithmic biases and misinterpretations. Moreover, there is a tangible risk of function creep—expanding the original use of FER systems into ethically questionable areas, such as behavior control, diagnosing mental disorders without consent, or even profiling individuals based on perceived emotional risk.

Therefore, as authors, we recommend that any implementation of FER technology in work settings—especially remote environments—be preceded by systemic regulation. This should include not only legal frameworks but also ethical standards, codes of conduct, auditing mechanisms, and a genuine option for individuals to opt out without facing negative consequences. Only an approach based on transparency, voluntariness, and participatory design can ensure that these technologies serve to support humans rather than control them.

This study contributes to the development of practical FER applications in the realities of remote work, demonstrating that even simplified models—when appropriately tuned—can effectively support the monitoring of psychological well-being without the need for advanced or costly systems. In the future, research on multimodal FER systems, combining visual data with voice, text, or physiological signals, may prove particularly valuable. Such approaches could not only improve the accuracy of emotion recognition but also reduce the risk of misinterpretation stemming from the one-sided analysis of facial expressions.

Technology that can perceive emotions has the potential to become a powerful ally—provided it is accompanied by attentiveness to the human being.

REFERENCES

Aslam, A., Hussain, B. (2021). Emotion recognition techniques with rule based and machine learning approaches, pp. 1-27.

Baes, N., Speagle, H., Haslam, N. (2022). Has psychology become more positive? Trends in language use in article abstracts. *Frontiers in Psychology*, 13, pp. 1–8.

Barrett, L.F. (2017). *How Emotions Are Made: The Secret Life of the Brain*. New York: Houghton Mifflin Harcourt.

Becker, W.J., Belkin, L.Y., Tuskey, S.E. (2022). Surviving remotely: How job control and loneliness during a forced shift to remote work impacted employee work behaviors and well-being. *Human Resource Management*, 61(1), pp. 449-464.

Berry, Y. (2023). Examining the workplace wellbeing of elementary school teachers whose students participated in a social and emotional learning program. *Doctoral thesis*, Pepperdine University.

Boyd, K.L., & Andalibi, N. (2023). *Automated emotion recognition in the workplace: How proposed technologies reveal potential futures of work*. Proceedings of the ACM on Human-Computer Interaction, 7(CSCW2), pp. 1–27.

Brown, A., Leite, A.C. (2023). The effects of social and organizational connectedness on employee well-being and remote working experiences during the COVID-19 pandemic. *Journal of Applied Social Psychology*, 53(1), pp. 134–152.

Buolamwini, J., Gebru, T. (2018). Gender Shades: Intersectional Accuracy Disparities in Commercial Gender Classification. *Proceedings of Machine Learning Research*, 81, pp. 1–15.

Cavoukian, A. (2019). *Privacy by Design: The 7 Foundational Principles*. Toronto: Information and Privacy Commissioner of Ontario.

Czapiński, J. (2004). Psychologiczna teoria dobrostanu. In: J. Czapiński (Ed.), *Psychologia pozytywna*. Warsaw: PWN, pp. 19–42.

Dalal, N., Triggs, B. (2005). Histograms of Oriented Gradients for Human Detection. *Proceedings of the IEEE Computer Society Conference on Computer Vision and Pattern Recognition*, 1(1), pp. 886–893.

Das, N., Das, S. (2023). Epoch and accuracy based empirical study for cardiac MRI segmentation using deep learning technique. *PeerJ*, 11, pp. 1–15.

Dietterich, T.G. (2000). Ensemble methods in machine learning. *Lecture Notes in Computer Science*, 1857, pp. 1–15.

Elman, J.L. (1990). Finding structure in time. *Cognitive Science*, 14(2), pp. 179–211.

Goodfellow, I., et al. (2013). Challenges in representation learning: A report on three machine learning contests. *Neural Networks*, 64, pp. 59-63.

Guo, R., Guo, H., Wang, L., Chen, M., Yang, D., Li, B. et al. (2024). Development and application of emotion recognition technology — a systematic literature review. *BMC Psychology*, 12:95, pp. 1-15.

Hadjar, H., Vu, B., Hemmje, M. (2025). TheraSense: Deep Learning for Facial Emotion Analysis in Mental Health Teleconsultation. *Electronics*, 14(3), pp. 1-17.

Hajric, E., Najar Arevalo, F., Bruce, L., Smith, F.A., Michael, K. (2024). Facial Emotion Recognition in the Future of Work: Social Implications and Policy Recommendations. *IEEE Transactions on Technology and Society*, pp. 1–10.

He, K., Zhang, X., Ren, S., Sun, J. (2016). Deep Residual Learning for Image Recognition. *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, pp. 770–778.

Hersh, W. (2005). Evaluation of biomedical text-mining systems: lessons learned from information retrieval. *Brief Bioinformatics*, 6(4), pp. 344–356.

Hochreiter, S., Schmidhuber, J. (1997). Long Short-Term Memory. *Neural Computation*, 9(8), pp. 1735–1780.

Hossain, M.S., Muhammad, G. (2017). An Emotion Recognition System for Mobile Applications. *IEEE Access*, 5, pp. 2281-2287.

Ismail, S.N.M.S., Razak, S.F.A., & Aziz, N.A.A. (2024). *Transfer learning for improved electrocardiogram diagnosis of cardiac disease: exploring the potential of pre-trained models*. Bulletin of Electrical Engineering and Informatics, 13(5), pp. 1–15.

Kas, M., Ruichek, Y., & Messoussi, R. (2021). *New framework for person-independent facial expression recognition combining textural and shape analysis through new feature extraction approach*. Information Sciences, 572, pp. 10–25.

Kau, F.S., Flotman, A.P. (2025). The subjective well-being experiences of mine employees in a South African mining organisation. *SA Journal of Industrial Psychology*, 51(0), pp. 1–14.

Khalfallah, J., Ben Hadj Slama, J. (2015). Facial expression recognition for intelligent tutoring systems in remote laboratories platform. *Procedia Computer Science*, 73, pp. 274-281.

Khan, U.A., Xu, Q., Liu, Y., Lagstedt, A., Alamäki, A., Kauttonen, J. (2024). Exploring contactless techniques in multimodal emotion recognition: insights into diverse applications, challenges, solutions, and prospects. *Multimedia Systems*, 30, pp. 1-48.

Keyes, O. (2019). The Misgendering Machines: Trans/HCI Implications of Automatic Gender Recognition. *Proceedings of the ACM on Human-Computer Interaction*, 3(CSCW), pp. 1-22.

Lampinen, A. (2024). Employee Well-Being Management in the Post-COVID Era – Insights from HR Professionals in Large Information Technology Companies in Finland. *Master's thesis*, Aalto University.

LeCun, Y., et al. (1998). Gradient-based learning applied to document recognition. *Proceedings of the IEEE*, 86(11), pp. 2278–2324.

Leong, D.C.P. (2022). Factors Affecting the Psychological Well-Being of Educators: A Study on Private College Lecturers Succeeding COVID-19 Pandemic. *Master's thesis*, Borneo Journal of Social Science & Humanities, pp. 11-31.

Li, S., Deng, W. (2022). Deep Facial Expression Recognition: A Survey. *IEEE Transactions on Affective Computing*, pp. 1195-1215.

Minaee, S., Minaei, M., Abdolrashidi, A. (2021). Deep-Emotion: Facial Expression Recognition Using Attentional Convolutional Network. *Sensors*, 21(9), 3046, pp. 1-16.

Mohammad, S. (2022). Ethics Sheet for Automatic Emotion Recognition. *Computational Linguistics*, 48(2), pp.239–278.

Mollahosseini, A., Chan, D., Mahoor, M.H. (2016). Going deeper in facial expression recognition using deep neural networks. *IEEE Winter Conference on Applications of Computer Vision*. pp.1-10.

Nozari, Zahra & Seyedsalehi, Sadaf (2024). *Building Bridges in Digital Spaces – Enhancing the Sense of Belonging among Remote Employees in a Multinational Company*. Master Thesis, University of Gothenburg.

O'Hare, D., Gaughran, F., Stewart, R., Da Costa, M.P. (2024). A cross-sectional investigation on remote working, loneliness, workplace isolation, well-being and perceived social support in healthcare workers. *BJPsych Open*, 10(1), pp. 1–6.

Palaniswamy, S. (2019). *A robust pose & illumination invariant emotion recognition from facial images using deep learning for human-machine interface*. IEEE International Conference on Consumer Electronics (ICCE), pp. 1–6.

Pataki-Bittó, F., Kun, Á. (2022). Exploring differences in the subjective well-being of teleworkers prior to and during the pandemic. *International Journal of Workplace Health Management*, 15(3), pp. 320-338.

Rajan, S., Chenniappan, P., Devaraj, S. (2020). Novel deep learning model for facial expression recognition based on maximum boosted CNN and LSTM. *IET Image Processing*, pp. 1373–1381.

Rathour, N., Khanam, Z., Gehlot, A., Singh, R., Rashid, M., AlGhamdi, A.S., Alshamrani, S.S. (2021). Real-Time Facial Emotion Recognition Framework for Employees of Organizations Using Raspberry-Pi. *Applied Sciences*, 11(22), pp. 1-17.

Rodríguez-Leudo, Andrea Lucía & Navarro-Astor, Elena (2024). *Workplace happiness in architectural companies in the city of Valencia: a gender comparison*. Doctoral Thesis, Universitat Politècnica de València.

Ryff, C. (1989). Happiness is everything, or is it? Explorations on the meaning of psychological well-being. *Journal of Personality and Social Psychology*, 57(6), pp. 1069–1081.

Seligman, M. (2011). *Pełnia życia*. Poznań: Media Rodzina.

Simonyan, K., Zisserman, A., (2015). Very Deep Convolutional Networks for Large-Scale Image Recognition. *International Conference on Learning Representations (ICLR)*, ss. 1–14.

Viola, P., Jones, M. (2001). Rapid Object Detection using a Boosted Cascade of Simple Features. *Proceedings of the 2001 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR)*, 1(1), pp. 511–518.

Wegrzyn, M., Vogt, M., Kireclioglu, B., Schneider, J. (2017). Mapping the emotional face. How individual face parts contribute to successful emotion recognition, pp. 1-15.

Yen, C.T., & Li, K.H. (2022). *Discussions of different deep transfer learning models for emotion recognitions*. IEEE Xplore, pp. 1–6.

Yi, D., Ahn, J., & Ji, S. (2020). *An effective optimization method for machine learning based on ADAM*. Applied Sciences, 10(3), 1073.

Zimnoch, I. (2024). Dobrostan kadry zarządzającej w sektorze ekonomii społecznej oraz w sektorze biznesowym. *Master's thesis*, WSB Merito University in Poznań.

Environmental Impact of Contaminant Diffusion and Synergistic Effects on XLPE Insulation Cables

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Abstract

In recent years, the use of underground high-voltage (HV) cables for power transmission has significantly increased. Cross-linked polyethylene (XLPE) insulation systems are preferred for the highest transmission voltages due to their exceptional performance, which is largely dependent on cleanliness. However, the presence of impurities in the insulation material leads to premature aging and poses a major concern for power utilities. A three-dimensional (3D) and two-dimensional (2D) model of spheroidal contaminants on cable layers has been developed using Finite Element Method (FEM)- based software. The impact of pulse voltage on the geometry of contaminants, considering different sizes and locations, has been investigated. This study focuses on the presence of contaminants in the insulation and shield regions, though research on specific contaminants like silicon, selenium, phosphorus, and sulfur remains limited. The electrical stress enhancement and current density caused by these contaminants has been evaluated through a comparative study, identifying key factors that contribute to the stochastic degradation of insulation. The results demonstrate the severity of local electric stress under the influence of various contaminants in the cable, and this advanced method has been successfully applied to monitor actual XLPE contaminated insulation.

Keywords: XLPE, contaminants, degradation, electric field amplification, current density

INTRODUCTION

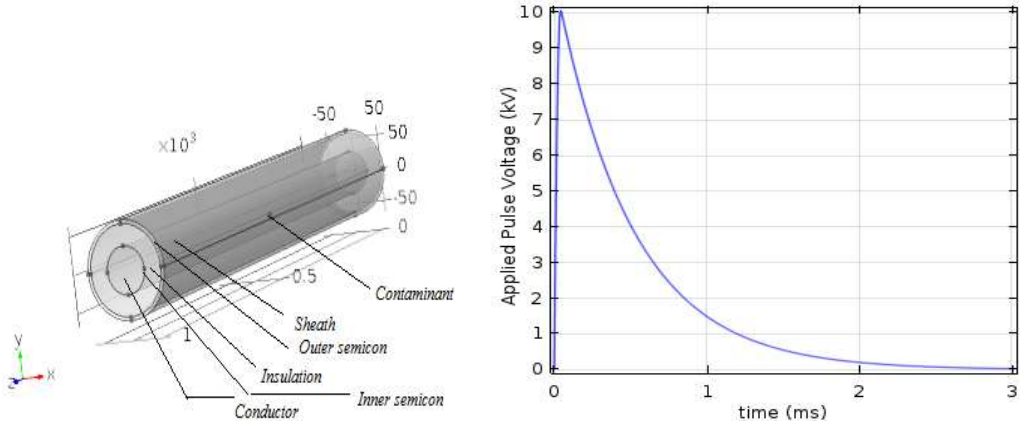
Polymers have been used in the cable business since ancient times. Low density polyethylene (LDPE), high density polyethylene (HDPE), and cross-linked polyethylene (XLPE) are the three polymers that have replaced paper and polyvinyl chloride (PVC). Avoiding the variability of cable insulating material throughout the production and installation processes is extremely challenging (Yang Xu, Pan Luo et.al., 2014). Previous research found that water treeing and electrical treeing are the causes of failure and degradation in polymeric materials. Water treeing is caused by the presence of water, an electric field, and contaminants. A. T. Bulinski 1998 reported that macrostructured trees contain large quantities of metals and ionic contaminants. According to theory, water treeing and thermal bond breakage at faults occur when molecular chain bond energies exceed local tensions (A. T. Bulinski 1998). Carboxylates are the most major oxidative byproduct (R. Ross et al., 1992). The concentration of oxidative byproducts in the water tree area rises with oxidation. Fan & Yoshimura 1996 discovered that the chemical reduction potential is the most important feature of metal ions. According to James J. Xu & Steven A. Boggs 1994, several transition metal ions cause polymer oxidation at the polymer/water contact. The material's main electrical features include dielectric measurements, conduction currents, and space charge characteristics (J.C.Fothergill et al. 2003). Contaminants, protrusions, and voids are the weakest points that cause electrical failure in polymeric cables. Carbon black material is another possible source of contamination, as is the interaction of strong electrical stresses with ionic species inside semiconductors to produce water trees (Karl-Michael Jager et al., 2005). According to the electro-osmosis hypothesis, a distributed ion/contaminant undergoing repeated recombination and resolving processes fatigues the insulation surrounding the ion/contaminant sites, resulting in irreversible mechanical damage to the polymer (Andrew J. Thomas et al., 2008). A method of variable charge mobility lowers the local activation energy. Zepeng Lv et al., 2017 shown that local electric field distortion is required to induce polymer chain movement. The primary elements assessed by Neutron activation analysis (NAA) in XLPE cables are sodium (Na), silicon (Si), aluminum (Al), sulfur (S), chlorine (Cl), potassium (K), calcium (Ca), and copper (Cu) (Serge Pdlissou 1990). According to Takeo Kubota et al. 1994, impurities (metallic impurity in insulation) account for 74% of breakdown, whereas protrusions account for 26%.

CABLE CONFIGURATION AND OVERVIEW

A 400kV, single core, 2500 sq.mm Extra High Voltage AC underground power cable is explored and investigated for a simulation analysis. The suggested study is based on the implementation of contaminant particles implanted in cable. Figure 1a depicts the preferred cable configuration, which has four primary layers: conductor, inner and outer semi-conductive screens, insulation, and sheath. The extruded primary insulation provides for a maximum allowed conductor continuous operation

temperature of 90°C. This research examines the both normal design of a single core XLPE underground healthy cable and a contaminated cable. Table 1 illustrates the cable specification with thickness values for each layer.

In the earlier studies, the primary interest is the presence of different contaminants and focuses solely on the pulse voltage with varied amplitude and pulse widths of 3 msec, as illustrated in Figure 1b, when applied to the conductor boundary conditions and zero potential on metallic sheaths. This short duration pulse parameter is tested for modeling purposes.



(a) (b)

Fig. 1 (a) Structure of the 400kV cable with presence of contaminant (b) Applied Pulse voltage (Priya Selvamany et al., 2019)

The maximum electric field can be calculated as

$$E_{max} = V/R_{in} \ln(R_{out}/R_{in}) \quad (1)$$

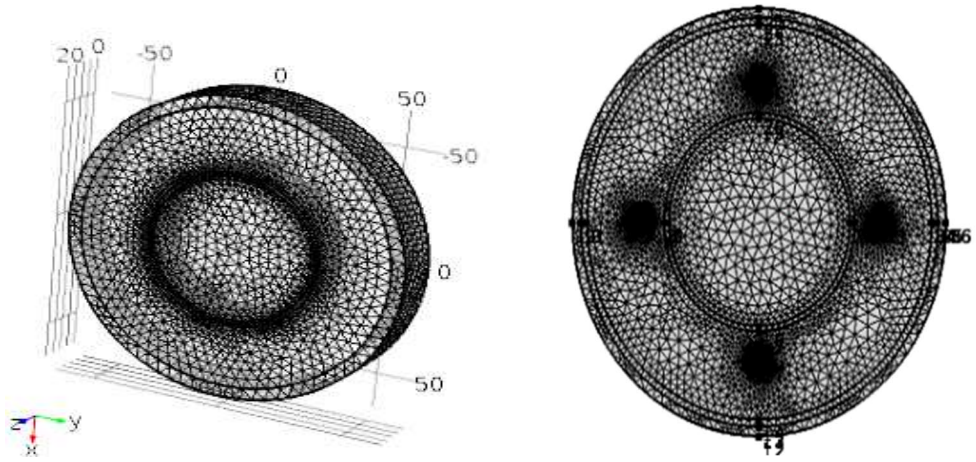
The analytical value obtained for maximum dielectric stress at conductor screen is 10.9 kV/mm whereas for insulation screen is 6 kV/mm is obtained by using equation 1.

Table 1 Thickness (T) value for each layer (Priya Selvamany et al., 2019)

Description	Particulars	T(mm)
Conductor diameter	Copper	63.5
Conductor screen	Semi-conducting thermosetting compound	1.7mm
Insulation	Cross-linked polyethylene	27mm
Insulation screen	Semi-conducting thermosetting compound	2.2mm
Metallic sheath	Cu-Te lead alloy	2.9mm
Over sheath	Black HDPE compound	6.0mm

SIMULATION USING FINITE ELEMENT METHOD(FEM)

Numerical simulations are used to test the cable model using pulse voltage of peak value 10 kV in cross-linked polyethylene (XLPE), and a full explanation is provided. Figure 2 depicts in detail the three- and two-dimensional (2D) cable description models, as well as the presence of contamination geometries. The contamination geometry is represented as a spheroidal form, with radius R. For simulation analysis, spheroidal contaminants are sized at 10μm, 20μm, 40μm, and 80μm radius. Extensive study is conducted on contaminants such as sulphur, selenium, phosphorus, and silicon.



(a) **(b)**

Fig. 2 Mesh formation in XLPE cable with inclusion of contaminants (a) 3D (b) 2D

The simulations with and without contaminants in the cable model are used for analysis. The Evolution of Global AC/DC electric current equation is as follows:

$$-\nabla.(\boldsymbol{\sigma} + \boldsymbol{j\omega\varepsilon_0})\nabla \boldsymbol{V} = \boldsymbol{Q_j} \qquad (2)$$

The set of equations relating electric field E to electric potential V reads as

$$E = -\nabla V \qquad (3)$$

The physics interface solves a current conservation equation:

$$J = \left(\sigma + \varepsilon_0 \varepsilon_r \frac{\partial}{\partial t}\right) E + J_e \qquad (4)$$

The correctness of the solution is highly influenced by the size and form of the mesh components. For 3D geometry, a mapped mesh with free tetrahedral components consists of 6 domains, 40 borders, 72 edges, and 44 vertices. A complete mesh consisting of 189952 domain elements, 15864 boundary elements, and 1104 edge elements was generated. The minimal element quality is 0.1986, and the number of degrees of freedom solved is 1485359. This software generates an incredibly tiny mesh for the completed 2D geometry, which contains 9 domains, 36 borders, and 36 vertices,

with a total degree of freedom of 128821.The simulation study aids in understanding the detailed performance of the contaminated cable, and the results of several parametric calculations such as current density are reported. As a result, the following parameters are utilized to replicate the various contaminants as assigned from table 2.

Table 2 Material properties of contaminants (Priya Selvamany et al., 2019)

Description	Relative permittivity	Electrical conductivity (S/m)
Copper	1	$5.8x10^{7}$
XLPE	2.3	$1x10^{-15}$
Inner and outer semiconductive screen	3.2	$1x10^{-14}$
Silicon	11.68	$1.56x10^{-3}$
Sulphur	2.7	$5x10^{-16}$
Selenium	5.4	$1x10^{-4}$
Phosphorous	4.1	$1x10^{-9}$

RESULTS AND DISCUSSION

In this study, for a pulse width of 3ms, the suggested applied pulse voltage has a rising and declining part with varied amplitude. The impact of rising part of pulse voltage 10kV at instant 0.05ms is illustrated in the next subdivision. Furthermore, the influence of the decaying part is evaluated for a time of roughly 0.4ms and a voltage magnitude of 5kV. First, the contaminant location is chosen on the insulation region at a distance of 9mm from the inner semiconductor surface, and then the particle is embedded in the center of the conductor shield, and their results are evaluated and reported here. Distinctive results are delivered in power cable configurations. The acquired findings represent the fundamental pattern and serve as a baseline for comparing the presence of various contaminants in both 2D and 3D views.

EFFECTS OF NON-CONTAMINATION IN XLPE CABLE: IMPLICATIONS FOR ELECTRICAL PERFORMANCE AND SYSTEM INTEGRITY

To assess the impact of actual impurities on XLPE insulation, it is essential to compare the results with those of a non-contaminated (healthy) cable. As a baseline, a healthy 400 kV cable was simulated to understand the natural behavior of the insulation without impurities. This simulation aimed to achieve a uniform distribution of the electric field and equipotential lines across a 20 mm section of the cable insulation. The resulting data is presented as a surface plot with distinct color gradients, illustrating the hierarchical variation of key electrical parameters, as shown in Fig. 3.

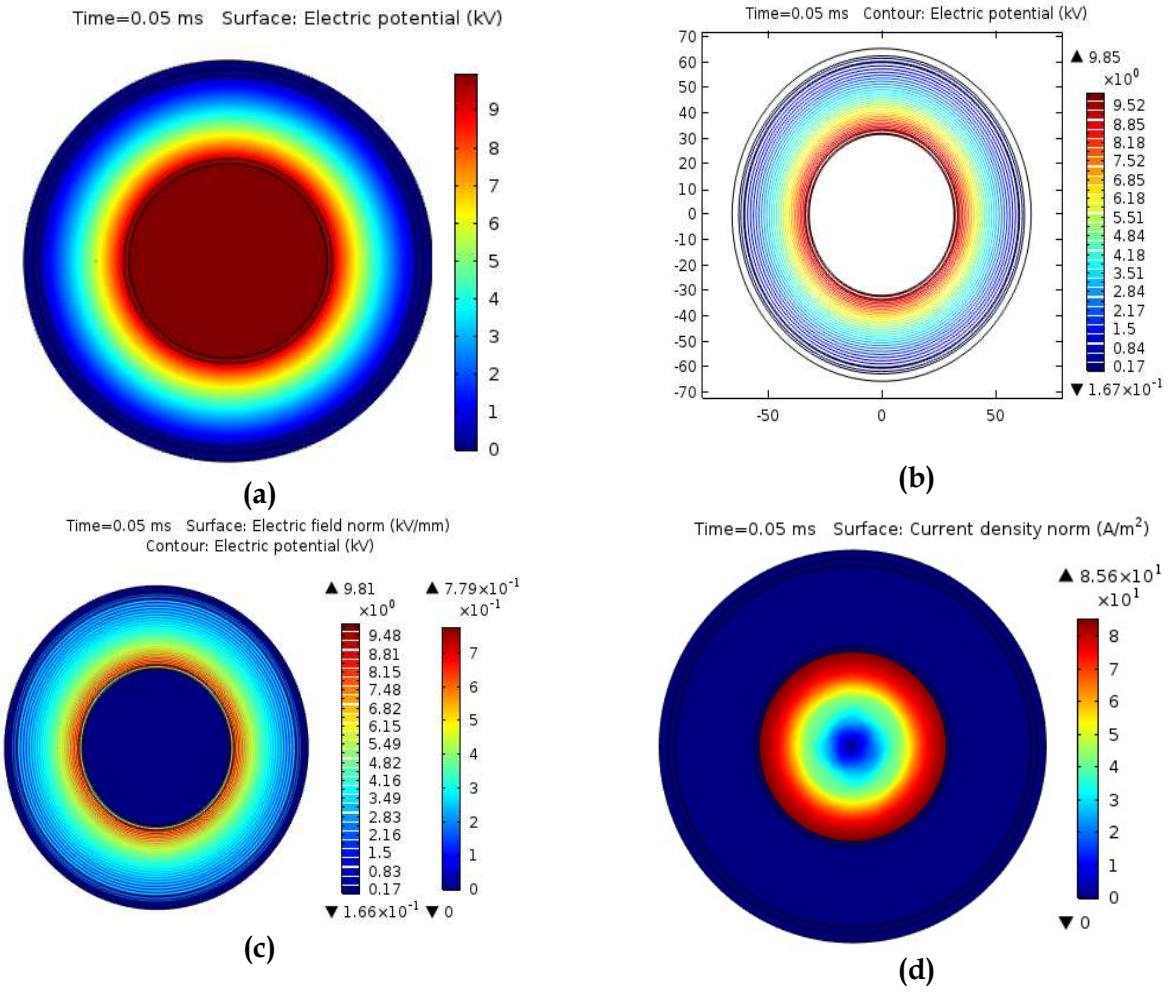


Fig.3 (a) Surface plot of electric potential (b) Contour plot of electric potential (c) surface plot of electric field distribution in XLPE cable (d) surface plot of surface plot of current density in XLPE cable

IMPACT OF CONTAMINANTS ON XLPE CABLE: CONSEQUENCES FOR OPERATIONAL RELIABILITY AND INSULATION QUALITY

Carbon black is used to create semi-conductive screening materials, and other necessary additives are included into the polymer matrix (Parpal J.-L et al., 1993). Previous research indicated that shield resin is highly polluted (Pelissou 1994). The authors Kwang S. Suh, Sun J. Hwang, Jin S. Noh, and Tatsuo Takada 1994 report on the ambiguity of charge buildup properties in XLPE. The mechanism of homocharge accumulation is known as space charge production, whereas heterocharge variation in XLPE is known as spatial charge. This disparity might be attributed to the composition of XLPE. However, very little study has been published on the fluctuation of current density caused by different contaminants in XLPE cable. Two instances have been recognized in relation to contaminants found in the insulation and shield regions. The current density and pulse voltage influence in situations are investigated. The reason is

that the influence of impurities on the shield causes a high intensity local effect, and therefore the influence of same impurities in the region far from the conductor is little due to uniform current distribution. Hence, the impact of current density involves inhomogeneous heating. Furthermore, when the contamination in the region far from the conductor is compared to the position of the inner shield, as illustrated in Figure 4.

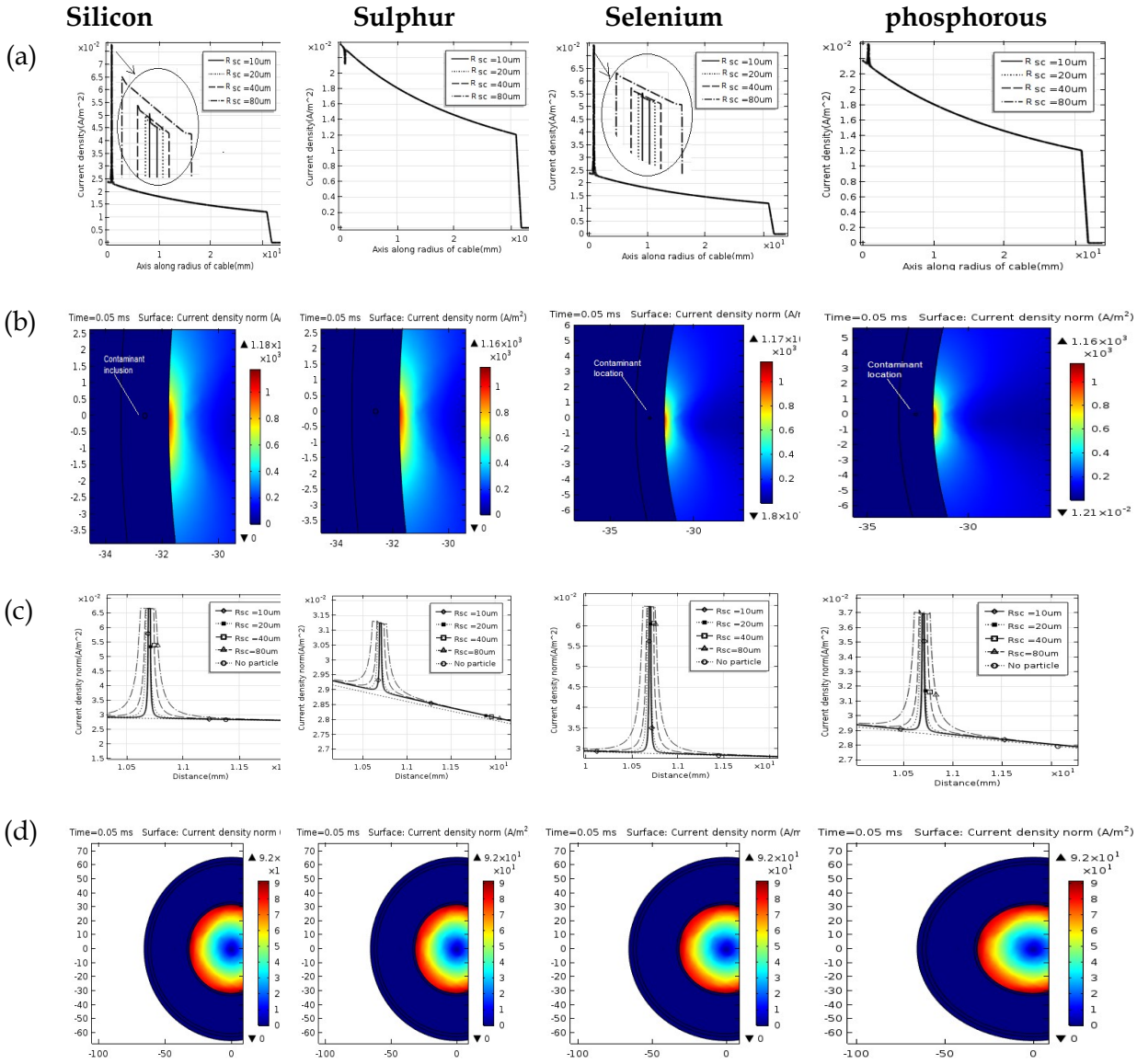


Fig.4 Intensity of Current density due to various contaminant on 400 kV XLPE cable (a, b) centre of inner shield at t,0.05ms (c,d) 1/3rd distance in the insulation

Fig. 4a and 4c explode the variation of current density under the presence of impurities in insulation and shield region. When the contaminant located on insulation as well as in shield region, the conductor achieved maximum current density of 58A/m² and 71.7A/m² respectively. It is found that the current density is not much varied due to utilization of smaller microns in both cases. From the above observed

results, the contaminant electrical conductivity equals even though contaminant size varies. The simulated value for each domain layer of XLPE cable is inner semicon 0.395 A/m², insulation 0.27 A/m², outer semicon 0.21A/m² .Compared to various impurities, the maximum current density obtained for silicon contaminant which is located in insulation region as 0.604 A/m² and for shield region is 0.79 A/m² . In the earlier study, simplified 2D model was repeatedly used to examine the influence of the contaminants. The different nature of spherical contaminants simulated by 3D model, which leads to better accuracy.

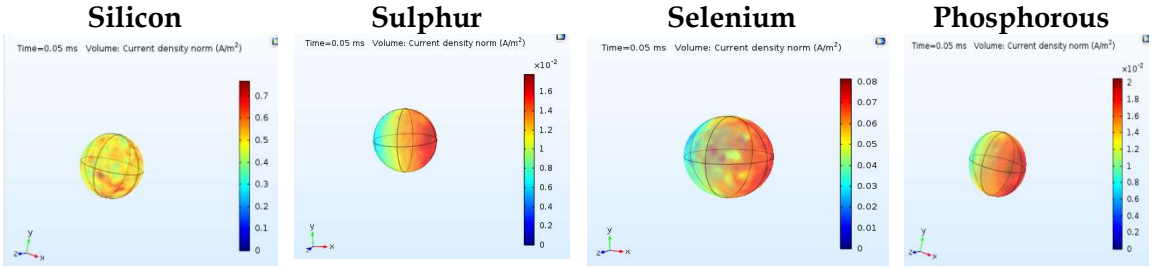


Fig. 5 Current density in the presence of 3D spherical contaminant with respect to time at center of the shield

Figure 5 signposts a volume plot and graphical pattern of current density for center of the shield location. According to the colour code, it is well cleared about the non-uniform distribution of current intensity in each contaminant case. The effect of selenium contaminant within inner shield is to increase the current density comparable to insulation region. Comparison between 2D and 3D results for same conditions of pulse voltage on spherical contaminants shows that sulphur contaminant result in smaller current density while silicon results larger. The nearer the contaminant to the conductor shield, the larger the current density. From figure 6, it may be accounted for comparing the results of various contaminant such as silicon 23.5%, sulphur 9.2%, selenium 22.4% and phosphorous 11.4% increase in the current density against position of contaminant in insulation region. It is well agreed with 2D and 3D simulation results are coordinated with each other.

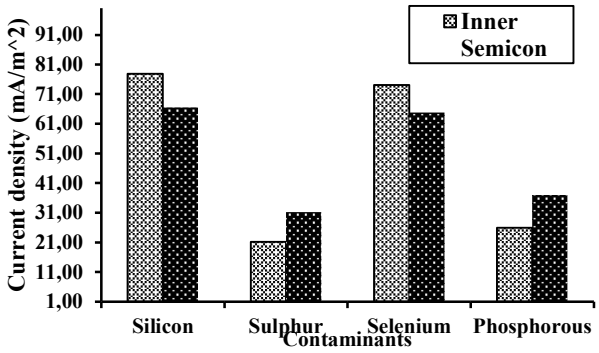


Fig. 6 Current density comparison for various contaminants in the location of XLPE cable

CONCLUSION

This study investigates the effects of impurities confined within the insulation and inner semiconductor shield of XLPE cables. The current density distribution within the contaminated regions under pulsed voltage conditions was analyzed. Results show that contaminants such as silicon and selenium, when present in the insulation layer, significantly increase electric field stress, potentially promoting water-treeing phenomena. Among all contaminant positions, those located in the insulation have a more pronounced impact compared to those in the conductor shield. Notably, the presence of sulfur on either the insulation or inner shield surfaces tends to reduce current density, whereas silicon contamination on the shield results in the highest current intensity—approximately 23.5% higher than when located in the insulation. These findings are based on the studied range of contaminant size, position, and material properties outlined in this work.

REFERENCES

[1]. Yang Xu, Pan Luo, Man Xu (2014), Investigation on Insulation Material Morphological Structure of 110 and 220 kV XLPE Retired Cables for Reusing, IEEE Transactions on Dielectrics and Electrical Insulation, vol. 21, no. 4, pp1686-1696.

[2]. T. Bulinski (1998), Polymer Oxidation and Water Treeing, IEEE Transactions on Dielectrics and Electrical Insulation, vol. 5,no. 4, pp.558-570.

[3]. R. Ross and J. J. Smit (1992), Influence of Aging Conditions on Water Tree Growth Processes, Proc. 1992 Intern. Conf. Conduct. Breakd. Solid Dielectr., pp. 368-72.

[4]. Z. H. Fan and N. Yoshimura (1996), Silver Tree, IEEE Trans. Dielectr. Electr. Insul., Vol. 3, pp, 131-135.

[5]. James J. Xu and Steven A. Boggs (1994), The Chemical Nature of Water Treeing: Theories and Evidence,"IEEE Electrical Insulation Magazine, vol.10, no.5, pp.29-37.

[6]. J.C.Fothergill, G.C. Montanari,et.al(2003), Electrical, Microstructural, Physical and Chemical Characterization of HV XLPE Cable Peelings for an Electrical Aging Diagnostic Data base, IEEE Transactions on Dielectrics and Electrical Insulation, vol. 10, no. 3,pp.514-527.

[7]. Karl-Michael Jäger and Lena Lindbom (2005), The Continuing Evolution of Semiconductive Materials for Power Cable Applications, IEEE Electrical Insulation Magazine, vol. 21, no. 1,pp.20-34

[8]. Andrew J. Thomas, Tapan K. Saha (2008), A New Dielectric Response Model for Water Tree degraded XLPE Insulation – Part A: Model Development with Small Sample Verification, IEEE Transactions on Dielectrics and Electrical Insulation,vol.15, no. 4, ,pp.1131-1143.

[9]. Zepeng Lv, Simon M Rowland (2017), A model and simulation of fast space charge pulses in polymers, Journal of Physics D: Applied Physics, 50, 445304 (10pp)

[10]. Serge Pdlissou (1990), Impurities in XLPE Cables, IEEE International Symposium on Electrical Insulation, pp.339-342.

[11]. Selvamany, Priya & Varadarajan, Gowri. (2019). Exploration of cross-linked polyethylene material morphological structure and its dielectric properties studied by the effect of pulse voltage. 1-5. 10.1109/CATCON47128.2019.CN0069.

[12]. J. . -L. Parpal, J. . -P. Crine, A. Houdayer and P. Hinrichsen (1993), Study of semiconductor impurity diffusion in XLPE cable insulation under electrical aging, Third International Conference on Power Cables and Accessories 10kV - 500kV, pp. 153-156.

[13]. S. Pelissou (1994), Impurities in XLPE cable resins, Proceedings of 1994 4th International Conference on Properties and Applications of Dielectric Materials (ICPADM), pp. 412-415 vol.1.

[14]. Kwang S. Suh, Sun J. Hwang, Jin S. Noh (1994), Effects of Constituents of XLPE on the Formation of Space Charge, IEEE transactions on Dielectrics and Electrical Insulation,1(6),pp.1077-1083.

[15]. Takeo Kubota,Yoshihisa Takahashi et.al, "Development of 500-kV XLPE Cables and Accessories for Long Distance Underground Transmission Line,"IEEE Transactions on Power Delivery, vol. 9, no. 4, ,pp.1741-1749. October 1994.

Predicting Energy Dissipation in Stepped Spillways Using Feature Selection and Machine Learning

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Abstract

Stepped spillways are vital hydraulic structures for flood control, requiring accurate prediction of energy dissipation ($\Delta E/E_0$) for optimal design. Traditional methods often face limitations in capturing complex flow dynamics. This study investigates the application of various soft computing techniques: Multivariate Adaptive Regression Splines (MARS), Artificial Neural Networks (ANN), Support Vector Regression (SVR), Decision Tree (DT), Gaussian Process Regression (GPR), and Ensemble Trees (En-T), for predicting energy dissipation on stepped spillways. Utilizing a published experimental dataset, we employed MARS for feature selection to identify the most influential hydraulic parameters. Two sets of models were developed: M1 using all initial features, and M2 using MARS-selected features (Froude number Fr_1 and drop number $DN=q^2/gH_w^3$). Performance was evaluated using R^2, RMSE, MAE, and MAPE. Results indicated that MARS, GPR, and particularly ANN models achieved superior accuracy and generalization. Feature selection via MARS (M2 models) yielded comparable or slightly improved performance over models using all features (M1 models), demonstrating the potential for more efficient and interpretable models. This research highlights the effectiveness of soft computing, especially ANN and MARS, combined with feature selection, for enhancing the design and optimization of stepped spillways.

Keywords : Stepped spillway; Energy dissipation predicton; Selection feature; MARS; ML

1. Introduction

Stepped spillways play a crucial role in hydraulic engineering by safely conveying floodwaters and dissipating excess energy, thereby protecting downstream areas. Accurate prediction of the relative energy dissipation, $\Delta E/E_0$, where E_0 is the upstream energy and ΔE is the energy dissipated, is essential for the safe and economic design of these structures. Traditional predictive methods can be complex or limited in their ability to capture the non-linear relationships involved.

Recent advancements in soft computing and machine learning offer promising alternatives for modeling complex hydraulic phenomena. Techniques such as Multivariate Adaptive Regression Splines (MARS), Artificial Neural Networks (ANN), Support Vector Regression (SVR), Decision Tree (DT), Gaussian Process Regression (GPR), and Ensemble Trees (En-T) have shown potential in various engineering fields due to their ability to learn from data and model non-linearities.

This paper investigates the application of these machine learning methods to predict energy dissipation on stepped spillways using a published experimental dataset. A key aspect of this study is the use of MARS for feature selection to identify the most critical parameters affecting energy dissipation. We compare the performance of models developed using all available features versus those using only the MARS-selected features to assess the impact of feature selection on predictive accuracy. The objective is to demonstrate the potential of these data-driven techniques for improving the design and optimization of stepped spillways.

2. Literature Review

Research on energy dissipation in stepped spillways has evolved significantly. Early studies relied heavily on physical hydraulic modeling. Researchers like Pegram et al. (1999), Chamani and Rajaratnam (1994), and Chanson (2001) conducted laboratory experiments to understand flow regimes (nappe, transition, skimming) and the influence of geometry on energy dissipation. While foundational, physical models struggle with complex non-linear relationships.

Recognizing these limitations, researchers turned to data-driven approaches. Salmasi and Özger (2014) pioneered a neuro-fuzzy approach, combining neural networks and fuzzy logic to handle imprecise hydraulic data, finding it more accurate than traditional regression for predicting energy dissipation in skimming flow. Jiang et al. (2018) combined Support Vector Regression (SVR) with a Genetic Algorithm (GA) for optimization, using parameters like relative critical flow depth, number of steps, and slope, achieving high accuracy (R2=0.9540) and outperforming a Back-Propagation Neural Network (BPNN). Nouri et al. (2020) compared AI-based methods (M5P, stochastic M5P, Random Forest) with regression, finding AI methods, particularly those using neural networks trained on large datasets, superior in capturing the complex factors influencing energy loss.

Soft computing techniques like MARS, ANN, SVR, DT, GPR, and En-T have proven effective in various hydraulic engineering problems, such as predicting river

stages, scour depth, sediment transport, flood forecasting, and water resource optimization. Their application in related fields like environmental and geotechnical engineering further supports their potential for stepped spillway analysis. This study builds upon this body of work by systematically comparing multiple ML techniques and explicitly incorporating feature selection using MARS to improve model efficiency and interpretability for stepped spillway energy dissipation prediction.

3. Methodology

3.1. Dataset and Preprocessing

This study utilizes the experimental dataset published by Salmasi and Özger (2014). The experiments were conducted in laboratory flumes at Shahid Chamran University, Iran, covering 20 stepped spillway configurations with varying step numbers (3-50), heights, and slopes (15°,25°,45°) under flow rates from 7 to 50 l/s. The dataset includes parameters like discharge (q), upstream and downstream energy (E_0 ,E_1), flow depths (y_1,y_2), and step geometry.

Dimensional analysis, following Salmasi and Özger (2014), was used to define relevant dimensionless parameters. The relative energy dissipation $\Delta E/E_0=1-E_1/E_0$ was expressed as a function of dimensionless groups derived using the Buckingham π-theorem. The key dimensionless input variables considered initially were Froude number (Fr1), relative critical depth (yc/h), drop number ($DN=q^2/gH_w^3$), number of steps (N), and spillway slope (S).

The dataset comprises 154 data points, split into a training set (108 points, 70%) and a testing set (46 points, 30%). Data preprocessing involved normalization to ensure suitability for ML models. Based on comparative performance evaluation, Z-Score standardization was selected as the normalization technique for subsequent modeling.

3.2. Feature Selection using MARS

Multivariate Adaptive Regression Splines (MARS) was employed for feature selection to identify the most influential input variables. MARS builds a model using piecewise linear basis functions, automatically selecting important variables and their interactions while avoiding overfitting. The optimal MARS model complexity (number of basis functions) was determined using Generalized Cross-Validation (GCV) and Mean Squared Error (MSE), identifying around 15 basis functions as optimal.

ANOVA decomposition and variable importance metrics (delGCV, nSubsets) from the MARS analysis (Table 3.1) indicated that the Froude number (Fr1) and the drop number ($DN=q^2/gH_w^3$) were the most significant predictors of energy dissipation. Variables y_c/h, N, and S showed negligible importance and were excluded by the MARS model.

Based on this, two modeling scenarios were defined:

M1: Models trained using all five initial dimensionless inputs (Fr1,yc /h,DN,N,S).

M2: Models trained using only the two MARS-selected inputs (Fr1,DN).

Table 3.1: Variable Importance and Subset Metrics for MARS model.

Variable	delGCV	nSubsets	subsRSS	subsGCV
Fr_1	39.473	16	100	100
y_c/h	0	0	0	0
q^2/gH^3	100	16	100	100
N	0	0	0	0
S	0	0	0	0

3.3. Machine Learning Models

Six machine learning techniques were implemented and compared using MATLAB (2019b):

MARS: Implemented as described above, using piecewise-linear functions based on comparative performance (Zeroual et al., 2024).

ANN: Feed-forward networks trained using backpropagation. Optimization involved selecting activation functions (Tansig chosen), training algorithms (Levenberg-Marquardt chosen), and the optimal number of hidden neurons (10 for M1, 5 for M2) via trial-and-error minimizing MSE.

SVR, DT, GPR, En-T: Implemented using MATLAB's Regression Learner App. Hyperparameters were optimized using 10-fold cross-validation. Optimal parameters (e.g., linear kernel for SVR, boosted ensemble for En-T) are detailed in Table 3.2.

Table 3.2: Optimal parameters of the four RLT models.

RLT method	Parameters	M1	M2
DT	Minimum leaf size	12	12
SVR	Box constraints	12	
	Epsilon	0.00031804	0.00031804
	Kernel function	Linear	Linear
	Standardised data	False	False
GPR	Sigma:	0.16623	0.16623
	Basis function	Zero	Zero
	Kernel function:	Isotropic exponential	Isotropic exponential
	Kernel scale	0.66404	0.66404
	Standarised data	true	true
EnT	Ensemble method	Boost	Boost
	Number of learners	57	57
	Minimum leaf size	2	2
	Number of predictors to	8	8

3.4. Performance Evaluation

Model performance was assessed using standard statistical metrics calculated on both the training and testing datasets:

- Coefficient of Determination (R2)

- Root Mean Squared Error (RMSE)
- Mean Absolute Error (MAE)
- Mean Absolute Percentage Error (MAPE)

The optimal model was selected based on maximizing R2 and minimizing RMSE, MAE, and MAPE, particularly on the testing set to evaluate generalization ability.

4. Results and Discussion

4.1. Performance Comparison (M1 vs. M2)

The performance metrics for all six ML techniques under both M1 (all features) and M2 (MARS-selected features) scenarios are presented in Tables 3.3 and 3.4, respectively.

Table 3.3: Values of performance parameters for model M1.

Set	Performance parameter	MARS	En-T	GPR	DT	SVR	ANN
Training	R^2	0.9994	0.9873	0.9975	0.9699	0.9594	0.9924
	RMSE	0.0230	0.1070	0.0479	0.1648	0.1913	0.0830
	MAE	0.0171	0.0691	0.0208	0.1052	0.1288	0.0536
	MAPE (%)	5.2017	16.9766	8.3347	33.6952	38.0409	18.5068
Testing	R^2	0.9932	0.9354	0.9008	0.8654	0.6374	0.9964
	RMSE	0.0804	0.2482	0.3077	0.3583	0.5881	0.0589
	MAE	0.0595	0.1927	0.2514	0.2722	0.4496	0.0448
	MAPE (%)	11.1624	57.9999	39.7419	93.3461	62.7608	17.6501

Table 3.4: Values of performance parameters for model (M2)

Set	Performance parameter	MARS	En-T	GPR	DT	SVR	ANN
Training	R^2	0.9998	0.9864	0.9999	0.9686	0.9023	0.9992
	RMSE	0.0147	0.1106	0.0005	0.1683	0.2970	0.0267
	MAE	0.0107	0.0736	0.0003	0.1115	0.2297	0.0174
	MAPE (%)	2.7666	20.2488	0.0988	37.5945	68.5699	5.2908
Testing	R^2	0.9977	0.9307	0.9811	0.8645	0.8566	0.9997
	RMSE	0.0471	0.2571	0.1343	0.3596	0.3699	0.01778
	MAE	0.0296	0.1972	0.0915	0.2743	0.2808	0.01143
	MAPE (%)	5.9658	58.4232	19.2713	95.0417	116.3142	3.5033

Training Performance: For both M1 and M2, MARS, GPR, and ANN models generally showed excellent fits on the training data, with R2 values close to 1 and very low error metrics (RMSE, MAE, MAPE). En-T, DT, and SVR showed comparatively lower performance on the training set.

Testing Performance (Generalization): The ANN and MARS models consistently demonstrated superior generalization ability on the unseen testing data for both M1 and M2 scenarios, maintaining high R2 values and low error rates. The ANN model, particularly ANN(M2), achieved the best testing performance overall (R2=0.9997, lowest RMSE, MAE, MAPE). GPR also performed well on the test set but showed a larger increase in error compared to training, suggesting some overfitting. En-T, DT, and SVR models exhibited weaker generalization, with noticeable drops in R2 and increases in error metrics on the testing set, indicating overfitting issues.

Impact of Feature Selection: Comparing M1 and M2 results, the models using only the two MARS-selected features (M2) achieved performance levels that were comparable to, or even slightly better than, the models using all five initial features (M1). This was particularly true for the top-performing models (ANN, MARS, GPR). This indicates that the MARS feature selection successfully identified the most critical predictors (Fr1 and DN) and that including the other variables (y_c/h,N,S) did not significantly improve, and in some cases might have slightly hindered, the predictive performance, especially for generalization. The M2 models offer the advantage of reduced complexity and potentially better interpretability without sacrificing accuracy.

Regression plots (Figures 3.1-3.2) visually confirm these findings, showing tight clustering around the ideal line for ANN and MARS in testing, while other models show more scatter, especially in testing. Boxplots of relative errors (Figures 3.3-3.4) further illustrate the lower error distribution and variance for MARS and ANN compared to other methods, particularly in the testing phase.

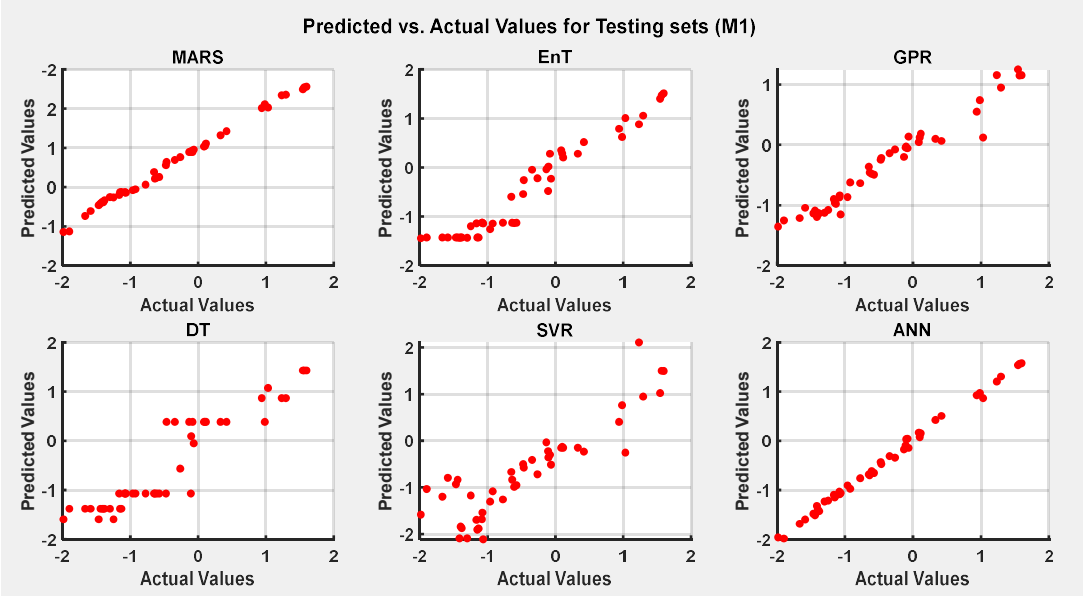


Figure 3.1: Regression plots between actual and predicted values for testing set. (M1).

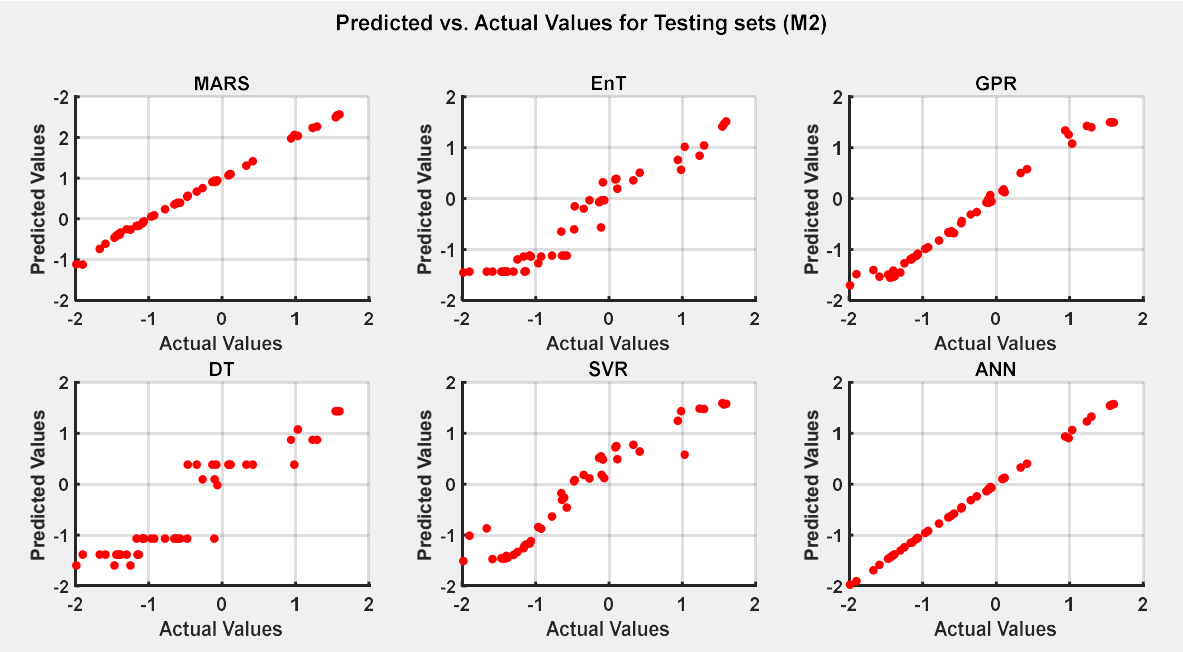


Figure 3.2: Regression plots between actual and predicted values for testing set (M2).

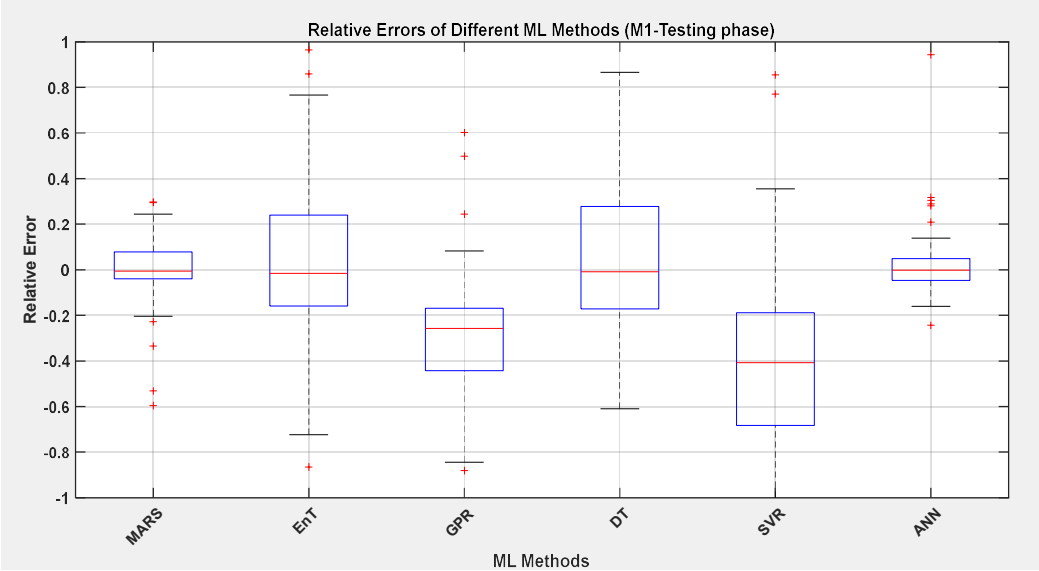


Figure 3.3: Representation of the relative errors for each method using boxplot diagram for model (M1)

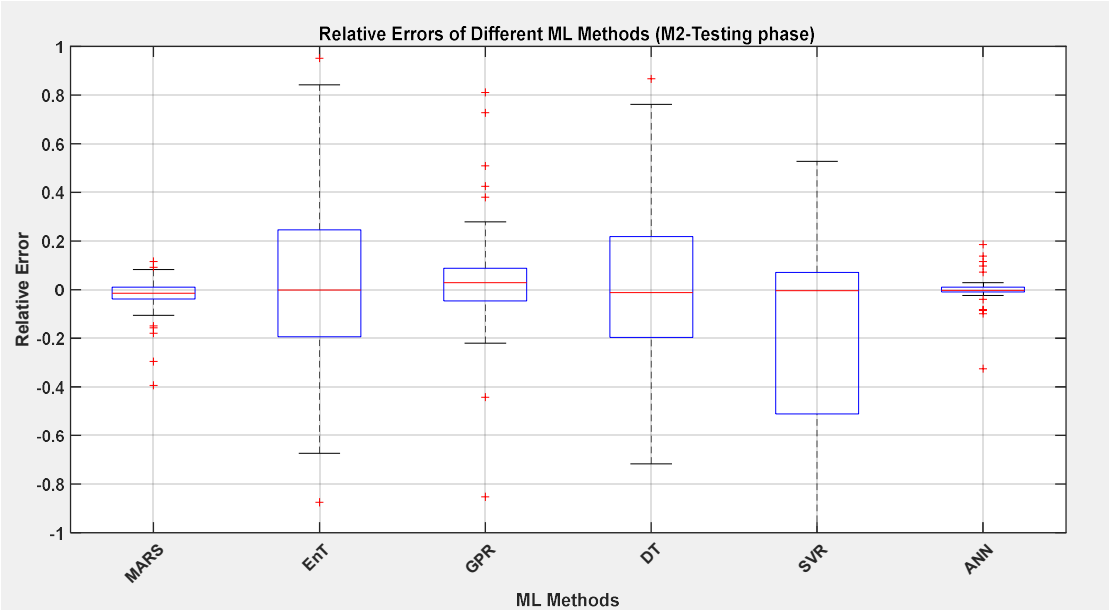


Figure 3.4: Representation of the relative errors for each method using boxplot diagram for model (M2).

4.2. Discussion

The results strongly suggest that machine learning techniques, particularly ANN and MARS, are highly effective for predicting energy dissipation on stepped spillways. The ANN model demonstrated the best overall performance and generalization capability.

The MARS feature selection proved valuable, identifying Fr1 and DN as the key drivers of energy dissipation in this dataset. Using only these two features (M2 models) led to simpler models with excellent predictive power, highlighting the benefit of feature selection for improving model efficiency and potentially interpretability.

The superior performance of data-driven models like ANN and MARS over potentially simpler models like DT or SVR (in this specific implementation) underscores their ability to capture the complex, non-linear hydraulic processes involved in energy dissipation over stepped structures. The enhanced accuracy offered by these models can lead to more reliable and optimized stepped spillway designs, improving safety and cost-effectiveness.

5. Conclusion

This study successfully demonstrated the application of various machine learning techniques (MARS, ANN, SVR, DT, GPR, En-T) for predicting energy dissipation ($\Delta E/E0$) on stepped spillways using a published dataset. MARS was effectively used for feature selection, identifying the Froude number (Fr1) and drop number (DN) as the most influential parameters.

Comparing models built with all initial features (M1) versus only MARS-selected features (M2), the results showed that M2 models provided comparable or slightly superior predictive accuracy, particularly for the top-performing algorithms (ANN, MARS, GPR). The ANN and MARS models consistently outperformed the other techniques, exhibiting high accuracy (R2>0.99 on testing) and excellent generalization capabilities.

The findings confirm that soft computing techniques, combined with effective feature selection, offer powerful tools for hydraulic engineers. They enable more accurate predictions of complex phenomena like energy dissipation, leading to improved design, enhanced safety, and optimization of hydraulic structures like stepped spillways. Future work could involve validating these models on broader datasets, exploring hybrid modeling approaches, and further investigating the physical interpretation of the model findings.

References

Chamani, M. R., & Rajaratnam, N. (1994). Jet flow on stepped spillways. Journal of Hydraulic Engineering, 120(2), 254-259. https://doi.org/10.1061/(ASCE)0733-9429(1994)120:2(254)

Pegram, G. G., Officer, A. K., & Mottram, S. R. (1999). Hydraulics of skimming flow on modeled stepped spillways. Journal of hydraulic engineering, 125(5), 500-510.

Chanson H. The hydraulics of stepped chutes and spillways [M]. Lisse, The Netherlands: A. A. Balkema, 2001.

Chanson, H., & Toombes, L. (2002). Energy dissipation and air entrainment in stepped storm waterway: Experimental study. Journal of Irrigation and Drainage Engineering, 128(5), 305-315. https://doi.org/10.1061/(ASCE)0733-9437(2002)128:5(305)

Jiang, L., Diao, M., Xue, H., & Sun, H. (2018). Energy dissipation prediction for stepped spillway based on a genetic algorithm–support vector regression. Journal of Irrigation and Drainage Engineering, 144(4), 04018003. https://doi.org/10.1061/(ASCE)IR.1943-4774.0001293

Nouri, M., Sihag, P., Salmasi, F., & Kisi, O. (2020). Energy loss in skimming flow over cascade spillways: Comparison of artificial intelligence-based and regression methods. Applied Sciences, 10(19), 6903.

Salmasi, F., & Özger, M. (2014). Neuro-fuzzy approach for estimating energy dissipation in skimming flow over stepped spillways. Arabian Journal for Science and Engineering, 39, 6099-6108. https://doi.org/10.1007/s13369-014-1240-2

Zeroual, A., Sekiou, F., Fourar, A., Ataoua, Z., Djeddou, M., & Seghir, T. (2024). Quantifying 3D and suction-induced effects on soil slope stability during rapid drawdown: a sensitivity study using the MARS-WOA approach. Modeling Earth Systems and Environment, 1-29. https://doi.org/10.1007/s40808-024-01954-z

Pervaporation Separation of Water-Ethanol Mixtures Using Blend Membranes of Poly (Ethylene Glycol) and Sodium Alginate

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Abstract

This study presents the development and evaluation of blend membranes composed of Sodium Alginate (NaAlg) and Poly (ethylene glycol) (PEG) for the pervaporation separation of water–ethanol mixtures. The membranes were fabricated via solution casting and cross-linked using glutaraldehyde in a water–acetone medium. Pervaporation experiments were conducted at 30 °C using aqueous ethanol feed mixtures containing 10–15 wt% water. Sorption studies were performed in both pure liquids and binary mixtures to assess polymer–liquid interactions and membrane stability in aqueous environments. Membrane performance was evaluated in terms of permeation flux and selectivity. Results revealed that the membrane exhibited the highest selectivity and lowest flux at 10 wt% water in the feed, while an increase in water content led to higher flux but reduced selectivity. The performance of the NaAlg–PEG blend membranes was compared with that of pristine NaAlg membranes, demonstrating enhanced separation efficiency for isopropanol dehydration. Membranes were characterized using Differential Scanning Calorimetry (DSC) and Fourier Transform Infrared Spectroscopy (FTIR), confirming successful blending and cross-linking. The membrane thickness ranged between 35 and 40 μm. Gravimetric sorption experiments, conducted on circular disc-shaped membrane samples, further validated the interaction behavior of the membranes in water–ethanol systems.

Keywords: Sodium Alginate, Poly(ethylene glycol), Pervaporation, Water–Ethanol Separation, Flux, Selectivity, Sorption, Cross-linking

Introduction

Pervaporation (PV) has emerged as a promising membrane-based separation technique for the selective separation of close-boiling and azeotropic liquid mixtures, particularly aqueous-organic systems where conventional methods such as distillation become energetically inefficient or economically unviable [1,2]. In a typical PV process, the liquid feed mixture flows along one side of a dense, non-porous membrane, while

the permeate is collected as vapor on the opposite side under reduced pressure or sweeping gas conditions. The overall transport through the membrane follows a solution–diffusion mechanism involving three sequential steps: (i) sorption and partitioning of the feed components at the membrane–feed interface, (ii) diffusion through the swollen polymer matrix, and (iii) desorption at the permeate side under vacuum [3]. PV offers several advantages over conventional separation techniques, including high selectivity, low energy consumption, mild operating conditions, and suitability for heat-sensitive and chemically reactive systems [4]. Polymeric membranes have been extensively employed in PV due to their tunable properties, ease of processing, and cost-effectiveness. Applications span across dehydration of alcohols, removal of organics from aqueous streams, separation of isomers, and aroma recovery from fermentation broths [5,6]. Recently, the development of polymeric blend membranes has gained significant attention to combine desirable properties such as high permeability from one component and mechanical robustness or selectivity from another. In this context, membrane modification strategies such as blending, crosslinking, and copolymerization have been explored to enhance performance characteristics [7].

Natural polymers, especially polysaccharides, are increasingly favored for membrane fabrication due to their renewability, biocompatibility, and functional versatility [8–10]. Sodium Alginate (NaAlg), a water-soluble anionic polysaccharide derived from brown seaweed, is particularly attractive owing to its excellent film-forming ability and modifiable structure. Composed of alternating blocks of β-D-mannuronic acid (M) and α-L-guluronic acid (G), the physicochemical properties of NaAlg—including hydrophilicity, flexibility, and ion-binding capacity—can be tailored by varying the M/G ratio or introducing crosslinking agents such as glutaraldehyde or multivalent cations [11–14]. Prior studies have demonstrated the utility of crosslinked NaAlg membranes in pervaporation, especially for the dehydration of alcohols and separation of water–organic mixtures [15–18]. Although efforts have been made to enhance NaAlg membrane performance through blending with hydrophilic polymers such as poly(vinyl alcohol) (PVA) or cellulose [19–21], studies involving Poly(ethylene glycol) (PEG) as a blending partner remain largely unexplored in the context of PV. PEG, a non-ionic, water-soluble polyether, exhibits excellent miscibility with other polymers, high chain flexibility, and good chemical stability. It has found wide applications in biomedical, pharmaceutical, and separation technologies due to its amphiphilic nature and molecular tunability [22–24]. Incorporating PEG into NaAlg matrices offers a unique opportunity to modulate hydrophilicity, enhance chain mobility, and potentially improve the sorption–diffusion dynamics critical to pervaporation [25,26].

To the best of our knowledge, there are no systematic reports on the pervaporation performance of NaAlg–PEG blend membranes for the separation of ethanol–water mixtures. This study aims to fill that gap by fabricating crosslinked NaAlg–PEG blend membranes and investigating their structural, sorptive, and separation properties. The membranes are characterized using Fourier Transform Infrared Spectroscopy (FTIR) and Differential Scanning Calorimetry (DSC), while their PV performance is evaluated in terms of flux and selectivity across varying water concentrations in the feed. The findings are compared with pristine NaAlg membranes to establish the synergistic role of PEG in modulating membrane behavior. These

insights are expected to contribute to the rational design of high-performance biopolymer-based membranes for energy-efficient liquid separations.

2. Experimental methodology

2.1 Preparation of PEG/NaAlg blend membrane

In this study, PEG/NaAlg blend membranes were synthesized via the solution casting method, a reliable and uniform film-forming technique commonly used for fabricating polymeric membranes. The blending ratio was optimized with 20% PEG and 80% sodium alginate (NaAlg), utilizing PEG for its hydrophilicity and NaAlg for its film-forming and ionic crosslinking properties. PEG was first fully dissolved in distilled water under constant magnetic stirring for 24 hours to ensure homogeneity. Subsequently, NaAlg was added to the solution. The resulting blend was cast onto a clean, dust-free glass plate and air-dried under ambient conditions to avoid bubble formation and ensure uniform film thickness. After drying, the membranes were crosslinked using a 75% aqueous-acetone bath containing glutaraldehyde (GA) and hydrochloric acid (HCl), promoting network formation through aldehyde-carboxylic interactions. This step enhances the membrane's mechanical strength and chemical stability. The final dried membranes exhibited a consistent thickness in the range of 30–35 µm, confirmed by micrometry.

2.2 Sorption studies

Sorption studies were conducted to assess the affinity of the blend membranes toward water and ethanol, which is essential for evaluating their pervaporation performance. Membranes were equilibrated with various feed compositions at 30°C for 48 hours in specially designed airtight chambers. After equilibration, swollen samples were carefully weighed following the removal of surface liquid using filter paper. The degree of sorption (DS) was calculated gravimetrically by comparing the weights of the swollen and dry membranes. This parameter provides critical information about the polymer's swelling behavior, influencing diffusion and transport selectivity during pervaporation[27] . After complete swelling, the % of sorption, DS, was calculated as:

$$\% \, DS = \left(\frac{W_\infty - W_0}{W_0} \right) \text{x } 100 \qquad \text{---------- 1}$$

where W_∞ and W_0 are weights of sorbed and dry membranes, respectively

2.3 Pervaporation experiments

Pervaporation (PV) experiments were performed to examine the dehydration performance of the PEG/NaAlg membranes. Before each experiment, membranes were equilibrated with the feed mixture for 2 to 4 hours. Permeate was collected over 4 to 5 hours in cold traps immersed in liquid nitrogen to minimize condensation losses. The weight of the permeate was measured using a high-precision balance, and flux was calculated based on the permeate weight, membrane area, and time of collection. Pervaporation selectivity (α_{PV}) was determined by comparing the water content in the permeate with that in the feed, as determined by refractive index analysis[28,29].

Pervaporation selectivity, (α_{PV}) was calculated as,

$$\alpha_{PV} = \left(\frac{P_A}{1-P_A}\right)\left(\frac{1-F_A}{F_A}\right) \quad \text{----------} \quad 3$$

4

Where F_A is wt % of water in the feed and P_A is wt % of water in the permeate.

All measurements were performed in triplicate to ensure accuracy and consistency under steady-state conditions.

2.4 Refractive index measurement

Quantitative compositional analysis of the permeate was carried out using an Abbe refractometer (Atago 3T, Japan) with a precision of ±0.0002. The instrument was equipped with a thermostatically controlled prism system to maintain constant temperature during measurements. The refractive index (nD) of the test liquid was determined by observing the boundary between light and dark fields in the viewfinder, allowing direct reading of nD values. The water content of permeates was estimated by comparing the measured values with a standard calibration curve.

2.5 Fourier transform infrared (FTIR) spectroscopy

FTIR spectroscopy was used to analyze chemical interactions and confirm the crosslinking in the PEG/NaAlg membranes. Finely powdered membrane samples were mixed with KBr and pressed into pellets under a hydraulic pressure of 600 kg/cm². To improve reproducibility, the pelleting process was repeated multiple times. FTIR spectra were recorded over a wavelength range of 400 to 4000 cm^{-1}. The presence and shifts of characteristic peaks corresponding to functional groups such as hydroxyl, carboxyl, and aldehyde confirmed successful blending and crosslinking.

2.6 Differential scanning calorimetry (DSC)

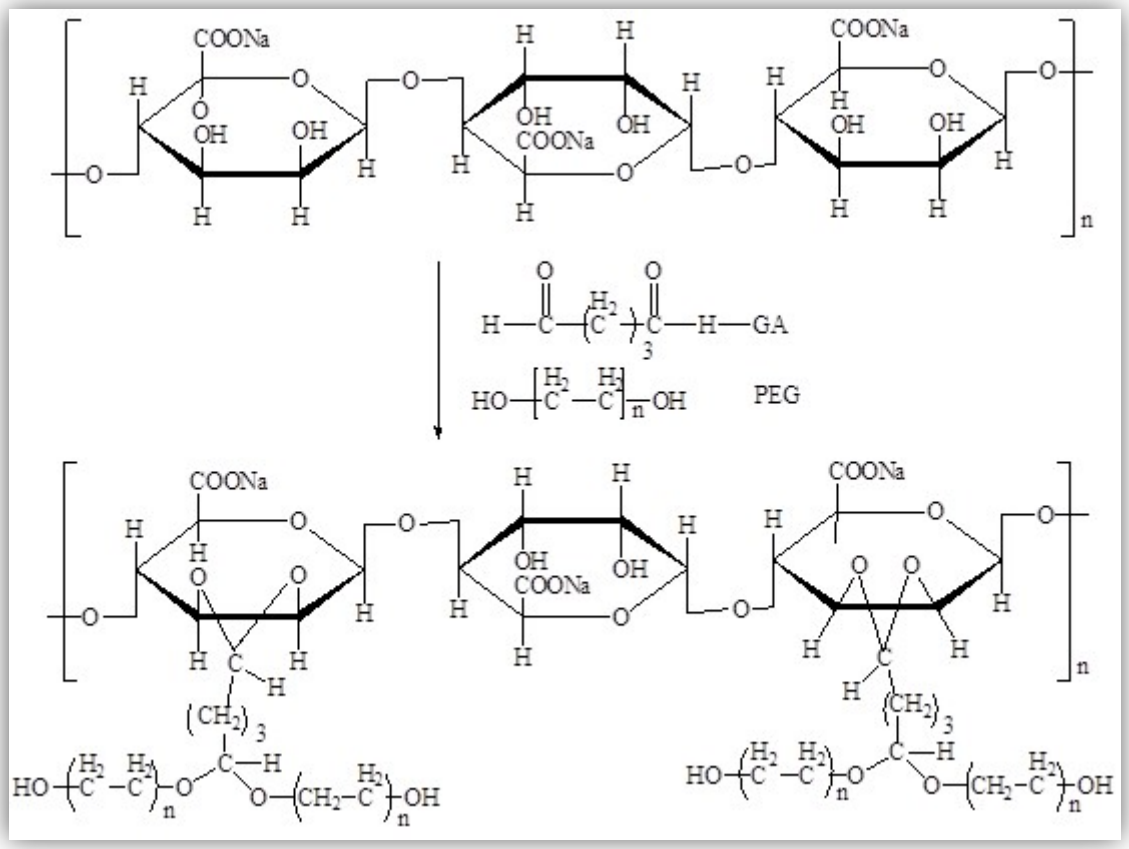
DSC analysis was performed to evaluate the thermal transitions and stability of the blend membranes. Samples were first heated to remove residual moisture. Thermograms were recorded from 30°C to 400°C at a heating rate of 10°C/min under a nitrogen atmosphere. The sample pan was conditioned before analysis to ensure measurement accuracy. Thermal data were used to assess the glass transition temperature, melting behavior, and phase interactions, providing insights into the membrane's structural and thermal stability.

3. Results and Discussion:

3.1. Crosslinking of NaAlg/PEG blend membrane

The solutions of PEG, NaAlg, and NaAlg–PEG blend were optically clear, showing no signs of phase separation or precipitation, even after 2–3 months at ambient temperature.

Scheme 1 illustrates the crosslink formation in the NaAlg–PEG blend via interaction with the –CHO groups of glutaraldehyde.



Scheme 1: Model structure of crosslinked NaAlg–PEG blend membranes

3.2. FTIR studies

FTIR spectra of (a) uncrosslinked and (b) crosslinked NaAlg–PEG blend membranes (Fig. 1) provide compelling evidence for the occurrence of crosslinking reactions. The prominent broad peak observed at 3401.03 cm^{-1} is attributed to O–H stretching vibrations from both NaAlg and PEG components, indicating hydrogen bonding and hydroxyl functionality in the polymeric matrix. Distinct sharp bands at 2925.5 cm^{-1} and 2863 cm^{-1} correspond to C–H stretching vibrations of aliphatic $–CH_2$ groups. A well-defined peak at 1647.34 cm^{-1} is associated with C=O stretching, likely from residual carboxylate groups of NaAlg. Notably, the marked increase in peak intensity at 1097 cm^{-1} in the crosslinked membrane signifies the formation of acetal linkages and ether bonds between hydroxyl groups of NaAlg/PEG and the aldehydic groups of glutaraldehyde. This increase strongly confirms the successful crosslinking reaction and structural modification of the membrane matrix

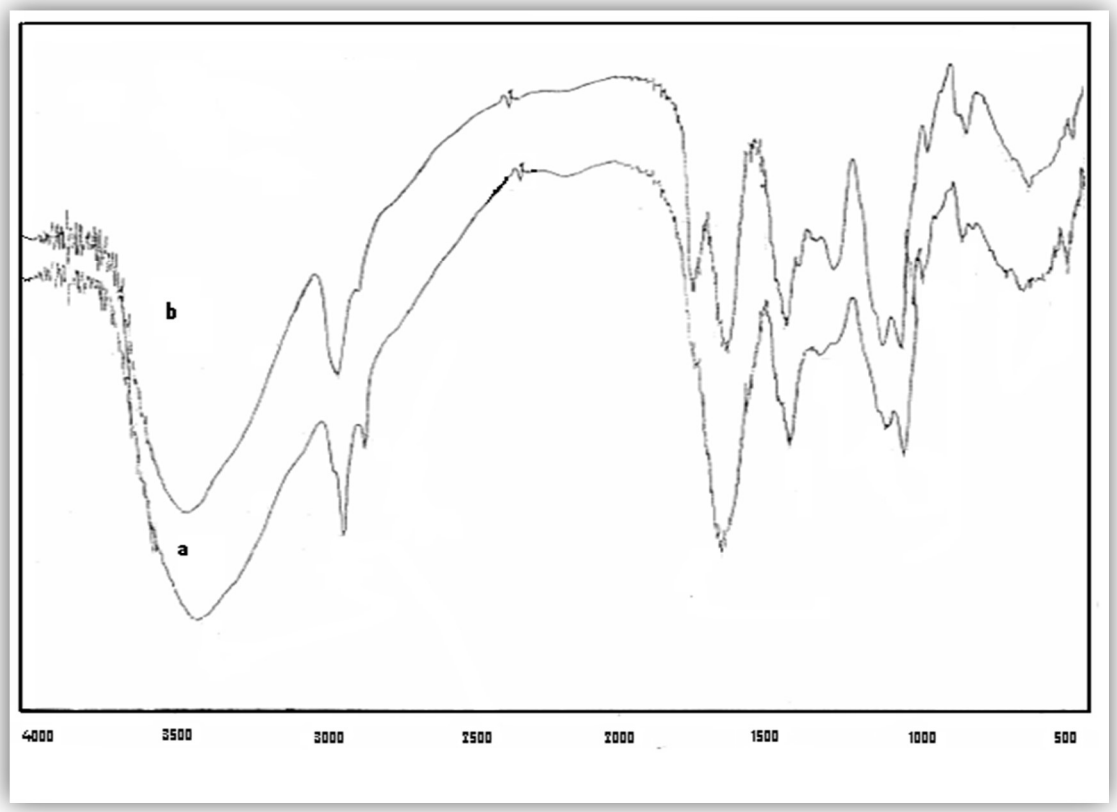


Fig. 1: FTIR spectra of (a) crosslinked and (b) uncrosslinked NaAlg–PEG blend membranes

3.3. DSC Analysis

Differential Scanning Calorimetry (DSC) analysis was performed to investigate the thermal behavior and phase transitions of NaAlg upon blending with PEG and subsequent crosslinking, as shown in Fig. 2. The thermogram of the crosslinked plain NaAlg membrane (Fig. 2a) exhibited a distinct endothermic peak at approximately 188°C, corresponding to its melting transition. In contrast, the uncrosslinked NaAlg–PEG blend membrane (Fig. 2b) showed a slightly reduced endothermic peak at around 182°C, indicating partial disruption of the crystalline structure due to the introduction of PEG into the NaAlg matrix. Further reduction in the melting transition to 178°C was observed in the crosslinked NaAlg–PEG blend membrane (Fig. 2c). This downward shift in melting temperature suggests a significant decrease in the crystallinity of the polymer matrix, attributed to the crosslinking process. The formation of covalent crosslinks likely hinders regular polymer chain packing, leading to reduced thermal stability and altered molecular mobility. These findings collectively confirm the structural modifications induced by both blending and crosslinking.

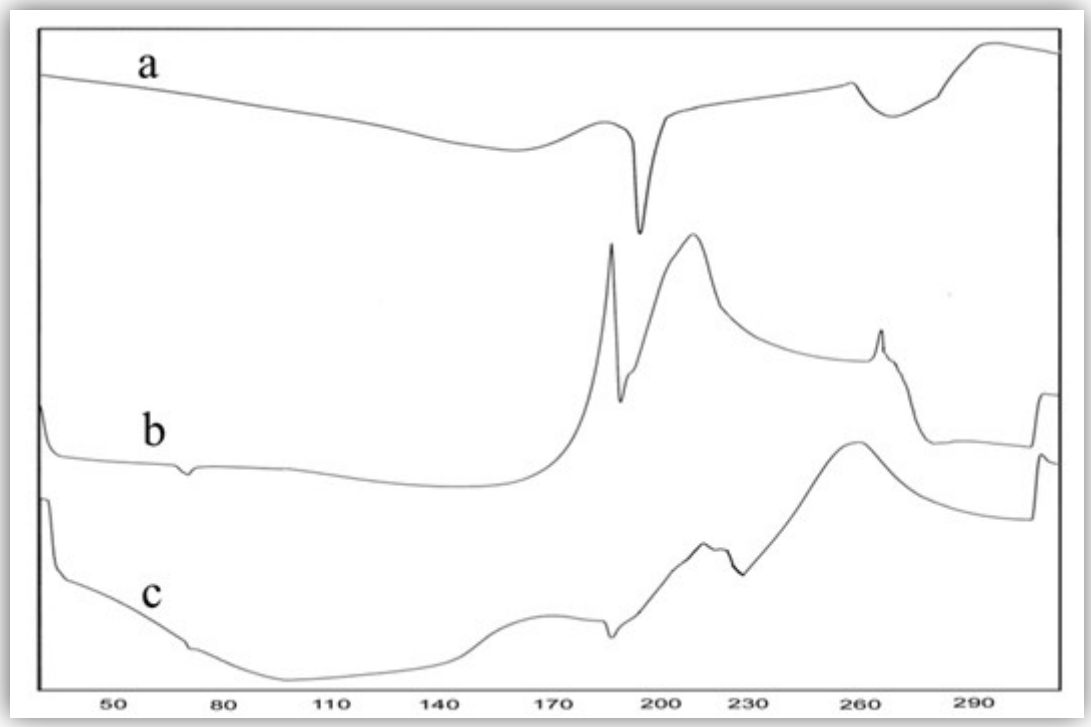


Fig. 2: DSC thermograms of (a) crosslinked plain NaAlg, (b) uncrosslinked NaAlg–PEG blend, and (c) crosslinked NaAlg–PEG blend membranes.

3.4. Swelling Results

The swelling behavior of NaAlg and NaAlg–PEG (80:20) membranes was evaluated in water–isopropanol mixtures with varying water content (0–100%) at room temperature, as shown in Fig. 3. Swelling is governed by the diffusion of solvent molecules relative to the relaxation of polymer chains, as described by Fick's theory [30]. The study revealed that swelling is inversely proportional to the degree of crosslinking, with crosslinked membranes exhibiting reduced swelling. The NaAlg–PEG (80:20) blend membrane demonstrated significantly higher swelling compared to plain NaAlg, indicating enhanced hydrophilicity. The presence of PEG in the blend increased membrane flexibility and free volume, thereby facilitating greater water uptake. These observations suggest that PEG incorporation enhances water selectivity and swelling capacity, making the blend membranes more suitable for aqueous separation applications.

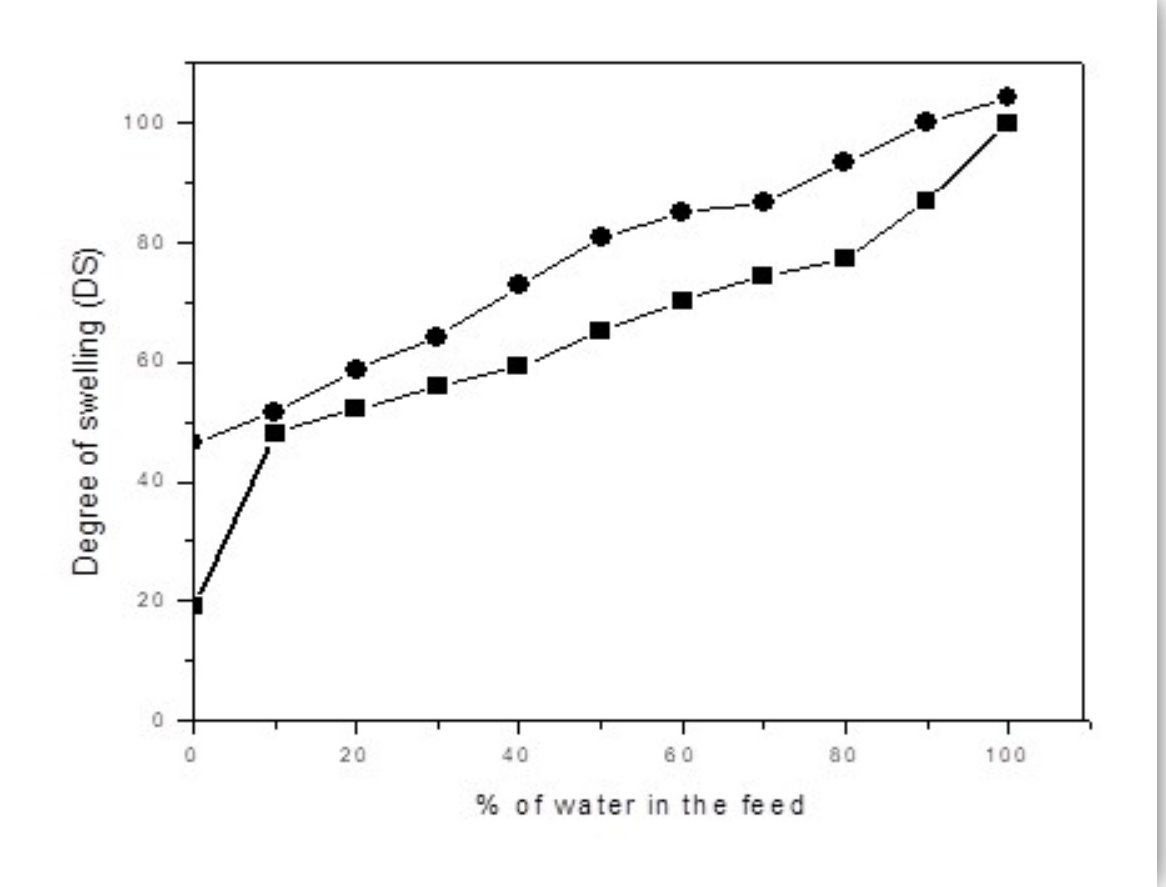


Fig. 3: Degree of swelling versus weight percentage of water in the feed for plain NaAlg (■) and NaAlg–PEG (80:20) (●) membranes at 30 °C.

3.5. Pervaporation (PV) results

3.5.1. Membrane performance

Pervaporation (PV) performance was evaluated by measuring flux and selectivity for water over ethanol, with molecular transport governed by the solution-diffusion model. The NaAlg–PEG blend membranes exhibited enhanced flux and selectivity compared to pure NaAlg membranes, primarily due to increased hydrophilicity and improved membrane swelling. This improved performance suggests that blending NaAlg with PEG positively affects the membrane's ability to separate water from ethanol in pervaporation applications [31,32]. Table 1 provides the detailed pervaporation performance data of both NaAlg and NaAlg–PEG blend membranes in water–isopropanol mixtures.

Table 1: Pervaporation performance of NaAlg and NaAlg–PEG blend membranes in water–isopropanol mixtures

S.No	Water in Feed (%)	Water Flux (kg/m² ·h)	Selectivity (α)	Water in Permeate (%)
Pure NaAlg membrane				
1	10	0.250	147.79	94.26
2	20	0.373	48.56	92.39
3	30	0.514	20.34	89.71
4	40	0.726	9.78	86.71
5	50	0.891	4.82	82.83
NaAlg–PEG (80:20) blend				
1	10	0.316	480.13	98.16
2	20	0.543	197.00	98.01
3	30	0.679	72.21	96.87
4	40	0.983	24.18	94.16
5	50	1.321	11.78	92.18

3.5.2. Effect of feed composition

The effect of feed composition on pervaporation performance was examined by varying the water content in the feed solution and evaluating its impact on both water flux and selectivity at 30°C. As shown in Fig. 4 and 5, for the pure NaAlg membrane, water flux increased significantly from 0.250 to 0.891 kg/m²·h as the water concentration in the feed rose from 10 to 50 wt%. This increase is attributed to enhanced membrane plasticization and swelling. However, a corresponding decline in selectivity was observed, dropping sharply from 147.79 to 4.82, indicating a trade-off between permeability and selectivity. In the case of the NaAlg–PEG (80:20) membrane, the flux rose even higher to 1.321 kg/m²·h with increased water content, reflecting greater swelling due to PEG's hydrophilic nature.

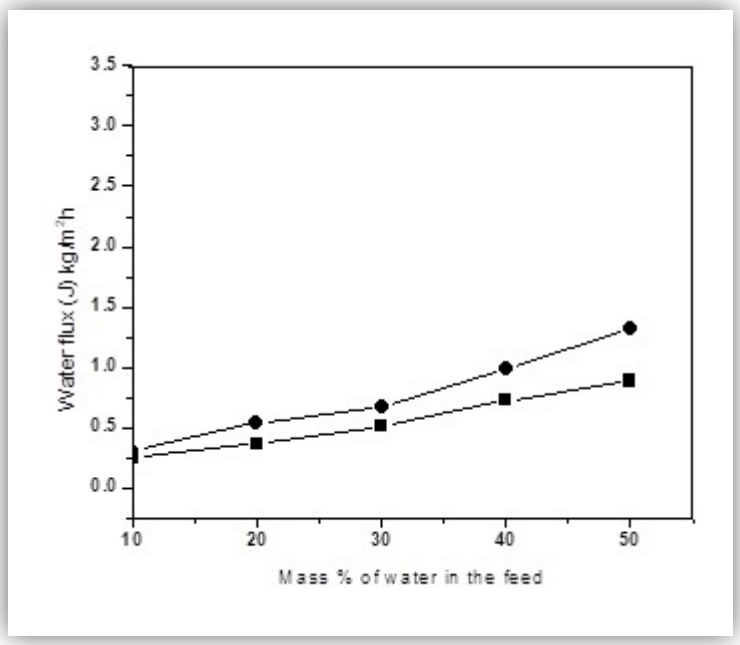


Fig. 4. Water flux vs. wt% of water in feed for plain NaAlg (■) and NaAlg–PEG (80:20) (●) membranes at 30°C.

Although selectivity also declined from 480.13 to 11.78; it remained higher than that of the pure NaAlg membrane across all compositions, demonstrating that PEG incorporation enhances water transport without compromising selectivity to the same extent.

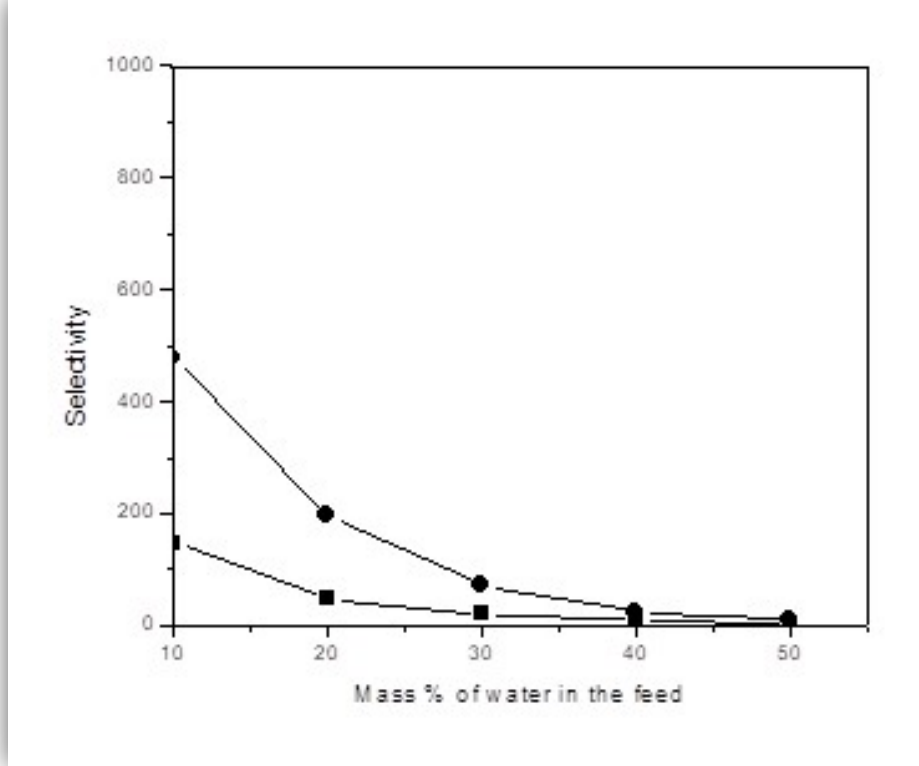


Fig. 5. Selectivity vs. wt% of water in feed for plain NaAlg (■) and NaAlg–PEG (80:20) (●) membranes at 30°C.

3.5.3. Comparison with literature

The pervaporation (PV) performance of the NaAlg–PEG (80:20) blend membrane developed in the present study demonstrates superior characteristics when compared with several literature-reported membranes for water–ethanol separation at 30°C. At a feed composition of 10% water, the NaAlg–PEG (80:20) membrane exhibited a flux of 0.316 kg/m² ·h and a remarkably high selectivity of 480.13. This is significantly higher than that of the plain NaAlg membrane from the current study, which showed a flux of 0.250 kg/m² ·h and selectivity of 147.79, indicating the positive impact of PEG incorporation in enhancing membrane hydrophilicity and transport performance. Compared to other reported systems (Table 2), such as the CS/NaAlg (50:50) membrane with 0.22 kg/m² ·h flux and selectivity of 436.45 at 13.56% water feed [33], the NaAlg–PEG (80:20) membrane provides a higher flux and better selectivity at a lower water feed concentration. Similarly, NaAlg/HEMA blend membranes at 10% water feed reported lower flux and significantly reduced selectivities—56 and 79 for 90:10 and 80:20 blends, respectively [34]. These comparisons clearly demonstrate that the NaAlg–PEG (80:20) membrane not only enhances water transport but also significantly improves water–ethanol separation efficiency, making it a promising candidate for efficient pervaporation applications.

Table 2: Comparison of PV performance of current NaAlg–PEG (80:20) blend membrane with literature-reported membranes for water–ethanol mixtures at 30°C

Membrane	Water in Feed (%)	Flux (kg/m² ·h)	Selectivity	Reference
Plain NaAlg	10	0.250	147.79	Present work
NaAlg–PEG (80:20)	10	0.316	480.13	Present work
CS/NaAlg (50:50)	13.56	0.22	436.45	[30]
NaAlg/HEMA (90:10)	10	0.210	56	[31]
NaAlg/HEMA (80:20)	10	0.245	79	[31]

Where: NaAlg: Sodium Alginate, CS: Chitosan, HEMA: Poly(hydroxyethyl methacrylate)

4. Conclusion

In the biopharmaceutical and chemical industries, ethanol is widely used as a solvent; however, its separation from water at the azeotropic point (89.4 mol% ethanol at 78°C) presents a significant challenge due to the formation of a constant boiling mixture. Traditional azeotropic distillation, which typically employs benzene as an entrainer, is not only energy-intensive but also raises concerns over product purity and safety due to the carcinogenic nature of benzene. In this context, pervaporation (PV) emerges as a promising alternative separation technique, offering lower energy consumption and eliminating the need for hazardous entrainers. The NaAlg–PEG (80:20) blend membrane developed in this study demonstrated excellent pervaporation performance with high water flux and selectivity at the azeotropic feed composition (10 wt% water), indicating its strong potential to effectively break the ethanol–water azeotrope. This performance highlights the membrane's suitability as a clean and efficient "third phase" in place of conventional entrainers. Moreover, the membrane's performance suggests its viability in hybrid separation systems, such as distillation–PV integration, for enhanced ethanol dehydration. Therefore, the NaAlg–PEG blend membrane not only offers a safer and greener alternative to conventional methods but also provides a robust platform for future industrial-scale applications in ethanol purification.

Acknowledgments

Not applicable

Availability of data and materials

All data generated or analysed during this review are included in this published article.

Competing interests

The author declare that they have no competing interests.

References

[1] Wang, X., Cui, W., Guo, W., Sun, B., Huang, M., Li, J., ... & Meng, N. (2024). Comprehensive Reviews in Food Science and Food Safety, 23(1), e13278.

[2] Cho, S. J., Choi, T. H., Jeong, H. G., Kwon, S. J., Hong, S. U., Kim, J. H., & Jeon, J. D. (2024). Journal of Environmental Chemical Engineering, 12(3), 112986.

[3] Dmitrenko, M., Mikhailovskaya, O., Dubovenko, R., Kuzminova, A., Myznikov, D., Mazur, A., ... & Penkova, A. (2024). Polymers, 16(9), 1206.

[4] Elewa, M. M. (2024). Separations, 11(10), 291.

[5] Aminabhavi, T. M., Khinnavar, R. S., Harogoppad, S. B., Aithan, U. S., Nyugen, Q. T., & Hansen, K. C. (1994). Journal of Macromolecular Science, Part C: Polymer Reviews, 34(2), 139–204. https://doi.org/10.1080/15321799408012833.

[6] R.W. Baker, E.L. Cussler, W. Eykamp, W.J. Koros, R.L Riley, H. Strathmann, Noyes Data Corp, Park Ridge, NJ, 1991.

[7] H. Okuno, T. Uragami, Polymer 33 (1992) 1459.

[8] L. Zhang, D. Zhou, H. Wang, S. Cheng, J. Membr. Sci. 124 (1997) 195.

[9] A. Chanachi, R. Jiraratananon, D. Uttapap, G.Y. Moon, W.A. Anderson, R.Y.M. Huang, J. Memebr. Sci. 166 (2000) 271.

[10] Benalaya, I., Alves, G., Lopes, J., & Silva, L. R. (2024). *International Journal of Molecular Sciences, 25*(2), 1322.

[11] K.S. Soppimath, T.M. Aminabhavi, A.R. Kulkarni, W.E. Rudzinsiki, J. Control. Rel. 70 (2001) 1.

[12] F. G. Fischer, H. Dorfel, Hoppe Seyler's Z. Physiol. Chem. 302 (1955) 186.

[13] A. Haung, B. Larean, O. Smolder, Acta Chem. Scand. 20 (1966) 183.

[14] S.T. Moe, K.I. Draget, G.S. Break, O. Smidsrod, Alginates, Marcel Dekker, New York, 1995, pp. 245-286.

[15] T. Uragami, M. Saito, Sep. Sci. Technol. 24 (1989) 541.

[16] A. Mochizuki, S. Amiya, Y. Sato, H. Ogawara, S. Yamashita, J. Appl. Polym. Sci. 40 (1990) 385.

[17] C.K. Yeom, K.H. Lee, J. Appl. Polym. Sci. 67 (1998) 209.

[18] R.Y.M. Huang, R. Pal, G.Y. Moon, J. Membr. Sci. 156 (1999) 101.

[19] C.K. Yeom, K.H. Lee, J. Appl. Polym. Sci. 67 (1998) 949.

[20] M.D. Kurkuri, U.S. Toti, T.M. Aminabhavi, J. Appl. Polym. Sci. 86 (2002) 3642.

[21] G. Yang, L. Zhang, T. Peng, W. Zhong, J. Membr. Sci. 175 (2000) 53.

[22] M.D. Kurkuri, U.S. Toti and T.M. Aminabhavi, J. Appl Polym Sci., 86 (2002) 3642.

[23] U.S. Toti and T.M. Aminabhavi, J. Appl. Polym. Sci., 85 (2002) 2014.

[24] T.M. Aminabhavi, S. Sridhar and B. Vijaya Kumar Naidu, J. Membr. Sci. 259 (2004) 105.

[25] J.H. Kim, J.Y. Kim, Y.M. Lee and K.Y. Kim, J. Appl. Polym. Sci., 45 (1992) 1711.

[26] S. Nakarsuka and A.L. Andrady, J. Appl. Polym. Sci., 44 (1992) 17.

[27] T.M. Aminabhavi, H.T.S. Phayde, J.D. Ortego, J.M. Vergnaud, Polymer, 37 (2000) 1677.

[28] T.M. Aminabhavi and H.G. Naik, J. Appl. Polym. Sci., 83 (2002) 273.

[29] T. M. Aminabhavi and H.G. Naik, J. Appl. Polym. Sci., 83 (2002) 244.

[30] J. Crank, The Mathematics of Diffusion, Clarenden Press, Oxford, (1975).

[31] R.C.Binning, R.J. Lee, J.F.Jennings, E.C.Martin, ind.Eng.Chem.Res. 53 (1961) 45.

[32] J.G. Wijmans, R.W. Baker, J. Membr. Sci. 107 (1995) 1.

[33] P. Kanti, K. Srigowri, J. Maduri, B. Smitha, S. Sridhar, Separation and purification Technology 40 (2004) 259-266.

[34] R.S. Veerapur, K.B. Gudasi, M.B. Patil, V. Ramesh Babu, S. D. Bhat, Sairam, T.M. Aminabhavi, Journal of Applied Polymer Science, Vol 101, 3324-3329 (2006).

Assessment of the Fishing Vessels and Marine Environment Protection in Albanian Coastal Areas

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Abstract

Oil spills through operational or accidental discharges are common in the activity of ships, especially in protected areas and in the Albanian coastal area. Due to the activity of fishing vessels and the presence of marine pollution, ecosystem development in the area is among the lowest in the region. The ecosystem along the coast is being threatened by constant erosion due to over fishing and the crude oil tanker traffic. Besides oil spills, ships activity emit other types of hazardous materials such as marine waste, hazardous and harmful substances that are sources of marine pollution. With increased shipping traffic, the current regime for environmental protection may not be sufficient to protect the marine environment of the area. With more ships traversing the area, safety and environmental concerns will become more acute for Albanian state. Fishing vessels usually do not comply with the rules of navigation and do not meet the standards required for the conservation of the marine environment.This paper examines this situation and proposes possible legal measures for coastal states to increase their regulatory power and enforcement that is limited by the application of the LOSC Convention. The proposed legal measures provide a platform to strengthen their power and to ensure that the marine environment can be protected from pollution and damage. An available option to assist in the protection of the coastal zone is to propose additional safeguards within the IMO competency such as the designation of separate areas under MARPOL 73/78. In adittion it is recommended that efforts be made to further promote the development of cooperation mechanisms between state and private institutions in the efficient management of the coastal zone. The coastal area is a navigational area, especially for cargo and fishing vessels, the proposed measures will not be fully applicable if their crews are unaware of them. Therefore, it is important for users of these tools to continue supporting existing plans for the protection and development of this area.This will ultimately promote a situation which maintains a better balance between the rights of navigation and the protection and preservation of the marine environment of the coastal area.

***Keywords*:** maritime transportation, fishing vessels, marine environmental, coastal areas, oil spills.

Introduction

The Republic of Albania is a country in South-Eastern Europe. It is bordered by Montenegro to the northwest, Kosovo to the northeast, the Former Yugoslav Republic of Macedonia to the east and Greece to the south and southeast. Albania has a coastline 427 km long with 273 km of coast in the West facing the Adriatic Sea and 154 km of coast in the South West on the Ionian Sea. Internal waters represent 735 km^2 and the territorial waters (extending from the internal waters to 12 nautical miles offshore) represent 5,322 km^2. Albania's marine ecosystems and coastal wetlands are rich in habitat typologies and associated biodiversity. They constitute an important part of natural heritage, not only for the country itself, but also for the Mediterranean region as a whole. The main threats to the coastal marine environment have been identified and are listed hereafter: uncontrolled urban and tourism development; increased pollution in particular due to untreated waste and sewage discharged into the sea; deforestation and erosion; low public awareness and education on marine and coastal issues; abusive interventions in river beds and watersheds; unsustainable land reclamation in coastal wetlands; illegal fishing and hunting; unsustainable fishery and aquaculture.[6,7]

Integrated Coastal Zone Management

Coastal erosion is a significant problem in the northern and central coastal regions. Sediment discharges from rivers are relatively large, which explains the very dynamic nature of the deltaic development of the coast, resulting in the rapid development of new coastal features, such as spits and lagoons. The main causes of coastal erosion are: sediment input (mainly brought by rivers); reduced sand amount in the coastal zone due to anthropogenic activities (sand extraction from beaches and the sea bottom – although this is prohibited by law); the changing location of river mouths in deltaic systems as a result of natural causes or anthropogenic effects; the alteration of the usual pattern of coastal currents and the associated sediment transport along and across the shoreline, due to manmade structures built along the coast.[1]

Management plans of protected areas will include at least the following:

a) Management objectives of a protected area;
b) Mechanisms and direction authority either of the Ministry of Environment, other state organs or organizations and juridical persons;
c) Processes and categories of activities which threaten or are menacing to the protected area and its surrounding areas inclusive;
d) Regulatory or administrative measures necessary to avoid or lessen the identified threats;
e) Permitted activities within the protected area;
f) The right activities for surrounding areas including buffer areas and beyond;
g) Conditions for control of tourism and other services;
h) Conditions for scientific research, inventory and monitoring;

Albanian coastal ecosystem resources and cultural assets to promote their sustainable development and management.[3,6]

The main outputs are:

- establishing an Integrated Coastal Zone Management institutional and policy framework;

- strengthening the broader regulatory and enforcement capacity at the central, regional and local levels for the protection of coastal and marine natural resources;
- increasing access to basic services associated with the improvement of the quality of life and attractiveness of the coastal areas; and
- implementing sub-projects aiming at promoting sustainable tourism development.

Implementation of Conventions for the Protection of Marine Environment

An emergency fishing incident is, first of all, the loss of the fishing gear. It is associated with failures of technical equipment, errors of vessels operators while fishing, meteorological conditions, etc. Fishing vessels must comply with the discharge restrictions, but are exempt from any specific ship-board equipment requirements.

In most cases this means that oily mixtures must be stored onboard for disposal at port waste reception facilities. This includes diesel, hydraulic fluids and bilge water with any concentration of oil.[4,9]

To reduce a potential oil discharge:

- All leakage of fuel oil, lubricating oil and cooling water should be dealt with as soon as it is detected. If repairs cannot be carried out by the crew at sea, they should be done as soon as the vessel reaches port.
- A drip tray should be fitted under all engines with suitable drainage to a holding tank or drum for disposal ashore.
- Make sure that engine rooms and other machinery spaces are fitted with sump plumbing so that any leakage is collected in the sump instead of the bilge.
- Make sure that the propeller shaft seal is in good working order.
- Where the manufacturer's warranty is not affected, high efficiency bypass oil filters can be installed that extend the life of the engine oil and reduce the need for frequent oil changes.

Lost fishing gear may harm the marine environment or create a navigational hazard.Garbage such as rope and plastic material can also get caught in propeller shafts or block water intakes, causing major damage and expensive repairs and posing a risk to the safety of vessels. Whenever practicable, fishing gear should have degradable panels of natural material to reduce the entanglement of marine life.[2]

The law states that fishing vessels must make every effort to retrieve all lost or damaged fishing gear. Fishing vessel operators are also required to record the discharge or loss of fishing gear in the garbage record book or ship log. The best way to avoid the discharge of garbage and the possibility of fines is to reduce the amount of potential garbage taken onboard and the amount of garbage generated through the use of packaged items. Where is possible, consider how much waste a product will generate when buying products.

The use of reusable and recyclable packaging and avoiding plastic packaging, unless it is reusable or recyclable, are all ways to reduce the amount of waste generated.

If fishing vessels are unable to incinerate their rubbish, they will need sufficient storage space and equipment-including cans, drums, bags or other containers-to retain all plastics for disposal ashore.[1,3]

Protecting the Marine Environment from Fishing Vessels

Fishing, including aquaculture, provides a vital source of food, employment, recreation, trade and economic prosperity to people around the world, present and future generations, and should therefore be addressed in a responsible manner.

Fisheries management bodies should through a suitable policy and appropriate legal framework, take measures for the conservation and sustainable use of fishery resources. Preservation and management measures at the local and national level should be based on the best scientific evidence and be conceived to ensure long-term sustainability to guarantee their existence for present and future generations.

The management of fishing and the impact on the environment objectives are:

- assessing the negative environmental consequences from human activities and where possible, correcting;
- reduce the consequences of pollution from waste, junk and lost fishing gear,
- development and use of fishing gear and techniques, economically viable and environmentally safe.

Where fishing capacity exists, such mechanisms should be established to include capacity monitoring of fishing fleets. Examine the characteristics of all existing fishing tools, methods and practices and take measures to ensure that tools, methods and practices that are not in line with technical standards are excluded and replaced with more acceptable alternatives.

Owners and managers should ensure that their vessels are equipped with the appropriate equipment as required by the MARPOL 73/78 Convention and must consider installing a combustion furnace for the relevant types of vessels for the purpose of handling waste of food and other waste generated during normal ship's service. In adittion, the fishing vessel crew must be familiar with the proper procedures of the ship board in order to ensure that the discharges do not exceed the levels established by MARPOL 73/78. These procedures should include the elimination of oil waste and the handling and collection of other shipboard waste.[3,10]

In the design and construction stage of ports and harbors for fishing vessels should be considered:

- to provide safe places for fishing vessels and adequate service structures for ships,
- ensure the supply of fresh water and sanitation facilities;
- to implement waste elimination systems, including the elimination of oil, oil residues and damaged fishing gear;
- minimize pollution from fishing activities and external factors;
- settle agreements between different actors to combat erosion and sedimentation effects,

- to establish an institutional framework for the improvement of port facilities for fishing vessels, which shall include consultation between the responsible authorities for the management of the coastal area.

In this aspect, little has been done in Albania to bring favorable conditions for fishing in the exercise of their normal activity. Today, most of the fishing ports are in bad conditions, whether in their structural conditions or in the opportunities they have to serve fishermen. Actually there are four fishing ports in Albania positioned in: Durres, Vlore, Sarande and Shengjin.

Tab 1 Fishing vessels statistics in Albanian ports

Port Name	Ship number	Amortization	Service Years
Durrës	90	30%	20-30
Vlora	65	40%	30-40
Saranda	45	25%	25-30
Shëngjin	55	30%	20

About 60% of the ships are imported after 1990 and about 40% are inherited from the state enterprise before 1990. Fishing vessels result in variations ranging from 10 to 33 m in length. The technical conditions are very bad with an average age of about 35 years old. Furthermore, fishing ports need to scrub, deepen and build new quays for vessels.

From frequent inspections it turns out that no ship is equipped with deposits for the collection of oil waste accumulated by the use of the vessel.

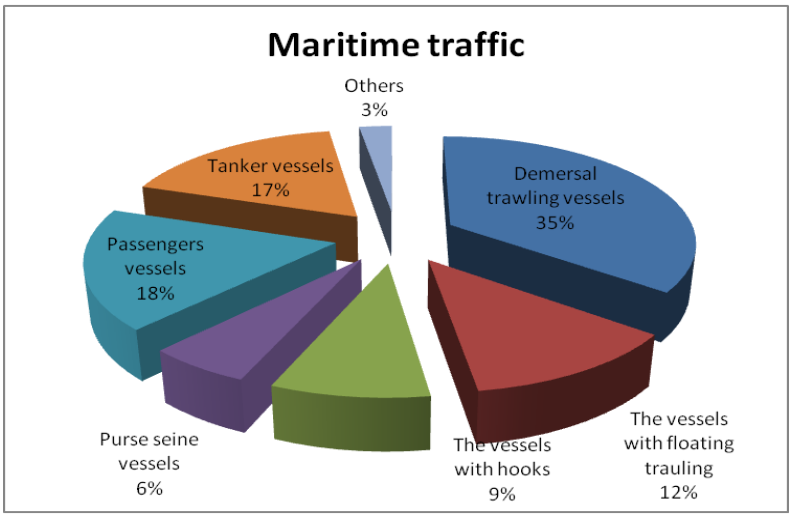


Fig 1 Maritime Traffic in Albania

There are no fuel filtration and separation plants for wastewater residues that are mandatory under the MARPOL 73-78 Convention. Furthermore, there is no company licensed for the removal of waste, such as oil, oil residues and other waste on board. As a result of these deficiencies, the wastewater mixed with engine oil is discharged into the sea, creating a major threat to the marine environment.



Fig 2. Fishing Port of Vlora

The fishing industry in Albania contributes significantly to the national economy both in terms of economic income for the country and employment. It is one of the industries that need investements to enhance shipping safety and to maintain the standards of uncontaminated marine environment. Meanwhile, fishing boats have been an important contributor to the reported marine pollution incidents. Fishermen have an increased responsibility not to pollute the sea that secures their livelihoods. [6,7]

Integration of Fishing Activities in Coastal Zone Management

Fishers must be recognized as major stakeholders, with their representatives included in general coastal management planning. Authorities should have a role in environmental impact studies, issuing construction permits, drafting laws and regulations, and in decisions regarding the use of coastal areas.

Internal disputes may arise between fishers from different places using the same area, and between different groups of fishermen, especially with regard to the use of different fishing gears. Regulations on when and where fishing may be done, or placing limitations on the use of different gears in different areas or at different times, are examples of ways to resolve internal disputes. These regulatory measures should be developed and implemented in consultation with the fishers. [1,9]

If potential conflicts between fishers and other groups using the marine environment are anticipated, some conflicts may be avoided. The important thing is that fisheries and coastal area management authorities work cooperatively to identify and resolve conflicts quickly and fairly.

This requires:

- to provide an appropriate policy, legal and institutional framework with the aim to achieve sustainable and integrated use of resources, taking into account

the fragility of coastal ecosystems and the finite nature of their natural resources and the needs of coastal communities.

- ensure that fishers and fishers representatives are consulted in decision-making processes and engage in other activities related to planning and development of coastal zone management.
- to develop, as appropriate, the institutional and legal framework for defining the potential use of coastal resources and managing the use of these resources, taking into account the rights of coastal fishing communities and their traditional practices, how they are in line with sustainable development.
- support the introduction of fishing practices that avoid conflict between fishery users, and between them and other users of the coastal zone.

With damage prevention in focus, it is important to identify potential effects of development activities as early as possible. Fishery authorities should monitor, or be able to collect information on areas of interest to the sector. Fisheries are best integrated into overall coastal development through informed cooperation with agencies representing other activities in the area. The aim is to balance various kinds of developments with the protection of the natural environment, for the benefit of all coastal area communities.

National Laws and International Conventions

In our national legislation, the basic norms related to the pollution of the coastal zone by vessels are set by recognizing the shipowner liability regarding sea pollution. This includes procedures relating to the prosecution of ships and their owners in the event of marine pollution and damage to coastal areas by vessels, including fishing vessels.

In accordance to the provisions of current national legislation, direct or indirect discharging of ballast and bilge water and dumping of any kind of waste and residues from ships and waterborne crafts into the sea within the territorial waters, free zones and Exclusive economic regions of Albania, inland waters, straits, harbors, canals and shores have been prohibited.

All marine and coastal protection activities are based on the implementation of national laws and international conventions that Albania has already ratified.[5,7]

The Conventions, with relevance and impact on coastal areas, rectified and signed by the Albanian state authorities include the following:

- In 1990, Albania acceded to Barcelona Convention for the Protection of Mediterranean Sea against Pollution;
- On November 29, 1995, Albania acceded to the Ramsar Convention and ratified it on March 29, 1996. This is very important in terms of management and administration of the wetland ecosystems, which are very prominent in the Albanian coast;
- In 2001 Albania ratified amendments of the Barcelona convention and its six protocols.
- Under the sub-agreement with UNESCO, Albania is making efforts to install pollution monitoring systems in the coastal areas.

- International Convention for the Prevention of Pollution from Ships, (MARPOL73-78),
- Law for the Protection of the Marine Environment of the Republic of Albania from pollution and damage 2002;
- The law on Environmental Impact Assessment in Albania 2003.
- The law on Ship and Port Security in Albania 2004.
- The law on Environmental Protection in Albania 2011.

CONCLUSIONS

Integrated Coastal Management is necessary to ensure that costal areas are planned, developed and managed in a responsible and longterm sustainable way. The coastal zone is subject to many competing uses and fisheries may be pushed out or marginalized and given lower priority because fishers and their communities are not as well organized or vocal as other interests such as those from the tourist industries, aquaculture, manufacturing, etc.[7,8]

To prevent engine spills from seeping off the coast;

- It is necessary to invest more in the professional training of the crew and captains, especially in those cases where the ships in which they work carries dangerous cargo;
- Apply monetary sanctions;
- All the shipping operators should be aware of their responsibilities in the event of pollution of the marine areas;
- Constant accurate measurement of oil concentrations in water via reliable real-time equipment.
- Establish a mechanism that helps long-term partnerships with industry, government, and local communities with the oversight of environmental problems in coastal areas;
- Involving local citizens in the process of preparing, approving, and revising contingency oil spill plans;
- National integration with each regional unit of priorities, programs and strategies for environmental protection;
- Port facilities are required to have all the capacity to manage risky situations in case of oil spills at sea.
- Use of new technologies that minimize negative environmental impacts.
- Perhaps the best strategy to reduce marine pollution is environmental education. Most people are unaware of the sources and the dangerous effects of marine pollution. Inform the population and all data should be made known.[2,6]

A "participatory or inclusive" approach to Integrated Coastal Management is important to ensure that all legitimate interests in the coastal zone are fairly and transparently represented. By involving all interests in this way, better policies and measures will be developed for management. More importantly, this type of participation should also lead to a greater level of compliance with measures and regulations after they are adopted and implemented. Furthermore, people from the

different interest groups will consider themselves to have been part of the development process and they will feel some "ownership" over it. [8,10]

REFERENCES

1. S.S. Moyseenko, L.E. Meyler & V.A. Bondarev "Risk Assessment for Fishing Vessels at Fishing Grounds" the International Journal on Marine Navigation and Safety of Sea Transportation Volume 9 Number 3 September 2015 pp 351-355.
2. West, A., Marine Pollution from Vessel Sewage in Queensland, Australian and New Zealand Maritime Law Journal, Vol. 18, Murdoch University, 2004, pp. 126-151.
3. International Convention for the Prevention of Pollution from Ships, (MARPOL73-78), Annex 1, regulation 16, pp 80.
4. United Nations Convention on the Law of the Sea 1982 (UNCLOS), Article 204, SECTION 4, Monitoring of the risks or effects of pollution, pp 101.
5. United Nations Convention on the Law of the Sea 1982 (UNCLOS), Article 211, SECTION 5, Monitoring of the risks or effects of pollution, pp 103.
6. Law for the Protection of the Marine Environment of the Republic of Albania from pollution and damage, Tirana 2002.
7. Sh. Sinanaj, "Albania National Strategy in Response to Coastal Pollution from Ships and Maritime Disasters" 6th International Maritime Science Conference, Solin Croatia 2014, pp 145-149.
8. Integrating Fisheries ito Coastal Area Manaxhement, the fish site editors 2009.
9. Law No. 15, dated 8 February 2024 on the Marine Environment Protection Strategy of the Republic of Albania.
10. Assessment of the State of Marine Environment in Albania (1991–2015).

The Role and Impact of Information and Communication Technology (ICT) in Higher Education

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Abstract

The digital transformation of higher education is one of the most significant shifts in global academic systems in recent decades. At the core of this transformation lies Information and Communication Technology (ICT), which has redefined how knowledge is created, disseminated, and consumed. This paper critically examines the role of ICT in higher education, exploring its impact on pedagogy, institutional governance, learner outcomes, research, and global academic engagement. The study also identifies key challenges such as infrastructural limitations, faculty readiness, policy inconsistencies, and the socio- economic digital divide. It concludes with recommendations for sustainable integration and potential future directions, emphasizing the need for a student- centric, inclusive, and innovation-driven higher education ecosystem. The paper draws upon both global and Indian contexts, recognizing the diverse challenges and opportunities ICT presents in a digitally evolving world.

Keywords: ICT, Higher Education, Digital Transformation, Pedagogy, Learning Outcomes, Virtual Classrooms, Online Assessment, Digital Divide, Policy, Blended Learning, Future Skills.

1. Introduction

The evolution of higher education over the past few decades has been inextricably linked with technological advancements. Among these, Information and Communication Technology (ICT) stands out as the most transformative force. ICT refers to a broad set of digital tools and resources used to create, store, manage, and share information. These include computers, the internet, broadcasting technologies (radio and television), and telephony.

The higher education sector, characterized by knowledge creation and intellectual exploration, has embraced ICT to meet the growing demands of mass education, global competition, and the need for lifelong learning. The COVID-19 pandemic further accelerated ICT adoption, compelling institutions to move beyond physical campuses to virtual platforms. This digital pivot was not just a temporary workaround but a glimpse into the future of learning.

ICT in higher education is not merely about replacing chalkboards with smart boards or classrooms with Zoom calls. It represents a paradigmatic shift in how learning is conceptualized, structured, delivered, and assessed. It enables personalization of education, encourages collaborative learning, and bridges geographical and socio-economic barriers.

However, despite its immense potential, the integration of ICT in higher education systems—particularly in developing countries like India—remains uneven. This paper investigates the evolving role of ICT in higher education and assesses its multifaceted impact while identifying challenges and proposing strategies for effective implementation.

2. Literature Review

2.1 Conceptual Foundations

ICT has been widely studied in educational research as both a pedagogical tool and a strategic enabler. According to Anderson and Dron (2011), ICT- enabled education has progressed through three major pedagogical paradigms: cognitive-behavioral (focused on content delivery), social- constructivist (focused on learner interaction), and connectivist (focused on digital networking and knowledge co-creation).

Laurillard (2012) introduced the concept of "teaching as a design science," emphasizing that digital tools allow instructors to design learning experiences that are responsive and adaptive. Bates and Sangrà (2011) stress the role of ICT in managing educational change and fostering scalable, cost-effective learning systems.

2.2 Global Perspectives

Globally, ICT integration in higher education has been most successful where it aligns with institutional goals, policy support, and faculty training. The European Commission's Digital Education Action Plan (2021) underscores the importance of fostering digital readiness across institutions, curricula, and teaching practices.

In the United States, universities increasingly offer MOOCs, flipped classrooms, and AI-driven adaptive learning systems. According to Educause (2020), over 80% of higher education institutions in the U.S. use LMS platforms to support hybrid learning environments.

2.3 Indian Context

In India, the National Education Policy (NEP) 2020 places significant emphasis on digital education, promoting initiatives like SWAYAM, DIKSHA, and the National Digital Library. While premier institutions like IITs and IIMs have pioneered ICT-driven innovations, many state and rural universities face challenges related to funding, connectivity, and training.

Sharma and Mishra (2017) note that ICT adoption in Indian higher education is often top-down and policy-driven, lacking adequate stakeholder engagement. Bridging this implementation gap remains a critical area of focus.

3. Methodology

This study adopts a qualitative, interpretive research methodology aimed at synthesizing existing literature, policy frameworks, and institutional case studies related to the integration of ICT in higher education. The focus is on understanding the conceptual underpinnings, implementation practices, and observable impacts of ICT within diverse higher education settings, with special reference to India.

3.1 Data Sources

The analysis is grounded in; Peer-reviewed journal articles, books, and conference papers on educational technology, Reports from national and international organizations (e.g., UNESCO, World Bank, MHRD, UGC), Government policy documents such as the National Education Policy (NEP) 2020, Institutional reports and case studies from selected universities implementing ICT- based learning environments.

3.2 Analytical Framework

The data were analyzed using thematic content analysis, guided by three broad themes; Adoption and integration: How ICT is embedded in teaching, learning, and administration, Impact and effectiveness: Measurable and observed benefits to students, teachers, and institutions, Barriers and challenges: Systemic, technical, and pedagogical constraints, The study does not involve primary empirical research but builds a strong conceptual and policy-oriented narrative, suitable for guiding future research or implementation strategies.

4. Discussion: Role and Impact of ICT in Higher Education

4.1 Transformation of Teaching and Learning

ICT has shifted the educational process from teacher-centered to learner-centered paradigms. With the proliferation of Learning Management Systems (LMS) such as Moodle, Blackboard, and Google Classroom, teachers now act more as facilitators than transmitters of knowledge.

Key innovations include; Flipped Classrooms: Students learn core content online and engage in active problem-solving during in-person sessions, MOOCs and Open Educational Resources: Platforms like SWAYAM, edX, and Coursera offer courses from leading institutions, democratizing access to quality learning, Simulation and Virtual Labs: Especially in engineering, medicine, and science, tools like Virtual Labs (India) enable hands-on learning without physical infrastructure.

4.2 Enhancing Student Engagement and Outcomes

ICT tools promote active learning through; Multimedia Content; Videos, animations, podcasts, and interactive modules improve comprehension and retention. Collaborative Tools; Forums, chats, and cloud-based group projects enhance peer interaction and teamwork. Self-paced Learning; Asynchronous access to learning materials allows students to learn at their own speed, accommodating different learning styles and schedules, Numerous studies (e.g., Tondeur et al., 2017) have found a positive correlation between ICT exposure and student performance, especially in terms of digital literacy, critical thinking, and academic confidence.

4.3 Research Facilitation

ICT accelerates academic research through Access to Global Databases; JSTOR, Science Direct, Scopus, and Google Scholar provide immediate access to global knowledge. Data Analysis Software; SPSS, R, NVivo, and MATLAB are integral to research methodology. Collaborative Research Platforms; Tools like ResearchGate and Mendeley support global academic networking.

4.4 Administrative and Institutional Benefits

Higher education institutions leverage ICT for Digital Admissions and Enrollment Systems, Online Fee Collection and Transcript Issuance, Academic Monitoring and Evaluation, Faculty Management Systems, Online Grievance Redressal Mechanisms.

5. Challenges in ICT Integration

Despite its transformational potential, ICT adoption faces numerous roadblocks in the higher education sector, particularly in low- and middle-income countries:

5.1 Infrastructure Deficits

Connectivity Issues: Many institutions, especially in rural India, suffer from unreliable internet and power supply. Digital Devices: Not all students can afford laptops or smartphones, exacerbating the digital divide. Obsolete Hardware: Many government-funded colleges use outdated computers and software.

5.2 Faculty Preparedness and Attitudes

A significant portion of faculty members lack pedagogical training in digital tools. There is often resistance to change, especially among senior educators accustomed to traditional methods. Time constraints and increased workload further demotivate staff from engaging with ICT meaningfully.

5.3 Policy and Planning Gaps

Lack of institution-wide ICT strategies that align with academic goals. Fragmented funding models and poor interdepartmental coordination. Inconsistent evaluation frameworks for monitoring ICT impact.

5.4 Socio- economic and Cultural Barriers

Students from marginalized communities face compounded challenges of language, connectivity, and unfamiliarity with digital tools. Gender gaps also persist in digital literacy and device ownership in some regions.

6. Conclusion and Future Directions

ICT has emerged as a cornerstone of transformation in higher education, offering powerful tools to improve learning outcomes, institutional management, and research capabilities. However, the true potential of ICT can only be realized when integrated within a visionary policy framework, adequate infrastructure, and a human-centered approach to pedagogy.

Future Recommendations:

Comprehensive Faculty Development; Regular workshops, certification programs, and incentives to motivate technology adoption. Public-Private Partnerships (PPP): Collaborations with Ed.Tech firms to support innovation and cost-sharing. Targeted ICT Policies: Institution-specific digital strategies aligned with NEP 2020 goals. Localized Content Development: More content in regional languages and tailored to cultural contexts. Digital Inclusion Strategies: Device distribution schemes, subsidized internet access, and digital literacy training for disadvantaged students. The future of higher education lies not just in digitization, but in digitally-enabled equity, innovation, and lifelong learning. ICT, when thoughtfully integrated, becomes not merely a tool but a catalyst for re-imagining education for the 21st century.

References

Anderson, T., & Dron, J. (2011). *Three generations of distance education pedagogy*. International Review of Research in Open and Distance Learning.

Bates, A. W., & Sangrà, A. (2011). *Managing Technology in Higher Education: Strategies for Transforming Teaching and Learning*. Jossey-Bass.

Laurillard, D. (2012). *Teaching as a Design Science: Building Pedagogical Patterns for Learning and Technology*. Routledge.

Selwyn, N. (2016). *Education and Technology: Key Issues and Debates*. Bloomsbury.

Tondeur, J., van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2017). *Understanding the relationship between teachers' pedagogical beliefs and technology use in education: A systematic review of qualitative evidence*. Educational Technology Research and Development.

UNESCO. (2014). *ICT in Education: A Critical Review and a Look Ahead*. United Nations Educational, Scientific and Cultural Organization.

Investigation of the Possible Role of CYP1A1 Gene M1(T>C) and M2(A>G) Polymorphisms in Bladder Cancer •

CYP1A1 Geni M1(T>C) ve M2(A>G) Polimorfizminin Mesane Kanserinde Olası Rolünün Araştırılması

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Abstract

Bladder malignancy is the most common malignant tumor of the urogenital system, being the second most common in its field and the tenth most common cancer globally. This cancer ranges from non-invasive, frequently recurring tumors To highly aggressive and invasive tumors with elevated mortality rates. Among the various genes involved in carcinogenesis, the cytochrome P450 (CYP) gene family has garnered notable focus because of its essential function in the Metabolizing a wide range of internal and external molecules, including environmental carcinogens. CYP450 enzymes, particularly CYP1A1, shape the individual's response to environmental exposures by activating and detoxifying various procarcinogens. Studies have shown that genetic variations in CYP450 are significantly associated with various cancer types, including lung cancer, breast cancer, colorectal cancer, and oral cancer. This study investigates the potential role of CYP1A1 gene polymorphisms m1 (T>C) and m2 (A>G) in bladder malignancy.

• Bu bildiri, Mersin Üniversitesi Sağlık Bilimleri Enstitüsünde yüksek lisans tezi olarak hazırlanan çalışmamızdan üretilmiştir. çalışmada kullanılan özgün bilgiler, şekil, tablo ve fotoğraflardan kaynak göstermeden alıntı yapmak 5846 sayılı Fikir ve Sanat Eserleri Kanunu hükümlerine tabidir.

The goal is to quantify the frequency of CYP1A1 polymorphisms in our region by analyzing allele distribution in the control group.

The study included 54 patients diagnosed with bladder cancer who had no other systemic diseases and 54 healthy individuals with no cancer or general illnesses, all of whom were referred to the Urology Clinic of Mersin University Hospital. Blood samples of 2 ml were collected from both patient and control groups in EDTA-coated hemogram tubes. DNA isolation was performed using a DNA isolation kit provided by Roche Diagnostics (Mannheim, Germany). The analysis of CYP1A1 gene polymorphisms m1 (T>C) and m2 (A>G) was conducted using the Roche LightCycler 480 RT-PCR device (Roche Diagnostics, Mannheim, Germany). Data analysis was carried out using Statistica v.13.3.0 and MedCalc v.11.5.0 software, with results considered significant at $p<0.05$.

According to the research results, The patient group and the control group showed no appreciable differences for CYP1A1 (rs1048943) polymorphisms in AA, GG, and AG genotypes ($p=0.193$) or for CYP1A1 (rs4646903) polymorphisms in TT and TC genotypes ($p=0.108$). Given the limited number of studies on this topic in the literature, We anticipate that our findings will add value to the current body of knowledge and offer guidance for future studies.

Keywords: Gene polymorphisms; CYP1A1; cytochrome CYP450; bladder cancer

Özet

Mesane malignitesi, ürogenital sistemin en sık görülen kötü huylu tümörü olup alanında ikinci, dünya genelinde ise en sık görülen onuncu kanser türüdür. Bu kanser, genellikle invaziv olmayan ve sık nüks eden tümörlerden, yüksek ölüm oranına sahip hastalığa özgü agresif ve invaziv tümörlere kadar geniş bir spektruma sahiptir. Karsinojenezde yer alan çeşitli genler arasında, sitokrom P450 (CYP) gen ailesi, çevresel karsinojenler de dahil olmak üzere çok sayıda endojen ve eksojen bileşiğin metabolizmasındaki önemli rolü nedeniyle önemli ölçüde dikkat çekmiştir. CYP450 enzimleri, özellikle CYP1A1, çeşitli prokarsinojenleri aktive edip detoksifiye ederek bireyin çevresel maruziyetlere verdiği tepkiyi şekillendirir. Yapılan çalışmalar CYP450 genetik varyasyonlarının , akciğer kanseri, göğüs kanseri, bağsak kanser ve oral kanseri gibi çeşitli kanser türleri ile anlamlı bir ilişki oluşturduğunu göstermiştir. Çalışmada CYP1A1 geni m1(T>C) ve m2 (A>G) polimorfizminin mesane malignitesindeki olası rolü araştırılmıştır. Kontrol grubu verileri ile de CYP1A1 polimorfizmi alel frekansı ölçülerek bölgemizde bulunma sıklığını belirlemek amaçlandı.

Çalışmaya Mersin Üniversitesi Hastanesi Üroloji polinikliğine başvuran herhangi bir sistemik hastalığı olmayan sadece mesane kanser tanısı alan 54 hasta ve rutin analiz ve klinik muayene sonucu kanser ve genel hastalığı bulunmayan 54 sağlıklı birey dahil edildi. Hasta ve kontrol gruplarından 2 ml'lik kan örnekleri EDTA'lı hemogram tüplerinde toplandı. DNA izolasyonu, Roche Diagnostics'in (Mannheim, Almanya) sağladığı DNA izolasyon kiti kullanılarak yapıldı. CYP1A1 geni için m1 (T>C) ve m2 (A>G) polimorfizm analizi, Roche LightCycler 480 RT-PCR cihazıyla (Roche Diagnostics, Mannheim, Almanya) yapıldı. Veri analizleri , Statistica v.13.3.0 ve MedCalc v.11.5.0 yazılımları ile gerçekleştirildi ve sonuçlar $p<0.05$ kayda değer olarak değerlendirildi.

Araştırma sonuçlarına göre, hasta grubu ve kontrol grubu arasında CYP1A1 (rs1048943) polimorfizmi için AA, GG ve AG genotipleri (p=0,193) ile CYP1A1 (rs4646903) polimorfizmi için TT ve TC genotipleri (p=0,108) arasında kayda değer bir fark gözlemlenmedi. Bu konuyla ilgili literatürde sınırlı çalışma bulunduğundan, elde ettiğimiz verilerin literatüre katkıda bulunacağını ve sonraki çalışmalara ışık tutacağını düşünüyoruz.

Anahtar Kelimeler: Gen polimorfizmleri; CYP1A1; sitokrom CYP450; mesane kanseri

1.GİRİŞ

İdrar kesesi kanserleri ve ürogenital sistem en sık teşhis edilen malignitelerinden biri olarak sıralanan önemli bir küresel sağlık sorununu temsil eder. İnsidansı ve prevalansı, farklı coğrafi bölgelerde büyük farklılıklar göstermekte olup, gelişmiş ülkelerde daha yüksek oranlar gözlenmektedir ve bu da yaşam tarzı ve çevresel faktörlerin olası katılımını düşündürmektedir (1). Mesane kanseri ağırlıklı olarak erkekleri etkiler ve artan yaşla ilişkilidir ve vakaların çoğu 55 yaş üstü bireylerde teşhis edilir (2). Tanı ve tedavi yöntemlerindeki ilerlemelere rağmen, mesane kanserinin prognozu, özellikle ileri evre hastalık için yetersiz kalmaktadır ve bu da, gelişimine neden olan altta yatan genetik ve çevresel faktörlerin anlaşılmasını zorunlu kılmaktadır (2).

Kanser temel olarak hücre proliferasyonu, farklılaşması ve apoptoz ile ilgili anahtar düzenleyici genlerdeki somatik mutasyonların ve değişikliklerin birikmesinden kaynaklanan genetik bir hastalıktır. Son araştırmalar, bir bireyin kansere duyarlılığını etkileyebilen kalıtsal genetik varyasyonların rolünü de vurgulamıştır. Karsinojenezde yer alan çeşitli genler arasında, sitokrom P450 (CYP) gen ailesi, çevresel karsinojenler de dahil olmak üzere çok sayıda endojen ve eksojen bileşiğin metabolizmasındaki önemli rolü nedeniyle dikkat çekmiştir (3). CYP enzimlerinin, özellikle CYP1A1'in çeşitli prokarsinojenleri aktive ettiği ve detoksifiye ettiği, böylece bireyin çevresel maruziyetlere tepkisini şekillendirdiği bulunmuştur(3).

15q24.1 kromozomunda yer alan CYP1A1 geni, başlıca akciğer, böbrek ve mesane gibi ekstrahepatik dokularda eksprese edilen bir enzimi kodlar (4). Polisiklik aromatik hidrokarbonların (PAH'lar), aromatik aminlerin, endüstriyel emisyonlarda ve bazı diyet bileşenlerinde bulunan diğer kanserojen bileşiklerin metabolizmasında merkezi bir rol oynar (5). Enzimatik aktivite yoluyla, CYP1A1 bu prokarsinojenleri, DNA'ya bağlanabilen, eklentiler oluşturan ve genetik mutasyonları indükleyen etkilere neden olarak kanserojen süreci başlatan reaktif ara ürünlere dönüştürebilir (6).

İnsan CYP1A1 geni, enzim aktivitesini ve ekspresyon seviyelerini etkileyebilen birkaç genetik polimorfizm sergiler. Ksenobiotik metabolizması açısından önemli iki polimorfizm, CYP1A1 geninin promotör bölgesinde yer alan m1 (T>C) ve m2 (A>G) varyantlarını içerir. m1 (T>C) polimorfizmi, bir ksenobiyotik yanıt elemanını bozarak CYP1A1 transkripsiyonel aktivitesini potansiyel olarak azaltırken, m2 (A>G) polimorfizmi, transkripsiyon faktörü bağlanmasını değiştirerek gen ekspresyonunda değişikliklere yol açabilir (7). CYP1A1 aktivitesi ve ekspresyonundaki bu fonksiyonel

değişiklikler, potansiyel olarak bir kişinin mesane kanseri de dahil olmak üzere kanser gelişimine duyarlılığını etkileyebilir (7).

CYP1A1 geninin kanserojenleri metabolize etmedeki merkezi rolü ve aktivitesini modüle edebilen genetik varyasyonlar göz önüne alındığında, çok sayıda çalışma CYP1A1 m1 (T>C) ve m2 (A>G) polimorfizmleri ile kanser riski arasındaki ilişkiyi araştırmıştır. Akciğer, meme, prostat ve kolorektal kanser gibi çeşitli kanser türlerinde araştırmalar yapılmıştır, ancak CYP1A1 polimorfizmlerinin mesane kanserindeki rolü nispeten az araştırılmış ve sonuçsuz kalmıştır.

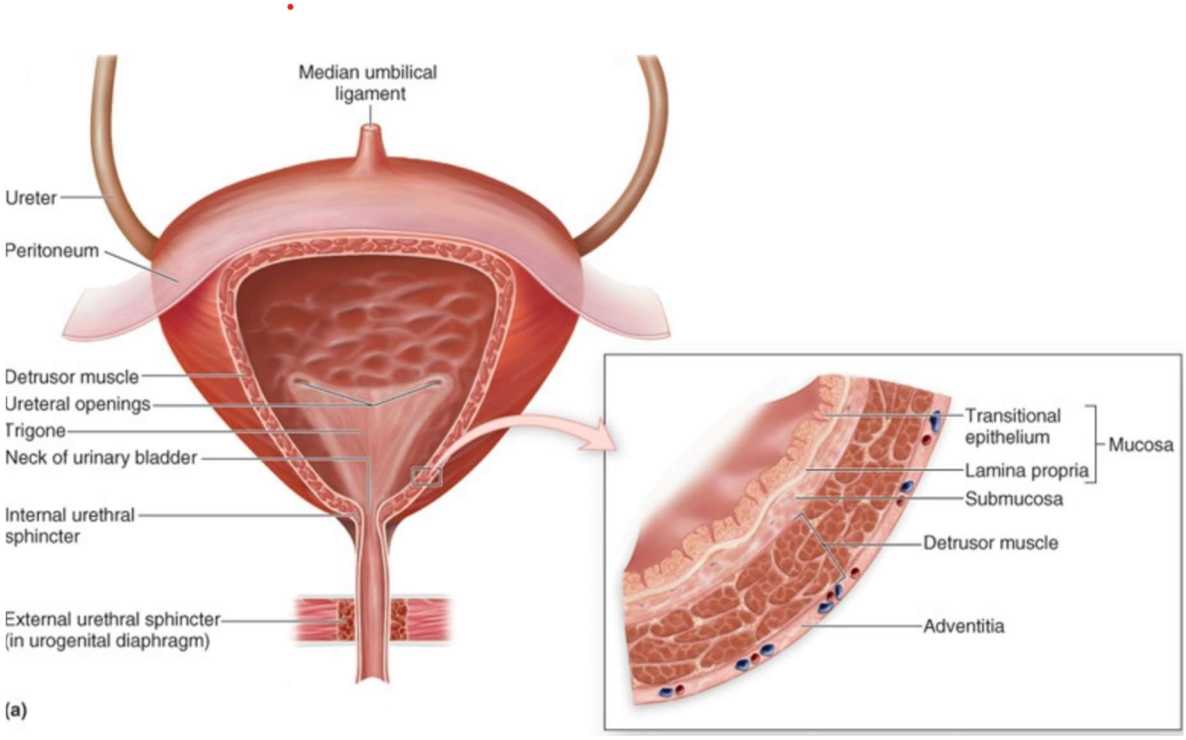
Bu detaylar dikkate alındığında, CYP1A1 geni polimorfizmleri m1 (T>C; rs4646903) ve m2 (A>G; rs1048943) ile mesane kanseri gelişimi arasında anlamlı bir ilişki olup olmadığını araştırmak hedeflendi.

2. KAYNAK ARAŞTIRMALARI

2.1. Mesane Anatomik Yapısı ve Histolojisi

Mesane, idrarın vücutta depolanması ve vücuttan atılmasından sorumlu olan üriner sistemin hayati bir organıdır. İşlevleri; anatomik, fizyolojik ve nöral mekanizmaların etkileşimi ile düzenlenir. Mesanenin ayrıntılı fizyolojisini anlamak, normal mesane fonksiyonunu ve mesane kanseri de dahil olmak üzere çeşitli mesane bozukluklarına yol açabilecek patofizyolojik değişiklikleri anlamak için oldukça önem arz etmektedir.

Mesane anatomik yapısı Şekil 1' de verilmiş olup, yapısına ve işlevine katkıda bulunan birkaç katmandan oluşur. En içteki katman, idrar ve toksik maddelerin alttaki dokulara girmesini engelleyen bir bariyer oluşturan ürotelyumdur (geçiş epiteli). Ürotelyumun altında, kan damarları ve sinirler açısından zengin bir bağ dokusu tabakası olan lamina propria bulunur. Detrüsör kası olarak bilinen kas tabakası, mesane duvarının büyük bölümünü oluşturur ve kasılma özelliklerinden sorumludur. Son olarak, en dıştaki tabaka, mesaneyi çevreleyen yapılara bağlayan bir bağ dokusu tabakası olan adventisyadır (8)

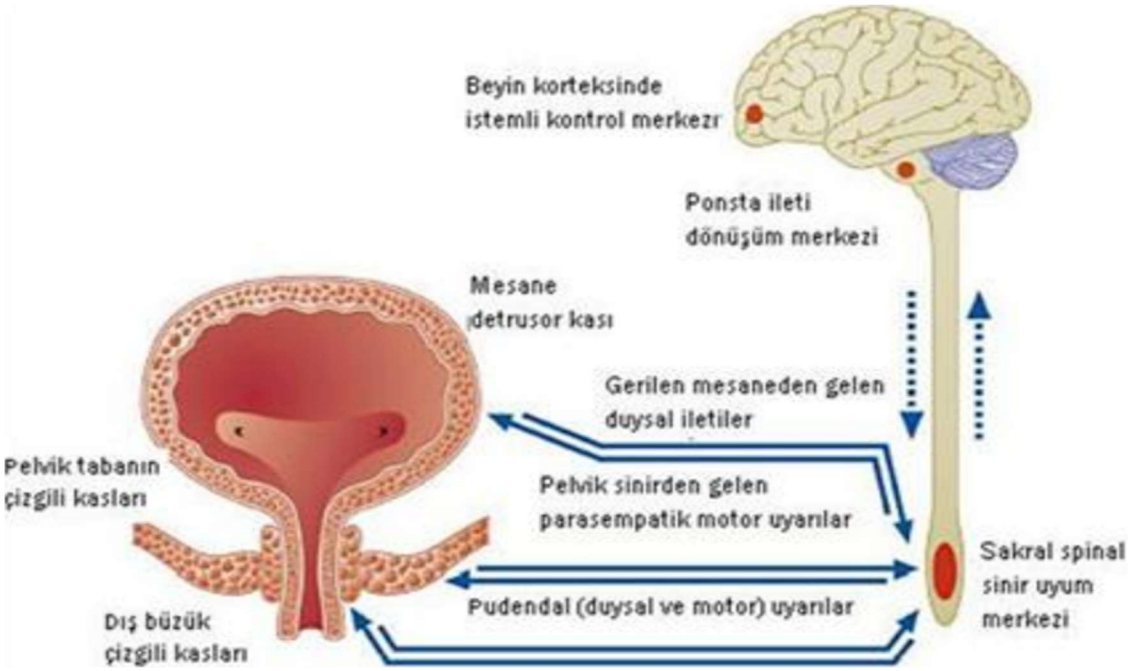


Şekil 2.1. Mesane anatomik yapısı [8]

İdrar Depolama ve Doldurma: Depolama fazı sırasında mesane gevşemiş halde kalır ve artan idrar hacimlerini barındırmasına izin verir. Detrüsör kası hareketsiz kalır ve mesane çıkışında bir düz kas halkası olan iç üriner sfinkter kontinansı korumak için kasılır. Mesane duvarı kompliyans sergiler ve basınçta önemli bir artış olmaksızın artan idrar hacmini esnetebilir ve barındırabilir. Mesane duvarında bulunan ve gerilme reseptörleri olarak bilinen duyu reseptörleri, merkezi sinir sistemine sinyaller ileterek mesanenin dolma derecesini gösterir ve idrar doluluk hissini tetikler (9).

İşeme Refleksi ve İşeme: Mesane kapasitesine ulaştığında işeme refleksi devreye girerek işeme sürecini başlatır. İşeme refleksi, hem inhibe edici hem de uyarıcı sinyalleri içeren karmaşık bir otonomik reflekstir. Mesanenin gerilme reseptörlerinden gelen duyusal bilgi, afferent sinirler yoluyla sakral omurilikteki işeme merkezine iletilir. Eşzamanlı olarak beyin sapı mesanenin doluluk durumu hakkında bilgi alır (10).

Mesane Fonksiyonunun Nöral Kontrolü: Sakral omurilikteki işeme merkezi, afferent girdileri birleştirir ve iç ve dış idrar sfinkterlerinin mesane kasılmasını ve gevşemesini koordine eden efferent sinyaller üretir. Detrüsör kasındaki muskarinik reseptörler yoluyla hareket eden parasempatik sinirler, mesane kasılmasını uyarır ve işemeyi başlatır. Bu sinirler, muskarinik reseptörleri aktive ederek detrüsör kas kasılmasına yol açan asetilkolin salgılar. Eşzamanlı olarak, iç üriner sfinkteri gevşeten, üretranın açılmasına ve idrar akışını kolaylaştırmasına izin veren sempatik sinirlere inhibitör sinyaller gönderilir. Beyin sapındaki istemli kontrol merkezi, uygun koşullarda eksternal üriner sfinkteri gevşeterek işemenin bilinçli kontrolünü sağlar (Şekil 2) (11)



Şekil 2.2. Mesanenin nöral kontrolü [11]

Yaşa Bağlı Değişiklikler ve Mesane İşlevi: Yaşlanmayla birlikte mesane işlevini etkileyebilecek değişikliklere uğrar. Mesane kompliansı, detrusor kas kontraktilitesinde ve nöral kontrol mekanizmalarında yaşa bağlı değişiklikler idrar sıklığında, aciliyette ve noktüride artışa neden olabilir. Bu değişiklikler ayrıca yaşlı popülasyonda yaygın olarak görülen çeşitli mesane disfonksiyonlarına da neden olabilir (12).

2.2. Mesane Kanseri Epidemiyolojisi

Mesane kanseri, üriner sistemin yaygın bir malignitesidir ve epidemiyolojisi, dünya çapında farklı popülasyonlar ve bölgeler arasında değişmektedir. Mesane kanseri insidansı, prevalansı ve mortalite modellerini anlamak, yüksek riskli grupları belirlemek, önleyici tedbirleri uygulamak ve erken teşhis ve tedavi için hedef stratejileri geliştirmek için oldukça önem arz etmektedir (13).

Mesane kanseri, ülkeler arasında insidans oranlarında önemli farklılıklar ile dünya çapında en sık teşhis edilen on kanser arasında yer almaktadır (13). Küresel Kanser Gözlemevi'ne göre, 2020'de tahmini 550.000 yeni mesane kanseri vakası ve 200.000 ölüm bildirilmiştir. Bu rakamlar, mesane kanserinin önemli halk sağlığı etkisini vurgulayarak, kapsamlı sürveyans ve önleme programlarına duyulan ihtiyacın altını çizmektedir (14).

Özellikle Kuzey Amerika ve Avrupa'daki yüksek gelirli ülkeler, düşük ve orta gelirli ülkelere kıyasla daha yüksek yaşa standardize edilmiş insidans oranları bildirmiştir (15). Ek olarak, çevresel karsinojenlere daha fazla maruz kalan sanayileşmiş bölgeler gibi ülkelerdeki belirli bölgeler, diğer bölgelere göre daha yüksek insidans oranlarına sahip olabilmektedir (15).

Mesane kanseri ağırlıklı olarak erkekleri etkilemektedir ve erkek-kadın oranı yaklaşık 3:1'dir (16). Erkeklerde daha yüksek insidans, genetik, hormonal ve davranışsal

faktörlerin bir kombinasyonuna bağlanmaktadır. Mesane kanseri öncelikle yaşlıların hastalığıdır ve vakaların çoğu 55 yaş üstü bireylerde teşhis edilir (17). İnsidans yaşla birlikte artar, en yüksek oranlar 75 yaş üstü bireylerde gözlenir (17).

Sigara içmek mesane malignitesi için bilinen en önemli risk faktörüdür ve vakaların büyük bir kısmından sorumludur. Tütün dumanında bulunan aromatik halkalar içeren amine gruplarına sahip organik bileşenler ve iki veya daha fazla benzen halkasının birleşmesiyle oluşan organik bileşenler gibi kanserojenler, kan dolaşımına emilir ve idrar yoluyla atılır ve mesane zarını potansiyel olarak zararlı bileşiklere maruz bırakır (18). Aromatik aminler ve endüstriyel boyalar gibi belirli kimyasallara mesleki maruziyet, özellikle kauçuk, tekstil ve boya gibi endüstrilerde çalışanlar arasında mesane kanseri riskinde artış bildirilmektedir (19).

Mesane kanseri duyarlılığı genetik faktörlerden etkilenir ve ailede mesane kanseri öyküsü olması yüksek risk ile ilişkilidir. Çeşitli genetik polimorfizmler ve kalıtsal genetik sendromlar, mesane kanseri gelişiminde rol oynamıştır. Örneğin, kanserojen metabolizması ve DNA onarım yollarında yer alan genlerdeki belirli tek nükleotid polimorfizmleri (SNP'ler), mesane kanserine karşı bireysel duyarlılığı değiştirebilir (20).

Mesane kanseri epidemiyolojisinde coğrafi ve çevresel faktörler önemli bir rol oynamaktadır. Arsenikle kirlenmiş içme suyuna maruz kalma, bazı bölgelerde artmış mesane kanseri riski ile ilişkilendirilir. Ayrıca Afrika ve Orta Doğu'nun belirli bölgelerinde yaygın olan paraziter bir hastalık olan Schistosoma haematobium enfeksiyonunun mesane kanseri ile bağlantısı saptanmıştır. Bu enfeksiyonların, mesane zarının kronik iltihaplanması ve tahrişi yoluyla mesane kanserine neden olduğuna inanılmaktadır (21).

Değiştirilebilir risk faktörlerinin etkisi göz önüne alındığında, birincil koruma çabaları sigarayı bırakmaya ve karsinojenlere mesleki maruziyeti azaltmaya odaklanmalıdır. Ek olarak, sağlıklı yaşam tarzı seçimlerini ve çevresel risk azaltmayı teşvik eden halk sağlığı girişimleri, mesane kanseri yükünün azaltılmasına yardımcı olabilir. Sigara içenler ve ailede mesane kanseri öyküsü olanlar gibi yüksek riskli bireyler arasında düzenli tarama ve erken teşhis, erken müdahale ve tedaviyi mümkün kılarak sonuçları iyileştirebilir (22).

2.3. Mesane Kanserinin Patofizyolojisi

Mesane kanseri, mesane zarındaki anormal hücrelerin kontrolsüz büyümesi ve çoğalmasından kaynaklanan bir hastalıktır. Mesane kanserinin patofizyolojisi, tümör gelişimine ve ilerlemesine neden olan genetik, moleküler ve çevresel faktörlerin bir kombinasyonunu içermektedir.

Onkogenler (MDM2, Myc, Ras, ERBB-2, PI3KCAvb) ve tümör supresör genler (PB, p53, SFRP1, PTEN, CDKN2A..vb); hücre döngüsü, P3K sinyal, histon modifikasyon, SWI/SNF nükleozom yeniden modelleme gibi yolaklarda farklılıklara neden olur ve mesane kanseri patofizyolojisi, invazif ve non-invazif vakalarda bu nedenle farklılıklar göstermektedir (23).

Çevresel kanserojenlere maruz kalma, mesane tümörü için önemli bir risk faktörüdür. Tütün kullanımı, mesleki olarak kimyasallara (örneğin, aromatik aminler) maruz ve mesane zarının kronik iltihaplanması artan mesane kanseri gelişme riski ile ilişkilidir (24).

Fosfatidilinositol 3-kinaz (PI3K)/AKT/mTOR yolu ve mitojenle aktive olan protein kinaz (MAPK) yolu gibi sinyal yolaklarının düzensizliği, mesane kanseri hücrelerinde hücrenin hayatta kalmasını, çoğalmasını ve anjiyojenezi desteklemektedir (25).

Mesane kanseri büyümesi ve ilerlemesi, tümöre besin ve oksijen sağlayan yeni kan damarlarının oluşumu olan anjiyogeneze bağlıdır. İmmün hücreler ve stromal bileşenler dahil olmak üzere tümör mikroçevre etkileşimleri, tümör davranışını ve tedaviye yanıtı etkilemektedir (26).

İleri mesane kanseri evreleri, mesane duvarının invazyonunu ve uzak bölgelere potansiyel yayılmayı içerir. Epitelial Mezenkimal Transition (geçiş) (EMT), kanser hücrelerinin metastazına katkıda bulunarak invaziv ve metastatik özellikler kazanmasına olanak sağlamaktadır (27).

2.4. Mesane Kanseri İnsidansını Etkileyen Faktörler

2.4.1.Çevresel Faktörler

Tütün Kullanımı ve Tütün Maruziyeti: Sigara içmek, mesane tümörü için en iyi bilinen çevresel tehlike föktörüdür. Tütün dumanı, karaciğerde metabolize edilen ve idrarla atılan aromatik aminler ve polisiklik aromatik hidrokarbonlar gibi çok sayıda karsinojen içerir. Mesaneye ulaştıktan sonra, bu karsinojenler doğrudan ürotelyum ile temas ederek DNA hasarına, mutasyonlara ve ardından tümör başlangıcına yol açar. Çok sayıda epidemiyolojik çalışma, sigara içmek ile yüksek mesane kanseri riski arasında güçlü bir ilişki olduğunu tutarlı bir şekilde göstermektedir (28).

Mesleki Maruziyetler: Bazı mesleki maruziyetler, mesane kanseri riskinin artmasıyla ilişkilendirilmiştir. Boya, kauçuk, tekstil, matbaa ve alüminyum üretimi içeren endüstrilerdeki işçiler, tehlikeli kimyasallara uzun süre maruz kalmaları nedeniyle daha yüksek mesane kanseri riskine sahiptir. Pek çok endüstriyel süreçte bulunan aromatik aminler, bilinen mesane karsinojenleridir. Ek olarak, benzidin ve beta-naftilamin gibi endüstriyel kimyasallara maruz kalma, artmış mesane kanseri riski ile ilişkilendirilmektedir (29).

Arseniğe Maruz Kalma: Belirli coğrafi bölgelerde, içme suyunda yüksek düzeyde arseniğe maruz kalma, artan mesane kanseri riski ile ilişkilendirilmiştir. Arsenik, doğal olarak oluşan bir metaloid ve bilinen bir insan karsinojenidir. Arsenikle kirlenmiş suyun kronik olarak yutulması, mesane epitelinde DNA mutasyonlarının birikmesine yol açarak tümör oluşumunu teşvik edebilir. Bu çevresel maruziyet özellikle Asya'nın bazı bölgelerinde, Güney Amerika'da ve Amerika Birleşik Devletleri'nin bazı bölgelerinde görülmektedir (30).

Enfeksiyonlar ve Kronik Enflamasyon: İdrar yolu enfeksiyonları gibi mesanenin kronik enfeksiyonları, mesane kanseri gelişimi ile bağlantılı olan kronik enflamasyona yol açabilir. Kronik inflamasyon, hasarlı hücrelerin çoğalmasını destekleyen ve genetik mutasyon riskini artıran bir ortam sağlar. Ek olarak, parazitik organizma Schistosoma haematobium'un neden olduğu enfeksiyonlar, endemik bölgelerde artmış skuamöz hücreli mesane kanseri riski ile ilişkilendirilmektedir (31).

Diyet Faktörleri: Diyet alışkanlıkları mesane kanseri riski ile ilişkilendirilmiştir. Yüksek oranda kırmızı et ve işlenmiş et tüketimi, muhtemelen pişirme sırasında oluşan

kanserojen bileşiklerin varlığından dolayı mesane kanseri riskinin artmasıyla ilişkilendirilmiştir. Tersine, antioksidanlar ve antienflamatuar bileşiklerin kaynakları olan meyve ve sebzeler açısından zengin diyetler, mesane kanseri riskinin azalmasıyla ilişkilendirilmiştir (32).

Pestisitler ve Kimyasal Maruziyetler: Pestisitler ve bazı endüstriyel kimyasallar, mesane kanseri riskinde artışın nedenleri arasında yer alırlar. Atrazin ve klorpirifos gibi herbisitlere ve böcek ilaçlarına maruz kalan tarım işçilerinde, bu kimyasallara uzun süre maruz kalma nedeniyle mesane kanseri riskinde artış olduğu gösterilmiştir (33).

2.4.2. Mesleki Faktörler

Mesleki faktörler, karsinojene maruz kalma nedeniyle daha yüksek risklerle karşı karşıya kalan belirli endüstrilerdeki işçilerde mesane kanseri insidansını önemli ölçüde etkilemektedir. Aromatik aminler, Polisiklik Aromatik Hidrokarbonlar (PAH'lar) organik çözücüler, ağır metaller ve dizel egzoz, mesane kanseri gelişimi ile ilişkili temel mesleki risk faktörleri arasındadır. Bu ilişkileri ve bunların altında yatan mekanizmaları anlamak, önleyici tedbirlerin uygulanması ve iş yeri sağlığı ve güvenliğinin iyileştirilmesi açısından oldukça önemlidir.

- Aromatik Aminler ve Mesleki Karsinojenler: Benzidin, beta-naftilamin ve 4-aminobifenil gibi aromatik aminler, mesane kanseri gelişimi ile ilişkili iyi bilinen mesleki karsinojenlerdir. Boya üretimi, kauçuk işleme ve belirli kimyasalların üretimi ile uğraşan endüstrilerdeki işçiler, bu tehlikeli maddelere maruz kalma nedeniyle artan bir mesane kanseri riski altındadır. Aromatik aminlerin karaciğerde metabolize edilmesi, idrarla atılan reaktif ara ürünlerin oluşmasına neden olarak mesane astarıyla doğrudan temas ederek DNA hasarına ve mutasyonlarına neden olur (34).
- Polisiklik Aromatik Hidrokarbonlar (PAH'lar): Kömür katranı, asfalt ve belirli yakma işlemlerini içeren mesleklerde çalışanlar (PAH'lar) maruz kalır. Bu bileşikler eksik yanma sırasında oluşur ve güçlü mesane karsinojenleridir. Maruz kalındığında, PAH'lar DNA'ya bağlanan reaktif ara ürünler oluşturmak için metabolik aktivasyona uğrayarak mesane kanseri gelişimine yol açabilir (35).
- Organik Çözücüler: Trikloretilen (TCE) ve aromatik hidrokarbonlar gibi belirli organik çözücüler, mesleki ortamlarda artan mesane kanseri riski ile ilişkilendirilmiştir. Metal yağ giderme, baskı ve boyama gibi bu solventleri kullanan endüstrilerdeki işçiler yüksek risk altındadır. Mesane karsinogenezisin mekanizması, mesane epitel hücrelerinde DNA hasarına ve mutasyonlara neden olabilen TCE ve aromatik hidrokarbonların metabolitlerini içerir (36).
- Ağır Metaller: Arsenik ve kadmiyum gibi bazı ağır metallere maruz kalma, mesleki ortamlarda mesane kanseri ile ilişkilendirilmiştir. Metal eritme, pil üretimi ve kaynaklama içeren endüstrilerdeki işçiler, bu kanserojen metallere uzun süre maruz kalmaları nedeniyle artan mesane kanseri riski altındadır. Özellikle arsenik, insanlar için bilinen bir

karsinojendir ve arseniğin kronik olarak yutulması veya solunması mesane kanserine yol açabilir (37).

- Mesleki Dizel Egzoz Maruziyeti: Kamyon şoförleri, tamirciler ve madenciler gibi dizel motor egzozuna maruz kalan işçiler, artan mesane kanseri riskiyle karşı karşıya kalabilir. Dizel egzozu, PAH'lar ve aromatik aminler dahil olmak üzere, solunabilen ve solunum yolu yoluyla emilebilen ve mesane kanseri gelişimine yol açan çok sayıda karsinojen içerir (38).

2.4.3.Genetik Faktörler

Genetik faktörler, hastalığa karşı bireysel duyarlılığı etkileyen anahtar genlerdeki varyasyonlarla mesane kanseri insidansında çok önemli bir rol oynamaktadır. Genetik duyarlılık genleri, Tek Nükleotid Polimorfizmleri (SNP'ler), ailesel kümelenme, Genom Çapında İlişkilendirme Çalışmaları (GWAS) ve epigenetik değişiklikler mesane karsinogenezine neden olur. Mesane kanserinin genetik resmini anlamak, kişiselleştirilmiş risk değerlendirmesi, erken teşhis ve hedefe yönelik terapötik stratejilerin geliştirilmesine yardımcı olabilir.

- Genetik Duyarlılık Genleri: DNA onarımı, hücre döngüsü kontrolü ve apoptoz ile ilişkili birkaç gen, mesane kanseri duyarlılığı ile ilişkilendirilmiştir. Tümor Protein 53 (TP53), Retinoblastoma 1 (RB1) ve X-ray repair cross-complementing (XRCC1) gibi genlerdeki polimorfizmler, mesane kanseri riski üzerindeki potansiyel etkileri açısından kapsamlı bir şekilde araştırılmıştır. Bu genlerin düzensizliği, DNA hasarının birikmesine ve genomik kararsızlığa neden olarak mesane karsinogenezine neden olabilir (39).
- Tek Nükleotid Polimorfizmleri (SNP'ler): Çeşitli genlerdeki tek nükleotid polimorfizmleri (SNP'ler), mesane kanseri duyarlılığı ile ilişkilendirilmiştir. Örneğin, CYP1A1 (Sitokro P450 1A1) geninin m1 (T>C) ve m2 (A>G) polimorfizmlerinin kanser riskindeki potansiyel rolleri araştırılmıştır. CYP1A1, çevresel kanserojenlerin metabolizmasında yer alır ve bu gendeki spesifik SNP'ler, mesane kanserine karşı bireysel duyarlılığı değiştirebilir (40).
- Ailesel Mesane Kanseri: Mesane kanserinin ailesel kümelenmesi, bazı durumlarda kalıtsal bir bileşeni düşündürür. Ailesel mesane kanserinde, Harvey Rat Sarcoma Virus (HRAS), Fibroblast büyüme faktörü reseptörü 3(FGFR3) ve Fosfatidilinozitol 3-kinaz katalitik alt ünite alfa (PIK3CA) dahil olmak üzere birkaç gen yer alır. Bu genlerdeki germ hattı mutasyonları, bir bireyin mesane kanseri geliştirme riskini artırabilir ve rollerinin anlaşılması, gelişmiş risk değerlendirmesi ve hedefli taramaya imkan verebilir (41).
- Genom Çapında İlişkilendirme Çalışmaları (GWAS): Mesane kanseri duyarlılığı ile ilişkili çok sayıda genetik lokus tanımlamıştır. Bu çalışmalar, mesane karsinojenezinin altında yatan potansiyel mekanizmalara ışık tutan çeşitli hücresel süreçlerde yer alan yeni aday genleri ortaya çıkarmıştır. Bununla birlikte, bu genetik varyantların

fonksiyonel önemine dair net bir kavrayış elde etmek amacıyla ek araştırmalara ihtiyaç bulunmaktadır. (42).

- Epigenetik Değişiklikler: DNA metilasyonu ve histon modifikasyonları gibi epigenetik değişiklikler mesane kanseri gelişimini etkileyebilir. Tümör baskılayıcı genlerin promotör bölgelerindeki anormal DNA metilasyonu, bunların susturulmasına yol açarak kontrolsüz hücre büyümesine neden olabilir. Ek olarak, histon modifikasyonları, mesane karsinogenezini etkileyerek gen ekspresyon modellerini etkileyebilir (43).

2.5. Mesane Kanseriyle İlişkili Genler

Hücre döngüsü düzenlemesi, DNA onarımı ve telomer bakımı ile ilgili anahtar genlerdeki genetik değişiklikler, mesane kanseri gelişimini önemli ölçüde etkiler. Tümor Protein 53 (TP53), Retinoblastoma 1 (RB1), Harvey Rat sarcoma virus (HRAS), Fibroblast büyüme faktörü reseptörü 3 (FGFR3), X-ray Repair Cross Complementing 1(XRCC1) ve Telomerase Reverse Transcriptase (TERT), mesane kanseri ile ilişkili önemli genler arasındadır. Bu genlerin moleküler fonksiyonlarını ve etkileşimlerini anlamak, mesane kanserli hastalar için hedefe yönelik tedaviler ve kişiselleştirilmiş tedavi stratejileri geliştirmek için hayati önem taşır.

Tümör Baskılayıcı Genler:

- TP53 (Tümor Protein 53): "Genomun koruyucusu" olarak da bilinen TP53, mesane kanserinde en sık mutasyona uğrayan tümör baskılayıcı genlerden biridir. TP53, DNA hasarı yanıtında ve hücre döngüsü düzenlemesinde kritik bir rol oynar. TP53'teki mutasyonlar, bozulmuş DNA onarımına, artan genomik kararsızlığa ve kontrolsüz hücre büyümesine yol açarak mesane kanseri gelişimini teşvik edebilir (44).
- RB1 (Retinoblastoma 1): Hücre döngüsü düzenlemesi ve büyüme kontrolünde yer alan bir tümör baskılayıcı gendir. RB1'deki mutasyonlar veya heterozigotluk kaybı gibi değişiklikler, mesane kanserinde kontrolsüz hücre çoğalmasına ve tümör gelişiminin artmasına neden olabilir (45).

Onkogenler:

- HRAS (Harvey Rat Sarcoma Virüs): Hücre büyümesinde ve çoğalmasında yer alan bir proto-onkogendir. HRAS'taki aktive edici mutasyonlar, kontrolsüz hücre büyümesini teşvik ederek ve mesane kanseri gelişimine katkıda bulunarak, aşağı akış sinyal yollarının kurucu aktivasyonuna yol açabilir (46).
- FGFR3 (Fibroblast Büyüme Faktörü Reseptörü 3): Mesane kanserinde yer alan başka bir proto-onkogendir. FGFR3'teki aktive edici mutasyonlar, düşük dereceli non-invaziv mesane tümörlerinin bir alt kümesinde tanımlanmıştır. Bu mutasyonlar hücre proliferasyonunu teşvik eder ve apoptozu inhibe ederek tümör büyümesine katkıda bulunur (47).

DNA Onarım Genleri:

- XRCC1 (X-ışını onarım çapraz tamamlayıcı 1): Çevresel ajanların neden olduğu DNA hasarını onarmaktan sorumlu baz eksizyon onarım yolunda yer alır. XRCC1'deki polimorfizmler, değişmiş DNA onarım kapasitesi ve artan mesane kanseri riski ile ilişkilendirilmiştir (48).

Telomeraz Genleri:

- TERT (Telomeraz Ters Transkriptaz): Telomer uzunluğunu koruyan bir enzim olan telomerazın katalitik alt birimini kodlar. TERT promotör mutasyonları mesane kanserinde tanımlanır ve artan telomeraz aktivitesi ile ilişkilendirilerek sınırsız hücre çoğalmasına ve tümör ilerlemesine katkıda bulunur (49).

2.5.1. Sitokrom P450 Genleri ve Mesane Kanseri ilişkisi

CYP (Sitokrom P450) enzim ailesi, mesane kanseri gelişimi ve ilerlemesinde kritik bir rol oynamaktadır. CYP1A1 (Sitokrom P450 1A1), CYP2E1 (Sitokrom P450 2E1), CYP1B1 (Sitokrom P450 1B1) ve CYP3A4 (Sitokrom P450 3A4), mesane karsinogenezinde yer alan anahtar üyeler arasındadır. Mesane kanserinde CYP enzimlerinin rolü karmaşık ve çok yönlüdür. CYP ailesinin bazı üyeleri karsinojenlerin aktivasyonunda yer alırken, diğerleri tanısal biyobelirteçler veya terapötik hedefler olarak işlev görebilir.

CYP genleri ile mesane kanseri arasındaki karmaşık ilişki, hastalığın patogenezinde genetik faktörlerin önemini vurgulamaktadır. CYP1A1 (Sitokrom P4501A1), CYP2E1 (Sitokrom P450 2E1), CYP1B1 (Sitokrom P450 1B1) ve CYP3A4 (Sitokrom P450 3A4), mesane kanseri gelişimi ve tedavi yanıtında yer alan anahtar CYP enzimleri arasındadır. Farmakogenomik ve biyobelirteç araştırmalarının klinik uygulamaya dahil edilmesi, hasta sonuçlarının iyileştirilmesine ve kişiselleştirilmiş terapötik stratejilere katkı sağlayabilir.

Mesane Kanseri ile İlişkili Olan CYP Ailesi

İlaç Metabolizmasında ve Detoksifikasyonda CYP Enzimleri:

- CYP1A1: CYP1 ailesinin bir üyesidir ve polisiklik aromatik hidrokarbonlar (PAH'lar) ve aromatik aminler gibi çevresel kanserojenler dahil olmak üzere çeşitli eksojen bileşiklerin metabolizmasında yer alır. Bu bileşiklerin CYP1A1 tarafından aktivasyonu, mesane kanserinin başlamasına ve ilerlemesine katkıda bulunan DNA eklentilerinin oluşumuna yol açar (50).
- CYP2E1 (Sitokrom P450 2E1): Mesane kanseri gelişimine katkıda bulunabilen nitrozaminler ve benzen gibi çeşitli çevresel toksinlerin ve prokarsinojenlerin metabolizmasında yer alır. Mesane kanseri dokularında yüksek CYP2E1 ekspresyonu gözlemlenmiştir, bu da mesane karsinogenezindeki potansiyel rolünü göstermektedir (51).

Tanısal Biyobelirteçler Olarak CYP Enzimleri:

- CYP1B1 (Sitokrom P450 1B1): CYP1 ailesinin bir üyesidir ve normal mesane dokularına kıyasla mesane kanseri dokularında aşırı eksprese

edilir. Yüksek CYP1B1 ekspresyonu, ilerlemiş tümör evresi ve kötü prognoz ile ilişkilendirilmiştir, bu da onu mesane kanseri için potansiyel bir tanısal ve prognostik biyobelirteç haline getirmektedir (52).

Terapötik Hedefler Olarak CYP Enzimleri:

- CYP3A4 (Sitokrom P450 3A4): CYP3A4, insan karaciğerinde en bol bulunan CYP enzimidir ve mesane kanseri tedavisinde kullanılan çok sayıda ilacın metabolizmasında kritik bir rol oynar. CYP3A4 aktivitesinde bireyler arası değişkenlik, ilaç etkinliğini ve toksisitesini etkileyebilir, bu da mesane kanseri tedavisinde kişiselleştirilmiş ilaç yaklaşımlarının önemini vurgular (53)
- CYP1A1 (Sitokrom P450 1A1), mesane kanseri gelişimi ile ilişkili çevresel karsinojenler olan PAH'lar ve aromatik aminlerin metabolizmasından sorumlu bir faz I ilaç metabolize edici enzimdir. CYP1A1 genindeki m1 (T>C) ve m2 (A>G) varyantları gibi belirli polimorfizmler, değişen enzimatik aktivite ve artmış mesane kanseri riski ile ilişkilendirildi (54).
- CYP2E1, mesane kanseri gelişimine katkıda bulunabilen nitrozaminler ve benzen dahil olmak üzere çeşitli çevresel karsinojenlerin metabolizmasında yer alır. CYP2E1 genindeki polimorfizmler, enzimin aktivitesini düzenleyerek kişinin mesane kanserine duyarlılığını etkileyebilir (55).
- CYP1B1, endojen hormonların ve ksenobiyotiklerin metabolizmasında yer alır ve mesane kanseri dokularında aşırı ekspresyonu gözlenmiştir. Yüksek CYP1B1 seviyeleri, ilerlemiş tümör evresi ve kötü prognoz ile ilişkilidir ve mesane kanseri için tanısal ve prognostik bir biyobelirteç olma potansiyelini gösterir (56).
- CYP3A4, insan karaciğerinde en bol bulunan CYP enzimidir ve mesane kanseri tedavisinde kullanılan çok çeşitli ilaçların metabolize edilmesinden sorumludur. CYP3A4 aktivitesindeki değişkenlik, ilaç yanıtını ve toksisiteyi etkileyebilir, bu da farmakogenomiklerin terapötik sonuçları optimize etmedeki önemini vurgular (57).

DNA Onarım Genlerinde Polimorfizmler:

- XRCC1 (X-ray Repair Cross Complementing 1): Çevresel ajanların neden olduğu DNA hasarını onarmaktan sorumlu baz eksizyon onarım yolunda yer alır. XRCC1'deki polimorfizmler, artmış mesane kanseri riskine yol açan, değiştirilmiş bir DNA onarım kapasitesi ile ilişkilendirilmiştir. XRCC1 genindeki polimorfizmlerin, proteinin fonksiyonel yapısını değiştirerek tamir etkinliğini olumsuz etkileyebileceği öne sürülmüştür. İnsanlarda kanser gelişimi üzerindeki rolünü incelemek amacıyla baş, boyun, kolon, mide, özefagus, akciğer, mesane, meme ve deri kanserleri gibi çeşitli hastalıklar üzerinde birçok hasta ve kontrol çalışması yapılmış ve farklı sonuçlar elde edilmiştir. (58).
- ERCC2 (Excision Repair Cross Complementing 2): Çevresel kanserojenlerin neden olduğu hacimli DNA lezyonlarını onaran nükleotid eksizyon onarım yolunun kritik bir bileşenidir. ERCC2'deki

polimorfizmler, özellikle çevresel genotoksik ajanlara maruz kalan kişilerde mesane kanseri duyarlılığı ile ilişkilendirilmiştir(59).

Metabolik Enzimlerde Polimorfizmler:

- NAT2 (N-Asetiltransferaz 2): Sigara dumanında ve endüstriyel kimyasallarda bulunan arilaminlerin metabolizmasında yer alır. NAT2'deki polimorfizmler, özellikle sigara içenlerde artan mesane kanseri riski ile ilişkilendirilmiştir (60).
- GSTM1 (Glutatyon S-Transferaz Mu 1) ve GSTT1 (Glutatyon S-Transferaz Teta 1): Glutatyon ile konjugasyon yoluyla karsinojenlerin detoksifiye edilmesinde yer alır. GSTM1 ve GSTT1 boş genotiplerinin varlığı, özellikle sigara içenlerde ve çevresel toksinlere maruz kalan kişilerde artmış mesane kanseri riski ile ilişkilendirilmiştir (61).

Bağışıklık Tepkisi Genlerinde Polimorfizmler:

- IL-10 (İnterleukin-10): Bağışıklık yanıtı düzenlemesinde yer alan bir sitokindir. IL-10 genindeki polimorfizmler, artan kanser riskine bağlı bazı varyantlarla mesane kanseri duyarlılığı ile ilişkilendirilmiştir (62).

Hücre Döngüsü Düzenleyicilerinde Polimorfizmler:

- TP53 (Tümör Proteini p53): Hücre döngüsü düzenlemesi ve DNA onarımında yer alan kritik bir tümör baskılayıcı gendir. TP53'teki polimorfizmler, değişen mesane kanseri riski ile ilişkilendirilmiştir (63).

3.MATERYAL ve METOD

3.1. Materyal

3.1.1. Kimyasal Madde ve Çözücüler

Saf Etil Alkol (Reidel-Haen, Almanya)

2-propanol (Merck, Almanya)

Bidistile su

3.1.2. Alet ve Gereçler

Santrifüj (Sigma k-15-1, Almanya)

Etüv (Nüve EN 500, Türkiye)

-20°C Soğutucu (Uğur Derin Dondurucu, Türkiye)

-80 ^{0}C Soğutucu (Jouan, Danimarka)

+4 ^{0}C Soğutucu (Bosch, Almanya)

1,5 ml'lik kapaklı mikrosantrifüj tüpü (Isolab, Almanya)

Otomatik ayarlanabilir pipet (Eppendorf, Almanya)

Gerçek zamanlı PCR cihazı (LightCycler480 II, Roche Diagnostics GmbH Mannheim, Almanya)

Lightcycler 480 multiwell plate 96 (Roche Kat No: 4729692)

Lightcycler 480 sealing foil (Roche Kat No: 4729757)

Taqman Universal Master Mix II (Thermo Kat No: 4440038)

Distile su cihazı (Milli pore, Fransa)

3 ml'lik %7,5 EDTA'lı tüp (BD, Vacutainer, İngiltere)

AU5800 BECKMAN COULTER

UNICEL DXI800

SYMEX XN1000

3.1.3. Kullanılan Kitler

High Pure PCR Template Preparation Kit (Cat. No. 11 796 828 001, Roche Diagnostics GmbH Mannheim, Almanya)

TaqMan® SNP Genotyping CYP1A1 rs4646903 Assay Kit (Thermo Kat No: 4351379)

TaqMan® SNP Genotyping CYP1A1 rs1048943 Assay Kit (Thermo Kat No: 4351379)

PureLink® Genomic DNA Mini Kit (Thermo Kat No: K182002)

Kreatinin, (Beckman Coulter, Inc, Brea, CA, USA)

HDL (Beckman Coulter, Inc, Brea, CA, USA)

LDL (Beckman Coulter, Inc, Brea, CA, USA)

VLDL (Beckman Coulter, Inc, Brea, CA, USA)

AST (Beckman Coulter, Inc, Brea, CA, USA)

ALT (Beckman Coulter, Inc, Brea, CA, USA)

CRP (Beckman Coulter, Inc, Brea, CA, USA)

Üre (Beckman Coulter, Inc, Brea, CA, USA)

WBC (Symex XN1000, USA)

RBC (Symex XN1000, USA)

Ferritin (Beckman Coulter, Inc, Brea, CA, USA)

3.2. Çalışma Grubu ve Kan Örnek Örneklerinin Toplanması ve Saklanması

3.2.1. Çalışma Grubu

Bu çalışmaya Mersin Üniversitesi Hastanesi, Üroloji polinikliğine başvuran herhangi bir sistemik hastalığı olmayan, sadece mesane kanser tanısı alan 18-80 yaş aralığındaki 55 hasta (Hasta Grubu) ve yine üroloji polikliniğine başvuran düzenli analiz

ve klinik muayene sonucu kanser ve genel hastalığı bulunmayan 18-80 yaş aralığında 56 sağlıklı birey (Kontrol Grubu) dahil edilmiştir. Bu çalışma 23/03/2022 tarihli ve 2022/197 sayılı kurul kararı ile Mersin Üniversitesi Klinik Araştırmalar Etik Kurulu tarafından onaylanmıştır.

Araştırmaya dahil edilmesi planlanan hasta ve kontrol grubuna ait örneklem genişliği hesaplamasında, gruplarda orta dereceli etki büyüklüğü belirlenip 0,30 olarak alınmıştır. Bu etki büyüklüğünün 0.05 Tip I hata ve 0.80 güç ile her bir grupta 54 vaka ile olmasına karar verilmiştir.

3.2.1.1. Hasta ve Kontrol Grubu İçin Dahil Edilme Kriterleri

Hasta Grubu:

1. Mersin Üniversitesi Tıp Fakültesi Hastanesi, Üroloji polikliniğinde takip edilen ve mesane kanseri tanısı alan ve mesane kanseri dışında herhangi bir sistemik hastalığı olmayan hastalar
2. 18 ila 80 yaş aralığındaki hastalar
3. Tüm dosya verileri sağlanmış hastalar
4. Gönüllü olur formunu imzalamış olan hastalar

Kontrol Grubu:

1- Mersin Üniversitesi Tıp Fakültesi Hastanesi, Üroloji Polikliniğinde takip edilen bireyler

2- 18 ila 80 yaş aralığındaki hastalar

3- Tüm dosya verileri sağlanmış hastalar

4- Gönüllü olur formunu imzalamış olan hastalar

3.2.1.2.Hasta ve Kontrol Grubu İçin Dışlanma Kriterleri

Hasta grubu

1- Mersin Üniversitesi Tıp Fakültesi Hastanesi, Üroloji Polikliniğinde kayıtlı olmayan hastalar

2- 18 yaş altı ve 80 yaş üstü hastalar

3- Dosya verileri tamamlanmamış hastalar

4- Gönüllü olur formunu imzalamamış olan hastalar

Kontrol grubu

1- Mersin Üniversitesi Tıp Fakültesi Hastanesi, Üroloji Polikliniğinde kayıtlı olmayan hastalar

2- 18 yaş altı ve 80 yaş üstü hastalar

3- Dosya verileri tamamlanmamış bireyler

4- Gönüllü olur formunu imzalamamış olan bireyler

3.3. Çalışma Gruplarından Kan Örneklerin Alımı ve Saklanması

Etik kurul onayı alındıktan sonraki tarihten itibaren (23/03/2022) 3 ay içinde hasta ve kontrol gruplarından EDTA'lı tüplere alınan 5 ml kan örneklerinden WBC ve RBC analizi aynı gün çalışıldı. Takiben CYP1A1 rs4646903 ve rs1048943 polimorfizm analizi için Tıbbi Biyokimya Laboratuvarında çalışma gününe kadar olan süre içinde $+4^0$C'de saklandı. Boş biyokimya tüplerine alınan kan örnekleri ise 3000 rpm'de 10 dakika santrifüj edildikten sonra ayrılan serum örneklerinde biyokimyasal parametrelerden Kreatinin, HDL, LDL, VLDL, AST, ALT, WBC, RBC, CRP ve Üre, Ferritin analizi aynı gün çalışıldı.

3.4. Metod

3.4.1. CYP1A1 rs4646903 ve rs1048943 Polimorfizm Analizi için DNA İzolasyonu

Çalışmaya katılmayı kabul eden hasta ve kontrol grubundaki bireylerden alınan ve +4°C'de saklanan EDTA'lı tüplerdeki kan örneklerinden DNA izolasyonu, Roche Diagnostics (GmbH, Mannheim, Almanya) tarafından sağlanan DNA izolasyon kiti kullanılarak gerçekleştirildi. Bu işlemde uygulanan presedür;

1- Steril bir 1,5 ml kapaklı tüpe 200 µL tam kan alındı. Üzerine sırasıyla 200 µL bağlayıcı tampon ve 40 µL proteinaz K eklendi. Proteinaz eklendikten sonra tüplerin kapakları hemen karıştırıldı.

2- Tüpler, 70 °C'de 10 dakika inkübe edildi.

3- İnkübasyonun ardından tüplere 100 µL izopropanol eklenip iyice karıştırıldı. Karışım, bir filtre tüpüne aktarıldı.

4- Karışım, 8000 g'de 1 dakika santrifüj edildi.

5- Toplama tüpü değiştirildi ve yeni tüpe 500 µL Inhibitor Removal Buffer eklendi. Bu tüp, 8000 g'de 1 dakika santrifüj edildi ve toplama tüpü tekrar değiştirildi.

6- Sonraki adımda, tüpe 500 µL wash buffer eklenip, 8000 g'de 1 dakika santrifüj edildi. Toplama tüpü değiştirildi.

7- Bu yıkama işlemi bir kez daha tekrarlandı ve toplama tüpü değiştirildi.

8- Tüpe herhangi bir çözelti eklenmeden, 13.000 g'de 10 saniye santrifüj edildi.

9- Son olarak 1,5 ml'lik kapaklı DNA saklama tüplerine filtre tüpleri yerleştirilerek içerisine 70 °C'de bekletilen elüsyon tamponundan 200 µL eklenerek 1 dakika 8000 g'de santrifüj edildi. Bu defa DNA elüsyon tamponunun yardımı ile 1,5 ml'lik kapaklı DNA saklama tüplerine geçtiği için filtre tüpleri uzaklaştırılıp ve DNA eldesi tamamlandı.

3.4.2 CYP1A1 rs4646903 Ve rs1048943 Polimorfizmi Analizi

CYP1A1 rs4646903 ve rs1048943 polimorfizmleri, elde edilen DNA örneklerinde Roche Diagnostics LightCycler 480 RT-PCR cihazı (GmbH, Mannheim, Almanya) ile analiz edildi. Analiz sırasında, üretici firmanın önerilerine uygun olarak aşağıdaki reaksiyon karışımı hazırlandı. Reaksiyon karışımında kullanılan materyaller ve miktarları Tablo 2'de belirtilmiştir.

Tablo 3.1. Reaksiyon karışımının hazırlanmasında kullanılan materyaller ve miktarları

İçerik	Miktar
H_2O	4 µL
Master Mix	10 µL
Primer-probe Assay	1 µL
Toplam karışım hacmi	15 µL
DNA	5 µL

Multiwell plate içerisine her bir örnek için 15 µL karışım ve karışımın üzerine 5 µL DNA eklendi. CYP1A1 rs4646903 ve rs1048943 polimorfizmlerinin analizi için uygulanan PCR koşulları Tablo 3'de verilmiştir.

Tablo 3.2. CYP1A1 rs4646903 ve rs1048943 polimorfizmlerinin analizi için PCR koşulları

PCR aşamaları		Hedefısı (°C)	Bekleme süresi (sn)
Denatürasyon		95	600
Amplifikasyon (40 Döngü)	Denatürasyon	95	15
	Anneal/extend	60	60
Soğuma		40	30

3.4.3. Biyokimyasal Parametrelerin Ölçümü ve Prensipleri

Kreatinin, HDL, LDL, VLDL, AST, ALT, CRP, Üre parametreleri Beckman Coulter, Inc, Brea, CA, USA AU5800 BECKMAN COULTER biyokimya otoanalizörü kullanılarak gerçekleştirildi.

Kreatinin; Kreatinin ölçüm prensibi, kreatininin alkalin ortamda pikrik asitle sarı-turuncu renkli bir bileşik oluşturmasına dayanır. 520/800 nm dalga boylarında renk değişimi, örnekte bulunan kreatinin konsantrasyonuyla doğru orantılıdır.

HDL; Enzimatik kolorimetrik analiz prensibi, anti-insan-β-lipoprotein antikorunun HDL dışındaki lipoproteinlere (LDL, VLDL ve şilomikronlar) bağlanması esasına dayanır. Oluşan antijen-antikor kompleksleri R2 eklendiğinde enzimatik reaksiyonları inhibe eder. HDL-kolesterol miktarı, bir enzim kromojen sisteminin kullanımıyla belirlenir.

LDL; Kolorimetrik yöntem, koruyucu bir ajanın LDL'yi enzimatik reaksiyonlardan korumasını esas alır. LDL dışındaki lipoproteinler (HDL, VLDL, CM), kolesterol esteraz (CHE) ve kolesterol oksidaz (CHO) ile parçalanır. Oluşan hidrojen peroksit, R1'deki katalaz tarafından yok edilir. LDL'nin ölçüm prensibi, sodyum azid gibi koruyucu reaktiflerin eklenmesiyle LDL'nin ve katalazın inaktive edilmesini içerir. Bu işlemden sonra, LDL miktarı CHO/PAP sistemi kullanılarak belirlenir.

VLDL; VLDL düzeyleri oransal olarak Friedwald eşitliğine göre (Trigliserid **÷5) hesaplanmıştır.**

AST; Bu yöntemde, aspartat aminotransferaz (AST), aspartat ile 2-oksoglutaratın transaminasyonunu katalize ederek L-glutamat ve oksalasetat üretir. Reaksiyon karışımına piridoksal fosfat eklenmesi, AST'nin en yüksek katalitik etkinliğini sağlar. Oksalasetat, malat dehidrojenaz (MDH) tarafından L-malata indirgenirken, eş zamanlı olarak NADH NAD^+'ya dönüşür. NADH'nin tüketilmesi, 340 nm'de absorbansta bir azalma ile ölçülür ve bu azalma numunedeki AST aktivitesiyle doğru orantılıdır. Ayrıca, endojen piruvat inkübasyon süresince LDH reaksiyonu ile temizlenir.

ALT; Amino grubu, 2-oksoglutarat üzerinde alanındaki piruvat (ALT) ve glutamat oluşturarak aktarılır. Reaksiyon karışımına piridoksal fosfat eklenmesi, ALT'nin en yüksek katalitik performansını garantiler. Piruvat, laktat dehidrojenaz (LDH) tarafından NADH ile katalize edilen bir reaksiyona girer ve bu süreçte laktat ile NAD+ açığa çıkar. NADH tüketimi 340 nm'de absorbansta gözlemlenen düşüşle ölçülür ve bu düşüş ALT aktivitesi ile ilişkilidir. Inkübasyon süresi boyunca endojen piruvat temizlenir.

CRP; İmmünotürbidimetrik ölçüm prensibi, R1 (Glycine buffer) ve R2 (anti-CRP antikorlarıyla kaplanmış latex süspansiyonu) ile karıştırıldığında CRP, çözünmeyen agregatlar oluşturacak şekilde özel olarak, lateks partiküllerinin üzerini kaplamış anti-insan CRP antikorları ile Reaksiyona girmesi prensibine dayanır. Bu agregatların absorbansı numunedeki CRP konsantrasyonu ile orantılıdır.

Üre; Üre ölçüm prensibi, ürenin su ve üreaz varlığında hidrolize olarak amonyak ve karbon dioksit açığa çıkmasına dayanır. İlk reaksiyonda oluşan amonyak, glutamat dehidrojenaz (GLDH) enziminde 2-oksoglutarat ve NADH ile birleşir, sonuç olarak glutamat ve NAD+ oluşur. Birim zaman içinde NADH'nin absorbansındaki azalma, üre konsantrasyonu ile doğru orantılıdır.

WBC ve RBC parametreleri Sysmex modeli SYMEX XN1000kan sayım cihazı cihazı kullanılarak gerçekleştirildi.

WBC; akım sitometri yöntemi ile hesaplanır.

RBC**;** impedans yöntemi ile hesaplanır.

Ferritin parametreleri Beckman Coulter, Inc, Brea, CA, USA UNICEL DXI800 hormon otoanalizörü kullanılarak gerçekleştirilmiştir. Acces Ferritin testi, iki bölgeli immünoenzimatik (sandviç) bir testtir. Testin gerçekleştirilmesi için reaksiyon kabına keçi anti-ferritin alkalin fosfataz konjugatı ve keçi anti-ferritin ile kaplı paramanyetik partiküller içeren örnek eklenir. Serum veya plazma (heparin) içindeki ferritin, katı fazda bulunan monoklonal anti-ferritin ile bağlanırken, keçi anti-ferritin enzim konjugatı ferritin moleküllerindeki farklı antijen bölgeleriyle etkileşime girer. İnkübasyon sonrası, bağlanmış maddeler katı fazda tutulur, bağlanmamış maddeler yıkanır ve manyetik alan kullanılarak tutulur. Daha sonra Lumi-Phos 530 kemilüminesans substratı eklenir ve reaksiyondan oluşan ışık bir luminometre ile ölçülür. Elde edilen ışık miktarı, örnekteki ferritin konsantrasyonu ile doğru orantılıdır. Analit miktarı, saklanmış olan kalibrasyon eğrisi kullanılarak hesaplanır.

3.4.4. İstatistiksel Analiz

Değişkenlerin normal dağılım Shapiro-Wilk testi ile kontrol edildi. Yaş değişkeni, ortalama ± standart sapma (SS) ile birlikte minimum-maximum, medyan, 1. çeyreklik ve 3. çeyreklik değerleri kullanılarak özetlendi. Sınıflandırılmış değişkenler ise sayı (n) ve yüzde (%) olarak tablolandı. İki grup arasındaki karşılaştırmalarda bağımsız örneklem t testi kullanıldı. Sınıflandırılmış değişkenler arasındaki ilişkiler Ki-Kare testi ile analiz edildi. Genotipler açısından Hasta ve Kontrol gruplarının Hardy-Weinberg dengesi kontrol edildi. Analizler Statistica v.13.3.1 yazılımı ile gerçekleştirildi ve $p<0,05$ istatistiksel anlamlılık sınırı olarak belirlendi.

4. BULGULAR

4.1.Çalışma Grubunu Oluşturan Bireylerin Tanımlayıcı Bilgilerine Ait Bulgular

Çalışmaya, Mersin Üniversitesi Tıp Fakültesi Hastanesi Üroloji polikliniğine başvurmuş, 18 yaşından büyük ve 80 yaşından küçük hastalar, dosya verileri tam olup bilgilendirilmiş gönüllü olur formunu imzalamış olan mesane kanseri tanısı konulan 55 hasta (yaş ortalaması: 66,87±6,48), ve mesane kanseri tanısı almamış olan 56 (yaş ortalaması: 58,48±13,69) sağlıklı kontrol olmak üzere 111 birey dahil edildi.

Tablo 4.1'de yaşa göre hasta ve kontrol gruplarının yaş ortalamalarına göre dağılımları bakımından verileri veilmiş olup hasta ve kontrol grubunda yaş ortalamaları bakımından anlamlı bir fark bulundu ($p<0,001$).

Tablo 4.1. Hasta ve Kontrol gruplarının yaş ortalamalarına göre dağılımları

	GRUP	N	Ort±S.Sapma	Min-Maks	p
Yaş	Hasta	55	66,87±6,48	49,00-81,00	**<0,001**

	Kontrol	56	58,48±13,69	26,00-85,00	

n: hasta/ kontrol sayısı, p:gruplar arası anlamlılık derecesi

Çalışma gruplarına ait cinsiyet, yaş, aile öyküsü, sigara kullanımı, alkol kullanımı, Hipertansiyon (HT), Diyabetes mellitus (DM), Kronik Obstrüktif Akciğer Hastalığı (KOAH) ve Koroner Arter Hastalığı (KAH) gibi demografik verileri Tablo 4.2'de verilmiştir.

Tablo 4.2. Çalışma Grubunu Oluşturan Bireylerin Demografik Verilerine Ait Bulgular

			Hasta	**Kontrol**		
Cinsiyet	Kadın	n	8	8	16	0,969
		%	%14,5	%14,3	%14,4	
	Erkek	n	47	48	95	
		%	%85,5	%85,7	%85,6	
Aile Öyküsü	Yok	n	50	56	106	**0,021**
		%	%90,9	%100,0	95,5	
	Var	n	5	0	5	
		%	%9,1	%0,0	%4,5	
Sigara Kullanımı	Yok	n	12	23	35	**0,028**
		%	%21,8	%41,1	%31,5	
	Var	n	43	33	76	
		%	%78,2	%58,9	%68,5	
DM	Yok	n	37	56	93	**<0,001**
		%	%67,3	%100,0	%83,8	
	Var	n	18	0	18	
		%	%32,7	%0,0	%16,2	
HT	Yok	n	31	56	87	**<0,001**
		%	%56,4	%100,0	%78,4	
	Var	n	24	0	24	
		%	%43,6	%0,0	%21,6	

KOAH	Yok	n	48	56	104	0,061
		%	%87,3	%100,0	%93,7	
	Var	n	7	0	7	
		%	%12,7	%0,0	%6,3	
KAH	Yok	n	51	56	107	0,122
		%	%92,7	%100,0	%96,4	
	Var	n	4	0	4	
		%	%7,3	%0,0	%3,6	

n: hasta sayısı, %: hasta yüzdesi, p:gruplar arası anlamlılık derecesi

*HT: hipertansiyon, DM: Diyabetes mellitus, KOAH: Kronik Obstrüktif Akciğer Hastalığı KAH: Koroner Arter Hastalığı

Mesane kanseri çalışma grubu cinsiyet dağılımı bakımından incelendiğinde, hasta grubunu oluşturan 55 katılımcının 8'si kadın, 47'si erkek olup, kontrol grubunu oluşturan 56 katılımcının ise; 8'i kadın, 48'i erkektir. Cinsiyet dağılımı bakımından gruplar arasında istatistiksel olarak anlamlı bir ilişki saptanmadı (p=0,969).

Bu çalışmada kontrol grubu herhangi bir sistemik hastalığı ve kanser öyküsü olmayan bununla birlikte aile öyküsünde de herhangi bir kanser öyküsü olmayan sağlıklı bireylerden oluşturuldu. Bu nedenle mesane kanseri grubunda aile öyküsü bulunanlar kontrol grubu aile öyküsü bulunanlara göre anlamlı derecede daha yüksek bulundu (p=0,021). Sistemik hastalıklar açısından hasta grubunda bulunan bireyler incelendiğinde, DM; %32,7, HT;%43,6, KOAH;%12,7, KAH;%7,3 oranında bulunduğu tespit edildi.

4.2. Kontrol ve Hasta Gruplarının CYP1A1 rs1048943 Polimorfizminde Genotiplerinde Hardy- Weinberg Dengesine Ait Bulgular

Çalışma grubunu rs1048943 polimorfizmdeki genotipler ile beklenen genotipler arasındaki uyum 'Hardy Weinberg' dengesine göre incelendi ve popülasyonun dengede olduğu bulundu.

Tablo 4.3. Hasta ve Kontrol Grubu CYP1A1 rs1048943 polimorfizmi açısından 'Hardy Weinberg' dengesindeki veriler

HASTA/KONTROL	GENOTİP	HWE	P Değeri

		Gözlenen Değer	Beklenen Değer	
rs1048943 Hasta	AA	43 (%78,2)	43,65	0,364
	AG	12 (%21,8)	10,69	
	GG	0 (%0,0)	0,65	
rs1048943 Kontrol	AA	49 (%87,5)	49,22	0,618
	AG	7 (%12,5)	6,56	
	GG	0 (%0,0)	0,22	

p: gruplar arası anlamlılık derecesi

Mesane kanseri çalışma grubunu oluşturan hasta grubu CYP1A1 (rs1048943) polimorfizmi açısından 'Hardy Weinberg' dengesindedir (p=0,364). Kontrol grubu CYP1A1 (rs1048943) açısından 'Hardy Weinberg' dengesindedir (p=0,618).

4.3. Kontrol ve Hasta Gruplarında CYP1A1 rs1048943 Polimorfizminde Genotip Dağılımına Ait Bulgular

Kontrol ve hasta grupları arasındaki CYP1A1 rs1048943 genotip dağılımı Tablo 4.4' de verilmiştir.

Tablo 4.4. CYP1A1 rs1048943 polimorfizminde hasta ve kontrol gruplarındaki genotip dağılımı

Polimorfizm	Genotip		Grup		Total	P değeri
			Hasta	Kontrol		
rs1048943	AA	n	43	49	92	0,193
		%	%78,2	%87,5	%82,9	
	AG	n	12	7	19	
		%	%21,8	%12,5	%17,1	

n: hasta sayısı, p: gruplar arası anlamlılık derecesi

CYP1A1 rs1048943 polimorfizmi için genotip dağılımları incelendiğinde, hasta grubunda AA genotipine sahip 43 katılımcı (%78,2) hasta, AG genotipine sahip 12 katılımcı (%21,8) hasta bulundu. Kontrol grubunda ise AA genotipine sahip 49 katılımcı (%87,5) hasta, AG genotipine sahip 7 katılımcı (%12,5) hasta bulundu. Hasta ve kontrol grupları toplam dağılımları incelendiğinde ise; AA genotipine sahip 92 katılımcı (%82,9), AG genotipine sahip 19 katılımcı (%17,1) ve GG genotipine sahip 0 katılımcı (%0,0) hasta

tespit edildi. Tüm bu bilgiler ışığında hasta-kontrol grubu ile CYP1A1 (rs1048943) polimorfizmi arasında kayda değer bir ilişki yoktur (p=0,193).

4.4. Kontrol ve Hasta Gruplarında CYP1A1 rs1048943 Polimorfizminde Allel Dağılımlarına Ait Bulgular

CYP1A1 rs1048943 polimorfizminde kontrol ve hasta grupları ile allel dağılımlarına ait veriler Tablo 4.5' de verildi.

Tablo 4.5. Kontrol ve hasta gruplarında CYP1A1 rs1048943 polimorfizminde allel dağılımlarına ait veriler

Alel	**Allel Oranları**			
		Kontrol	**Hasta**	**P Değeri**
A	n	105	98	0,541
	%	%84,7	%89,1	
G	n	19	12	
	%	%15,3	%10,9	

n: hasta sayısı, p: gruplar arası anlamlılık derecesi

CYP1A1 (rs1048943) polimorfizmi için hasta ve kontrol grupları ile allel dağılımlarında A alleli kontrol grubunda 105 katılımcı (%84,7), hasta grubunda 98 katılımcı (%89,1); G alleli oranı kontrol grubunda 19 katılımcı (%15,3), hasta grubunda 12 katılımcı (%10,9) olarak tespit edildi. Tüm bu veriler ışığında CYP1A1 (rs1048943) polimorfizmi için Hasta-Kontrol grupları ile allel dağılımları arasında kayda değer bir ilişki saptanmadı (p=0,541).

4.5. Kontrol ve Hasta Gruplarının CYP1A1 rs4646903 Polimorfizminde Genotiplerinde Hardy- Weinberg Dengesine Ait Bulgular

Mesane kanseri çalışma grubunu oluşturan kontrol ve hasta grubunda CYP1A1 rs4646903 varyantına ait olan T/C allellerinin oluşturduğu genotiplerle olması beklenen genotipler arasındaki uyum (Hardy-Weinberg Dengesi) Tablo 4.6' da verildi.

Tablo 4.6. Hasta ve Kontrol Grubu CYP1A1 rs4646903 açısından 'Hardy Weinberg' dengesindeki veriler

Hasta/Kontrol	**Genotip**	**HWE**		**P Değeri**
		Gözlenen Değer	**Beklenen Değer**	

rs4646903 Hasta	TT	41 (%74,5)	41,02	0,979
	CC	13 (%23,6)	12,95	
	TC	1 (%1,8)	1,02	
rs4646903 Kontrol	TT	50 (%89,3)	50,16	0,672
	CC	6 (%10,7)	5,68	
	TC	0 (%0,0)	0,16	

HWE: Hardy Weinberg Dengesi, p:gruplar arası anlamlılık derecesi

Çalışma grubu rs4646903 polimorfizmdeki genotipler ile beklenen genotipler arasındaki uyum 'Hardy Weinberg' dengesine göre incelendi ve popülasyonun dengede olduğu bulundu. Hasta grubu rs4646903 polimorfizmi açısından 'Hardy Weinberg' dengesindedir. (p=0,979). Kontrol grubu rs4646903 açısından 'Hardy Weinberg' dengesindedir (p=0,672).

4.6. Kontrol ve Hasta Gruplarında CYP1A1 rs4646903 PolimorfizmindeGenotip Dağılımına Ait Bulgular

Kontrol ve hasta grupları arasındaki CYP1A1 rs4646903genotip dağılımı Tablo 4.7' de verildi.

Tablo 4.7. Kontrol ve hasta gruplarında CYP1A1 rs4646903polimorfizminde genotip dağılımı

Polimorfizm	Genotip		Grup		Total	p
			Hasta	Kontrol		
rs4646903	TT	n	41	50	91	0,108
		%	%74,5	%89,3	%82,0	
	TC	n	13	6	19	
		%	%23,6	%10,7	%17,1	
	CC	n	1	0	1	
		%	%1,8	%0,0	%0,9	

n: hasta sayısı, p:gruplar arası anlamlılık derecesi

CYP1A1 (rs4646903) polimorfizmi için genotip dağılımları incelendiğinde, hasta grubunda TT genotipine sahip 41 katılımcı (%74,5) hasta, TC genotipine sahip 13 katılımcı (%23,6) hasta, CC genotipine sahip 1 katılımcı (%1,8) hasta bulundu. Kontrol grubunda ise TT genotipine sahip 50 katılımcı (%89,3) birey, TC genotipine sahip 6 katılımcı (%10,7) birey, CC genotipine sahip 0 katılımcı (%0) birey bulundu. Hasta ve kontrol grupları toplam dağılımları incelendiğinde ise; TT genotipine sahip 91 katılımcı

(%82), TC genotipine sahip 19 katılımcı (%17,1), CC genotipine sahip 1 katılımcı (%0,9) birey tespit edildi. Tüm bu bilgiler ışığında hasta-kontrol grubu ile CYP1A1 (rs4646903) polimorfizmi arasında anlamlı bir ilişki saptanmadı (p=0,108).

4.7. Kontrol ve Hasta Gruplarında CYP1A1 rs4646903 Polimorfizminde Allel Dağılımlarına Ait Bulgular

CYP1A1 rs4646903 polimorfizminde kontrol ve hasta grupları ile allel dağılımlarına ait veriler Tablo 4.8' de verilmiştir.

Tablo 4.8. Hasta-Kontrol grupları ile allel dağılımları

Allel Oranları			
	Kontrol	**Hasta**	**P Değeri**
T	100	83	0,871
	%89,2	%75,5	
C	12	27	
	%10,8	%24,5	

p:gruplar arası anlamlılık derecesi

CYP1A1 (rs4646903) polimorfizmi için hasta ve kontrol gruplarına ait allel dağılımlarında T alleli kontrol grubunda 100 sağlıklı katılımcı (%89,2), hasta grubunda 83 katılımcı(%75,5); C alleli oranı kontrol grubunda 12 sağlıklı katılımcı (%10,8), hasta grubunda 27 katılımcı (%24,5) olarak tespit edildi. Tüm bu veriler ışığında CYP1A1 (rs4646903) polimorfizmi için Hasta-Kontrol grupları ile Allel dağılımları arasında anlamlı bir ilişki saptanmadı (p=0,871).

5. TARTIŞMA

Mesane kanseri, mesane astarındaki hücrelerin anormal büyümesiyle karakterize edilen, dünya çapında önemli bir sağlık sorunudur. Gelişiminin ve ilerlemesinin altında yatan moleküler mekanizmaları anlamak, teşhis ve tedavi stratejilerini geliştirmek için önemlidir Son araştırmalar, bir bireyin kansere duyarlılığını etkileyebilen kalıtsal genetik varyasyonların rolünü de vurgulamıştır. Karsinojenezde

yer alan çeşitli genler arasında, sitokrom P450 (CYP) gen ailesi, çevresel karsinojenler de dahil olmak üzere çok sayıda endojen ve eksojen bileşiğin metabolizmasındaki önemli rolü nedeniyle önemli ölçüde dikkat çekmiştir (3). CYP1A1 ve CYP1A2'yi de içeren CYP450 enzimleri, tütün dumanında ve çevresel kirleticilerde bulunan kanserojenlerin metabolize edilmesinde önemli roller oynar. Bu enzimler, mesane kanseri için bilinen risk faktörleri olan aromatik aminlerin ve polisiklik aromatik hidrokarbonların (PAH'lar) aktivasyonunda rol oynar (63). Araştırmalar, CYP450 enzimlerindeki genetik varyasyonların mesane kanserine karşı bireysel duyarlılığı etkileyebileceğini düşündürmektedir (64). Bu nedenle, CYP1A1 genindeki m1 (T>C) ve m2 (A>G) varyantları gibi polimorfizmlerin mesane kanseri riski ile potansiyel ilişkileri açısından incelenmiştir(65). Bu genetik varyasyonlar enzim aktivitesini ve substrat metabolizmasını etkileyebilir, dolayısıyla bireyin kanserojen maruziyetlere karşı tepkisini modüle edebilir. CYP450 genetik polimorfizmlerinin mesane kanseri duyarlılığındaki rolünü anlamak, kişiselleştirilmiş risk değerlendirmesi ve önleyici stratejiler konusunda değerli bilgiler sağlayabilir (66,67)

Mesane kanseri ile CYP450 enzimleri arasındaki ilişki, onkoloji araştırmaları ve klinik uygulamalarda moleküler öngörüleri öneminin altını çizmektedir. Bilimsel buluşların hasta sonuçlarını iyileştirecek ve mesane kanserinin küresel yükünü azaltacak yenilikçi stratejilere dönüştürülmesi için disiplinler arası çabalara devam edilmesi gerekmektedir. Bu bilgilerin ışığında bu çalışmada, Sitokrom P450 enzimlerinden olan CYP1A1 geni ile ilişkili m1 (T>C; rs4646903) ve m2 (A>G; rs1048943) polimorfizmlerinin mesane malignitesi ile olan ilişkisinin araştırılması amaçlanmıştır.

Mesane kanseri üzerine yapılan çalışmalar sonucunda risk faktörü olarak bakılan; yaş, aile faktörü, sigara kullanımı, DM, HT, KOAH, KAH gibi parametrelerin etkili olduğu görülmüştür (68). Yaşın mesane kanseri için önemli bir tehlike unsuru olduğu tespit edilmiştir. Yapılan çalışmalarda, mesane kanserinin 55 yaş üstü bireylerde daha sık görüldüğünü ve hasta ile kontrol grupları arasında benzer yaş dağılımı olmadığını ortaya koyulmuştur. Ayrıca genç yetişkinlerde mesane kanseri görülme sıklığının arttığı gözlenmiştir. (69). Başka bir çalışmada mesane kanseri hastalarının % 27,3'ü 65 yaşından küçük, % 72,7'si 65 yaşından büyük olduğu ileri sürülmüştür (70). Bu çalışmaya dahil edilen hasta ve kontrol gruplarına ait bireylerin yaş ortalaması incelendiğinde, hasta grubunun yaş ortalaması 66,87±6,48 iken herhangi bir sistemik hastalığı ve kanser öyküsü olmayan sağlıklı bireylerden oluşturulan kontrol grubunun ise yaş ortalaması 58,48±13,69 olarak bulundu. Bu anlamlı yaş farklılığı ($p<0,001$), yaşlı bireylerde mesane kanseri prevalansının daha yüksek olduğunu gösterip risk faktörleri arasında yaşın önemli bir yere sahip olduğu görüldü. Bu kapsamda, bulgularımız literatür ile uyumludur.

Mesane kanseri insidansındaki cinsiyet dağılım modelleri geniş çapta araştırılmış olup, erkeklerde kadınlara göre daha yüksek bir prevalansın olduğu ortaya çıkmıştır (71). Bu cinsiyet eşitsizliği, mesleki maruziyetlerdeki farklılıklar, sigara içme alışkanlıkları ve hormonal etkiler dahil olmak üzere çeşitli faktörlere bağlanmıştır (71). Fajkovic ve arkadaşları ile Lutz ve arkadaşları da mesane kanseri demografisi üzerine geniş çaplı bir çalışma yürütmüş ve cinsiyete dayalı önemli bir eşitsizlik ortaya koymuştur (72, 73). Bu çalışmada, mesane kanseri için birçok risk faktöründe cinsiyet etkili olduğundan, kontrol grubu hasta grubuna cinsiyet sayısı bakımından eşleştirme yapılarak oluşturuldu. Bu nedenle yapılan analizler neticesinde mesane kanseri çalışma gruplarında cinsiyet dağılımı incelendiğinde hasta ve kontrol gruplarında Kadınlar ve

erkekler arasında anlamlı bir fark tespit edilmedi (p=0,969). Hasta grubundaki cinsiyet dağılımları, literatüre benzer şekilde, kadın birey sayısının % 14,3, erkek birey sayısı ise % 85,5 olduğu tespit edildi.

Ailede mesane kanseri öyküsünün, hastalığa genetik yatkınlığı düşündüren potansiyel bir risk faktörü olduğu belirlenmiştir. Birinci derece akrabalarında mesane kanseri tanısı alan bireylerin, bu durumu kendilerinde geliştirme riskinin yüksek olduğu gösterilmiştir (74-76). Mesane kanseri ile diyabet (DM), hipertansiyon (HT), kronik obstrüktif akciğer hastalığı (KOAH) ve koroner arter hastalığı (KAH) gibi eşlik eden hastalıklar arasındaki ilişki incelenmiştir (77). Bu komorbiditelerin, mesane kanserinin gelişimine ve ilerlemesine neden olabileceği düşünülen çeşitli mekanizmalar aracılığıyla, inflamasyon, oksidatif stres ve metabolik düzensizlik gibi etkenlerle ilişkilendirilmektedir (77). Oluşturulan hasta grubunda aile öyküsünde mesane kanseri olan oran % 9'dur ve yapılan analiz neticesinde aile öyküsü faktöründe anlamlı bir farklılık tespit edilerek kontrol grubuna kıyasla daha fazla sayıda hastanın ailesinde mesane kanseri öyküsü bulundu (p=0,021).

Çalışmamızda mesane kanserli hasta grubunda DM, HT, KOAH, KAH gibi durumların prevalansı ve bu durumlarla mesane kanseri arasında bir bağlantı olup olmadığına bakıldı. Veriler doğrultusunda; hasta grubu bireylerinde DM; % 67,2, HT; % 56,3, KOAH; % 87,2 KAH; % 92,7 oranlarında olduğu tespit edildi.

Sigara içimi, mesane kanseri vakalarının %50'inden fazlasında bulunan en büyük risk faktörüdür ve sigara kullanımı mesane kanseri gelişme riskini 2-4 kat artırmaktadır (68,78). Birçok araştırma, sigara içmenin sadece mesane kanseri oluşumunda etkili olmadığını, hastalığın ilerleyişinde ve sonuçlarında da rol oynadığını göstermiştir (79). Sigara kullanım süresi arttıkça, tümörlerin tanı anında daha büyük, daha ileri evrelerde ve daha agresif patolojik özellikler gösterme eğiliminde olduğu bulunmuştur. Sigara içme süresinin uzaması, hastaların tanı anındaki klinik ve patolojik özelliklerini olumsuz etkileyebilir. Bu da üroloji ve patoloji uzmanlarına, mesane tümörünün ilk tanı anında ne kadar agresif olabileceği konusunda önceden bilgi sağlayabileceği öngörülmüştür (80). Çalışmamızda yapılan analizler sonucunda hasta ve kontrol grupları, mesane kanseri ile sigara kullanımı arasında anlamlı bir fark bulunduğunu gösterdi (p= 0,028).

Mesane kanseri genellikle çevresel faktörlerin örneğin sigara içmek, mesleki deformasyonlara maruz kalmak gibi durumlarda etkisini arttırırken genetik yatkınlık da önemli bir rol oynamaktadır. Bazı genetik varyantlar mesane kanseri riskini artırabilir veya azaltabilir. Örneğin, birçok genom çapında ilişki çalışması (GWAS), mesane kanseri ile ilişkili genetik lokusları tanımlamıştır (81). Başka bir çalışmada ise; mesane kanseri ile genetik varyasyonlar arasında ilişkiler olduğu bildirilmiştir (82). Mesane tümörlerinde sıklıkla FGFR3 VE TP53 mutasyonları görüldüğü belirtilmiş olup PI3K yolağında da mutasyonlar tespit edildiği ve bunların AKT1,TSC1, PTEN VE PIK3CA genlerini içerdiği bildirilmiştir (83). Bununla birlikte, yeni yapılan çalışmaların, mesane tümörlerinin tedavisinde bu gen mutasyonunu hedef alan ajanlar için umut verici olduğu vurgulanmıştır (84).

CYP genlerinde birçok önemli tek nükleotid polimorfizmi (SNP) tanımlanmıştır ve bu genler içindeki bu tür polimorfizmler birçok kansere karşı bireysel duyarlılığı belirlemede önemli bir rol oynayabilir. CYP1A1'deki iki işlevsel SNP [CYP1A1 Ile462Val (CYP1A1 *2B ve *2C; rs1048943) ve MspI (3798 T > C; CYP1A1 *2A ve *2B; rs4646903)]

tanımlanmıştır. CYP1A1 rs1048943 ve rs4646903 polimorfizmleri farklı popülasyonlarda birçok kanser bölgesinde kapsamlı bir şekilde incelenmiştir (85)

Başka bir çalışmada ise; prokarsinojen aktivasyonunda *CYP* katılımına dair tüm araştırmalar arasında, rs1048943 A > G ve rs4646903 T > C *CYP1A1* polimorfizmleri en yaygın olarak çalışıldığı belirtilmiştir. (86) Çalışmada CYP1A1 rs1048943 A > G, CYP1A1'in 7. eksonunda 462. kodonda Ile'den Val'e (nükleotidler A'dan G'ye) doğru amino asit değişimine yol açtığı ve CYP1A1 rs4646903 T > C, genin 3'-yan bölgesindeki 3801. nükleotidde T'den C'ye mutasyonla karakterize edildiği belirtilmiştir (87).

CYP1A1 rs1048943 A > G ve rs4646903 T > C polimorfizmleri, yüksek minör alel sıklığı (MAF) ve akciğer kanseri, bağsak kanseri, göğüs kanseri, kan kanseri, özofageal karsinom ve prostat kanseri (88) gibi çeşitli karsinomların (89) artmış riskine katkıları nedeniyle daha geniş çapta incelenmiştir. Kanserlerin oluşumunu tetiklemenin yanı sıra, CYP1A1 polimorfizmleri ülseratif kolit, kolorektal adenom, ateroskleroz, miyokard enfarktüsü vb. gibi diğer hastalıklara da yol açabileceği (90-92) tespit edilmiştir. CYP1A1 gen polimorfizmlerinin akciğer, mesane, pankreas, meme, yumurtalık, prostat, oral ve servikal kanser de dahil olmak üzere jinekolojik maligniteler gibi çeşitli kanser türlerine yatkınlıkla ilişkisi farklı popülasyonlarda değerlendirilmiştir (93-99). CYP1A1 gen polimorfizmlerinin mesane kanseri riski üzerindeki etkileri farklı popülasyonlarda tartışmalı olarak kabul edilmiştir. Bir meta-analizde, CYP1A1 polimorfizminin Çinli, Türk ve Fransız popülasyonlarında mesane kanseri riskiyle ilişkili olmadığı belirtilmiştir (100). Ancak, Çin ve Kuzey Hindistan popülasyonlarında yapılan birkaç çalışmada ise CYP1A1 geninin mesane kanseri riskinin arttığı gözlemlenmiştir (101,102).

CYP1A1 rs1048943 polimorfizm ile yapılan bir çalışmada, Iraklı erkeklerde prostat kanseri ile CYP1A1 geni rs1048943 polimorfizmi arasındaki ilişki değerlendirilmiştir. Çalışma toplamda 100 hasta ve 150 sağlıklı kontrol ile PCR tekniği kullanılarak rs1048943 genotiplerinin prostat kanseri ile ilişkisi açısından incelenmiştir (103). Kontrol grubu; AA genotipi için % 61.3, AG genotipi için % 27.3 ve GG genotipi için % 11.3 olarak bulunmuştur. Hasta grubu ise; AA genotipi için % 70, GA genotipi için % 14 ve GG genotipi için %16 tespit edilmiştir. CYP1A1 geni rs1048943 polimorfizminin alel dağılımı; kontrol grubundaki A aleli oranı % 75 ve G alelinin oranı % 25 olarak; hasta grubundaki A ve G alellerinin oranları ise sırasıyla % 77 ve % 23 olarak bulunmuştur. G aleli ile referans A aleli arasında da anlamlı bir ilişki bulunmamıştır. CYP1A1'in rs1048943 polimorfizminde kontrol ve hasta grubunu temsil etmesi arasında önemli bir korelasyon bulunmuştur (103).

Kuzey Hindistan'da rahim ağzı kanseri CYP1A1 rs4646903 polimorfizmi genotip dağılımı üzerine bir çalışma yapılmıştır. Çalışmada tüm katılımcılar CYP1A1 m1 T>C rs4646903 varyantı PCR-RFLP kullanılarak incelenmiştir (104). CYP1A1 rs4646903 polimorfizmin TC ve CC genotiplerinin prevalansı vakalarda sırasıyla % 51 ve % 16 kontrollere %34 ve %10 göre daha fazla olduğu belirtilmiştir. TC ve CC genotiplerinin yüksek sıklığı, rahim ağzı kanseri riskinin artmasıyla anlamlı olarak ilişkili olduğu tespit edilmiştir (104).

CYP1A1 rs1048943 ve rs4646903 polimorfizmleri ile laringeal kanser riski arasındaki ilişkiyi inceleyen mevcut meta-analiz, bu polimorfizmlerin laringeal kanser riski ile anlamlı bir ilişki gösterdiğini ortaya koymuştur. Bu bulgular, CYP1A1 geninin farklı kanser türlerindeki rolünü anlamak için önemli kanıtlar sunmaktadır (85). Bu çalışmanın sonuçlarına göre, CYP1A1 rs1048943 polimorfizmi ile laringeal kanser riski

arasındaki ilişki incelenmiş ve şu bulgular elde edilmiştir: G/G alel taşıyıcılarında OR (Odds Ratio) değeri 1,77 olarak tespit edilmiştir. A/A alel taşıyıcılarında ise OR değeri 1,86 olarak belirlenmiştir. Etnik kökene göre yapılan analizde, Asyalılar arasında hem G alel taşıyıcıları hem de G/G genotipi için önemli riskler saptanmıştır. Ancak, Kafkasyalı popülasyonlar arasında G/G genotipi ile A/A ve G alel taşıyıcıları ile A/A arasında anlamlı bir ilişki bulunmamıştır. Bu bulgular, CYP1A1 rs1048943 polimorfizminin laringeal kanser riski üzerinde etnik farklılıklar gösterebileceğini göstermektedir (85). CYP1A1 rs4646903 polimorfizmi ile laringeal kanser riski arasındaki ilişki incelenmiş ve şu sonuçlar elde edilmiştir: A/A genotipi ile karşılaştırıldığında, G/G alel taşıyıcılarında Odds Ratio (OR) değeri 1,53 iken, G alel taşıyıcılarında OR değeri 1,33 olarak bulunmuştur. Etnik kökene göre yapılan tabakalı analizde, Asyalılar arasında hem G alel taşıyıcıları hem de G/G genotipi için önemli riskler gözlemlenmiştir. Ancak, Kafkasyalı popülasyonlar arasında G/G genotipi ile A/A ve G alel taşıyıcıları ile A/A arasında anlamlı bir ilişki saptanmamıştır. Bu bulgular, CYP1A1 rs4646903 polimorfizminin laringeal kanser riski üzerinde etnik farklılıkların rol oynayabileceğini belirtmişlerdir.

Yapılan başka bir meta-analiz çalışmasında ise; 26 çalışma üzerinden iki polimorfizm (rs1048943 A > G ve rs4646903 T > C) ile CRC riski arasındaki ilişkileri kapsamlı bir şekilde değerlendirilmiş ve rs1048943 A > G genetik varyasyonunun CRC riskinde artışla ilişkili olduğu gözlemlenmiştir. rs4646903 T > C ile CRC riski arasındaki ilişki anlamlılık düzeyine ulaşmadığı öne sürmüşlerdir (105).

Türkiye'de yapılan bir çalışmada; 60 kontrol ve 60 mesane kanseri hasta katılımcının oluşturulduğu çalışma grubunda PCR tekniği kullanılmıştır. CYP1A1 geninin c.*1189 için, mesane kanseri bireylerinde TT genotipi %50, TC genotipi %48,3, CC genotipi %1,7 oranında bulunmuştur. T alel frekans oranı %74,2 ve C alel frekans oranı %25,8 tespit edilmiştir. TC genotip ve C alel frekansları sağlıklı bireylere göre daha yüksek bulunmuştur. CYP1A1 c.*1189 TC genotipi ve C alelinin sıklığı mesane kanseri hastaları ve sağlıklı bireyler arasındaki ilişki anlamlı düzeyde tespit edilmiştir (106).

CYP1A1 gen polimorfizmleri ile mesane kanseri duyarlılığı arasındaki ilişkiyi belirlemek amacıyla sekiz vaka-kontrol çalışmasının verileri analiz edilmiştir. CYP1A1 mutasyonları ile mesane kanseri riski arasında kayda değerbir fark bulunmadığını göstermiştir. Bununla birlikte, Srivastava ve arkadaşları (2008), CYP1A1 (2A* T/C) mutasyonu ile mesane kanseri riski arasında hafif bir ilişki bulmuşlardır (OR = 1.56) ancak bu ilişki istatistiksel olarak anlamlı değildir. Literatürde, çevresel faktörlerin mesane kanserinin karsinojenik sürecinde CYP1A1'in rol aldığına dair kanıtlar mevcuttur. Örneğin, Murai ve diğerleri (1995) tarafından yapılan bir çalışmada, insan mesane kanseri örneklerinde immünohistokimya ile CYP1A1'in artmış ekspresyonu gözlemlenmiştir. Ayrıca, Wolf ve ekibi (2005) tarafından benzo[a]piren ile tedavi edilen hücrelerde CYP1A1 ekspresyonunda dramatik bir artış bulunmuştur. Benzer sonuçlar, tütün içeren bileşikler olan benzo[a]piren ve arilaminlere maruz bırakılan diğer deneysel hayvanlarda da rapor edilmiştir (107,108). Ancak, bu çalışmada, her iki CYP1A1 polimorfizmi ile mesane kanseeri duyarlılığı arasında herhangi bir kanıt bulunamamıştır; bu durum ekleyici, baskın veya resesif genetik modellere göre değişmemiştir (109).

Ufuk Berber ve ark. (2013), vücudun başka bölgelerinde herhangi bir kanser bulunan hastalar çalışmadan çıkarılarak, histolojik olarak teşhis edilmiş 114 mesane kanseri hastası (103 erkek, 11 kadın) ve 114 kontrol birey (103 erkek, 11 kadın) ile PCR

tekniği kullanılarak CYP450 1A1 geninin mesane kanseri üzerindeki riski çalışılmıştır(110).CYP1A1 genindeki Ile462Val polimorfizmi (rs1048943) varyantları, allele özgül PCR (ASPCR) yöntemi kullanılarak belirlendi (111). Bu çalışmada, kontrol ve hasta gruplarındaki genotip frekansları ile bunların mesane kanseri riski arasındaki ilişki incelenmiştir. CYP1A1 polimorfik varyantlarının ise kombinasyon analizinde mesane kanseri riskini artırmadığı tespit edilmiştir.CYP1A1 gen polimorfizmi, tek başına veya kombinasyonlu genotip analizinde kayda değer bir fark göstermemiştir (110).

Çalışmada; CYP1A1 rs4646903 polimorfizmi için genotip dağılımları incelendiğinde, hasta grubunda TT genotipine sahip olanların %74,5'i, TC genotipine sahip olanların %23,6'sı ve CC genotipine sahip olanların ise %1,8'i bulundu. Kontrol grubunda ise TT genotipine sahip olanların oranı %89,3, TC genotipine sahip olanların oranı %10,7 ve CC genotipine sahip olanların ise %0 bulundu. Toplamda, hasta ve kontrol gruplarındaki genotip dağılımları incelendiğinde, TT genotipine sahip olanların oranı %82, TC genotipine sahip olanların oranı %17,1 ve CC genotipine sahip olanların oranı ise %0,9 olarak belirlendi. Tüm bu veriler ışığında, hasta-kontrol grubu ile CYP1A1 rs4646903 polimorfizmi arasında kayda değer bir fark bulunmadığı görüldü (p=0,108) (112).

CYP1A1 (rs4646903) polimorfizmi açısından hasta ve kontrol gruplarındaki alel dağılımları incelendiğinde, kontrol grubunda T aleli oranı %89,2 ve C aleli oranı %10,8 olarak tespit edildi. Hasta grubunda ise T aleli oranı %75,5 ve C aleli oranı %24,5 bulundu. Yapılan analizler sonucunda, CYP1A1 (rs4646903) polimorfizmi için hasta ve kontrol grupları arasında alel dağılımları açısından anlamlı bir ilişki bulunmadı (p=0,871).

CYP1A1 rs1048943 polimorfizm genotip dağılımının mesane kanserli hastalarında ilişkisine bakıldı. Çalışmamızda, hem hasta hem de kontrol grubunda CYP1A1 rs1048943 polimorfizminin genotip dağılımları incelendiğinde belirgin farklılıklar gözlendi. Hasta grubunun çoğunluğunun % 78,2 AA genotipine sahip, % 21,8'i ise AG genotipine sahip olduğu tespit edildi. Benzer şekilde kontrol grubu, AG genotipine % 12,5 kıyasla AA genotipinin % 87,5 daha yüksek bir prevalansa sahip olduğunu gösterdi. Her iki gruptaki kümülatif genotip dağılımı % 82,9 AA genotipi ve % 17,1 AG genotipini gösterdiği tespit edildi. Bulgularımız, mevcut literatürle paralellik göstermektedir.

CYP1A1 rs1048943 polimorfizm hasta ve kontrol grupları arasında allel dağılımları incelendiğinde, kontrol grubunda A alleli oranı % 84,7, hasta grubunda ise % 89,1 olarak bulundu. G alleli oranı ise kontrol grubunda % 15,3, hasta grubunda ise % 10,9 olarak tespit edildi. Bu verilere göre, CYP1A1 rs1048943 polimorfizmi için hasta-kontrol grupları arasında kayda değer bir fark saptanmadı (p=0,541).

Bu bağlamda, çalışmada, mesane kanseri ile rs1048943 ve rs4646903 polimorfizmleri arasında anlamlı bir ilişki olmadığı bulundu. Mesane kanseri ile tek nükleotid polimorfizmleri arasındaki ilişkiyi inceleyen birçok çalışmada da, bu polimorfizmler ile hastalık arasında anlamlı bir ilişki olmadığı ancak ilaç metabolizmasının aktivasyonundaki öneminin de göz ardı edilemeyeceği bildirilmiştir. Bununla bir sonucu olarak, karsinogenezisin mesane kanserinde genetik yatkınlık için birden fazla genin etkileşimini gerektirdiğini gösteren çalışmada bulunmaktadır. Genetik polimorfizmler sonucu gelişen farklı ilişkilerin genotoksisiteye ve

karsinojenlere karşı farklı bireysel duyarlılıklara neden olduğunu bildirmiştir (113,114). Ayrıca, literatürde polimorfizler sonucu oluşan varyantların, karsinojenlerin aktivasyonu ve detoksifikasyonunda ne ölçüde etkili olduğu veya popülasyonlar içindeki farklılıkların kaynakları konusunda hala yeterli bilgi bulunmamaktadır. Bu nedenle coğrafik farklılıklar gözönünde bulundurarak, farklı SNP'lerin dahil edildiği, örneklem sayının arttırıldığı ileri çalışmalar yapılmasının katkısının önemli olacağını düşünmekteyiz.

6.SONUÇ VE ÖNERİLER

6.1. Sonuç

Yapılan çalışmanın neticesinde;

- Mesane kanseri çalışma grubu cinsiyet dağılımı bakımından incelendiğinde, hasta ve kontrol grubunu oluşturan 111 katılımcının %14.4 'i kadın, 85,6% si erkektir. Cinsiyet dağılımı bakımından bakıldığında gruplar arası anlamlı bir ilişki bulunmadı (0,969).
- Sigara kullanımı açısından gruplar incelendiğinde hasta ve kontrol gruplarında sigara kullananlar %68,5 olduğu tespit edildi. Mesane kanseri ile sigara kullanımı arasında anlamlı bir fark bulundu (0,028).
- Yaşa göre dağılımları verilen mesane kanseri hastalarının yaş ortalamaları Tablo 4.2' de verildi. Bu bakımından hasta ve kontrol grubunda yaş ortalamaları arasında kayda değer bir fark bulundu ($p<0,001$).
- Aile öyküsü açısından gruplar incelendiğinde ise; mesane kanseri grubundaki katılımcıların %9,1'inde ailede mesane kanseri öyküsü olduğu tespit edildi. Çalışmada, kontrol grubu herhangi bir sistemik hastalığı ve kanser öyküsü olmayan, bununla birlikte aile öyküsünde de herhangi bir kanser öyküsü bulunmayan sağlıklı bireylerden oluşturulduğundan, mesane kanseri grubunda aile öyküsü bulunanların oranı kontrol grubuna göre anlamlı derecede daha yüksek bulundu ($p=0,021$).
- Sistemik hastalıklar açısından hasta grubunda bulunan bireyler incelendiğinde, DM; %32,7, HT;%43,6, KOAH;%12,7, KAH;%7,3 oranında bulunduğu tespit edildi. Sistemik hastalıklar açısından anlamlı bir ilişki bulunmadı.
- CYP1A1 rs1048943 polimorfizmi için genotip dağılımları incelendiğinde, hasta grubunda AA genotipine sahip 43 (%78,2) ve AG genotipine sahip 12 (%21,8) hasta bulundu. Kontrol grubunda ise AA genotipine sahip 49 (%87,5) ve AG genotipine sahip 7 (%12,5) birey tespit edildi. Hasta ve kontrol gruplarının toplam dağılımları incelendiğinde, AA genotipine sahip 92 (%82,9), AG genotipine sahip 19 (%17,1) ve GG genotipine sahip 0 (%0,0) birey bulundu. Tüm bu bilgiler ışığında, hasta ve kontrol grupları arasında CYP1A1 (rs1048943) polimorfizmi açısından kayda değer bir ilişki tespit edilmedi ($p=0,193$).

- CYP1A1 (rs1048943) polimorfizmi için hasta ve kontrol gruplarındaki allel dağılımları incelendiğinde, A alleli kontrol grubunda 105 (%84,7), hasta grubunda 98 (%89,1); G alleli oranı ise kontrol grubunda 19 (%15,3) ve hasta grubunda 12 (%10,9) olarak tespit edildi. Tüm bu veriler ışığında, CYP1A1 (rs1048943) polimorfizmi için hasta ve kontrol gruplarındaki allel dağılımları arasında anlamlı bir ilişki bulunmadı (p=0,541).
- CYP1A1 (rs4646903) polimorfizmi genotip dağılımlarına bakıldığında, hasta grubunda TT genotipine sahip 41 (%74,5) hasta, TC genotipine sahip 13 (%23,6) hasta ve CC genotipine sahip 1 (%1,8) hasta tespit edildi. Kontrol grubunda ise TT genotipine sahip 50 (%89,3) birey, TC genotipine sahip 6 (%10,7) birey ve CC genotipine sahip 0 (%0) birey bulundu. Toplam dağılımlar incelendiğinde, TT genotipine sahip 91 (%82), TC genotipine sahip 19 (%17,1) ve CC genotipine sahip 1 (%0,9) birey belirlendi. Bu veriler doğrultusunda, CYP1A1 (rs4646903) polimorfizmi için hasta ve kontrol grupları arasında anlamlı bir ilişki bulunmadı (p=0,108).
- CYP1A1 (rs4646903) polimorfizmi için hasta ve kontrol gruplarına ait alel dağılımlarına bakıldığında, T aleli kontrol grubunda %89,2 (100) ve hasta grubunda %75,5 (83) oranında bulundu. C alleli ise kontrol grubunda %10,8 (12) ve hasta grubunda %24,5 (27) oranında tespit edildi. Bu veriler doğrultusunda, CYP1A1 (rs4646903) polimorfizmi için hasta ve kontrol grupları arasındaki alel dağılımları arasında kayda değer bir ilişki gözlenmedi (p=0,871).

6.2. Öneriler

Bütün bu çalışmalar değerlendirildiğinde:

- Mesane kanseri risk faktörlerini değerlendirmek ve kanserin evreleri ile ilişkilendirmek için önemli bir temel sağlayabilir.
- Coğrafi ve çevresel faktörler, sigara kullanımı, mesleki maruziyetler ve genetik faktörler gibi risk faktörlerini her biri için ayrı örneklem grupları oluşturularak incelenmesi, bu faktörlerin mesane kanserinin farklı evrelerindeki etkilerini anlamamıza yardımcı olabilir.
- Ayrıca, örneklem sayısının artırılması veya çeşitlendirilmesi, çalışmanın güvenilirliğini ve sonuçların genelleştirilebilirliğini artırabilir.
- Bu çalışmaların ötesinde, mesane kanseri ile ilişkili genler üzerindeki tek nükleotid polimorfizmleri (SNP'ler) gibi genetik bileşenlerin daha detaylı incelenmesi gerekebilir.

Bu şekilde, mesane kanserinin etiyolojisini daha iyi anlayabilir ve daha etkili tedavi ve önleme stratejileri geliştirebiliriz.

KAYNAKÇA

[1]- Antoni, S., Ferlay, J., Soerjomataram, I., Znaor, A., Jemal, A., & Bray, F. (2017). Bladder cancer incidence and mortality: A global overview and recent trends. *European Urology, 71*(1), 96-108.

[2]- Ma, M. (2023). Using high-throughput SNP technologies to identify variances associated with bladder cancer. *European Journal of Biomedical and Life Sciences*, (1), 3-9.
[3]- Gonzalez, F. J., & Gelboin, H. V. (1994). Role of human cytochromes P450 in the metabolic activation of chemical carcinogens and toxins. *Drug Metabolism Reviews, 26*(1-2), 165-183.
[4]- Zhou, S. (2018). *Cytochrome P450 2D6: Structure, function, regulation and polymorphism*. CRC Press.
[5]- Mallah, M. A., Changxing, L., Mallah, M. A., Noreen, S., Liu, Y., Saeed, M., ... & Zhang, Q. (2022). Polycyclic aromatic hydrocarbon and its effects on human health: An overview. *Chemosphere, 296*, 133948.
[6]- Das, D. N., Panda, P. K., Naik, P. P., Mukhopadhyay, S., Sinha, N., & Bhutia, S. K. (2017). Phytotherapeutic approach: A new hope for polycyclic aromatic hydrocarbons induced cellular disorders, autophagic and apoptotic cell death. *Toxicology Mechanisms and Methods, 27*(1), 1-17.
[7]- Autrup, H. (2000). Genetic polymorphisms in human xenobiotica metabolizing enzymes as susceptibility factors in toxic response. *Mutation Research/Genetic Toxicology and Environmental Mutagenesis, 464*(1), 65-76.
[8]- Panicker, J. N., Marcelissen, T., von Gontard, A., Vrijens, D., Abrams, P., & Wyndaele, M. (2019). Bladder-bowel interactions: Do we understand pelvic organ cross-sensitization? International Consultation on Incontinence Research Society (ICI-RS) 2018. *Neurourology and Urodynamics, 38*(S25-S34).
[9]- Andersson, K. E., & Arner, A. (2004). Urinary bladder contraction and relaxation: Physiology and pathophysiology. *Physiological Reviews, 84*(3), 935-986.
[10]- Fowler, C. J., Griffiths, D., & De Groat, W. C. (2008). The neural control of micturition. *Nature Reviews Neuroscience, 9*(6), 453-466.
[11]- Tekin, A., Bölge, Ç., & Çocuk Üroloji Kliniği. (2016). İşeme fizyolojisi ve işemenin nöral kontrolü. *Çocuk Cerrahisi Dergisi, 30*, 545-549.
[12]- Lein, M., Stibane, I., Mansour, R., Hege, C., Roigas, J., Wille, A., ... & Deger, S. (2006). Complications, urinary continence, and oncologic outcome of 1000 laparoscopic transperitoneal radical prostatectomies—experience at the Charité Hospital Berlin, Campus Mitte. *European Urology, 50*(6), 1278-1284.
[13]- Abbas, M., Shrivastav, K., Imran, M., & Banerjee, M. (2014). Association of CYP1A1 gene variants rs4646903 and rs1048943 with cervical cancer in North Indian population. *European Journal of Obstetrics & Gynecology and Reproductive Biology, 176*, 68-74.
[14]- Antoni, S., Ferlay, J., Soerjomataram, I., Znaor, A., Jemal, A., & Bray, F. (2017). Bladder cancer incidence and mortality: A global overview and recent trends. *European Urology, 71*(1), 96-108.
[15]- World Health Organization. (2020). *Global Cancer Observatory: Cancer Today*. Retrieved from https://gco.iarc.fr/today
[16]- Parkin, D. M. (2006). The global health burden of infection-associated cancers in the year 2002. *International Journal of Cancer, 118*(12), 3030-3044.
[17]- Babjuk, M., Burger, M., Compérat, E. M., Gontero, P., Mostafid, A. H., Palou, J., ... & Soukup, V. (2019). European association of urology guidelines on non-muscle-invasive bladder cancer (TaT1 and carcinoma in situ)-2019 update. *European Urology, 76*(5), 639-657.
[18]- Mitra, D., & Fisher, D. E. (2009). Transcriptional regulation in melanoma. *Hematology/Oncology Clinics, 23*(3), 447-465.
[19]- Zeegers, M. P., Tan, F. E., Dorant, E., & van den Brandt, P. A. (2000). The impact of characteristics of cigarette smoking on urinary tract cancer risk: A meta-analysis of epidemiologic studies. *Cancer, 89*(3), 630-639.
[20]- Koutros, S., Silverman, D. T., Baris, D., Zahm, S. H., Morton, L. M., Colt, J. S., ... & Karagas, M. R. (2011). Hair dye use and risk of bladder cancer in the New England bladder cancer study. *International Journal of Cancer, 129*(12), 2894-2904.
[21]- Stern, M. C., Lin, J., Figueroa, J. D., Kelsey, K. T., Kiltie, A. E., Yuan, J. M., ... & International Consortium of Bladder Cancer. (2009). Polymorphisms in DNA repair genes, smoking, and bladder cancer risk: Findings from the international consortium of bladder cancer. *Cancer Research, 69*(17), 6857-6864.

[22]- Miyake, H., Furukawa, J., Muramaki, M., Takenaka, A., & Fujisawa, M. (2010). Orthotopic sigmoid neobladder after radical cystectomy: Assessment of complications, functional outcomes and quality of life in 82 Japanese patients. *BJU International, 106*(3), 412-416.
[23]- Cancer Genome Atlas Research Network. (2014). Comprehensive molecular characterization of urothelial bladder carcinoma. *Nature, 507*(7492), 315-322. https://doi.org/10.1038/nature12965
[24]- Lobo, N., Afferi, L., Moschini, M., Mostafid, H., Porten, S., Psutka, S. P., ... & Lotan, Y. (2022). Epidemiology, screening, and prevention of bladder cancer. *European Urology Oncology*.
[25]- Miricescu, D., Balan, D. G., Tulin, A., Stiru, O., Vacaroiu, I. A., Mihai, D. A., ... & Stefani, C. (2021). PI3K/AKT/mTOR signalling pathway involvement in renal cell carcinoma pathogenesis. *Experimental and Therapeutic Medicine, 21*(5), 1-7.
[26]- Zhao, L., Guo, Y., Guo, Y., Ji, X., Fan, D., Chen, C., ... & Ji, Z. (2022). Effect and mechanism of circRNAs in tumor angiogenesis and clinical application. *International Journal of Cancer, 150*(8), 1223-1232.
[27]- Cao, R., Xiao, Y., & Liu, X. (2022). The role of epithelial-mesenchymal transition-related non-coding RNAs in cancer. *Frontiers in Molecular Biosciences, 9*, 839952.
[28]- Kiriluk, K. J., Prasad, S. M., Patel, A. R., Steinberg, G. D., & Smith, N. D. (2012, March). Bladder cancer risk from occupational and environmental exposures. In *Urologic Oncology: Seminars and Original Investigations* (Vol. 30, No. 2, pp. 199-211). Elsevier.
[29]- Olfert, S. M., Felknor, S. A., & Delclos, G. L. (2006). An updated review of the literature: Risk factors for bladder cancer with focus on occupational exposures. *Southern Medical Journal, 99*(11), 1256-1264.
[30]- Chiou, H. Y., Chiou, S. T., Hsu, Y. H., Chou, Y. L., Tseng, C. H., Wei, M. L., & Chen, C. J. (2001). Incidence of transitional cell carcinoma and arsenic in drinking water: A follow-up study of 8,102 residents in an arseniasis-endemic area in northeastern Taiwan. *American Journal of Epidemiology, 153*(5), 411-418.
[31]- Michaud, D. S. (2007, May). Chronic inflammation and bladder cancer. In *Urologic Oncology: Seminars and Original Investigations* (Vol. 25, No. 3, pp. 260-268). Elsevier.
[32]- Ros, M. M., Bas Bueno-de-Mesquita, H. B., Büchner, F. L., Aben, K. K., Kampman, E., Egevad, L., ... & Riboli, E. (2011). Fluid intake and the risk of urothelial cell carcinomas in the European Prospective Investigation into Cancer and Nutrition (EPIC). *International Journal of Cancer, 128*(11), 2695-2708.
[33]- Koutros, S., Alavanja, M. C., Lubin, J. H., Sandler, D. P., Hoppin, J. A., Lynch, C. F., ... & Freeman, L. E. B. (2010). An update of cancer incidence in the Agricultural Health Study. *Journal of Occupational and Environmental Medicine/American College of Occupational and Environmental Medicine, 52*(11), 1098.
[34]- International Agency for Research on Cancer (IARC). (2012). *IARC monographs on the evaluation of carcinogenic risks to humans: A review of human carcinogens: arsenic, metals, fibres, and dusts*. IARC Press.
[35]- Pedersen, M., Stafoggia, M., Weinmayr, G., Andersen, Z. J., Galassi, C., Sommar, J., ... & Raaschou-Nielsen, O. (2018). Is there an association between ambient air pollution and bladder cancer incidence? Analysis of 15 European cohorts. *European Urology Focus, 4*(1), 113-120.
[36]- Anttila, A., Pukkala, E., Riala, R., Sallmén, M., & Hemminki, K. (1998). Cancer incidence among Finnish workers exposed to aromatic hydrocarbons. *International Archives of Occupational and Environmental Health, 71*, 187-193.
[37]- Golka, K., Wiese, A., Carstens, C., & Klein, C. L. (2004). Occupational exposure to heavy metals: DNA damage induction and DNA repair inhibition prove co-exposures to cadmium, cobalt and lead as more dangerous than hitherto expected. *Carcinogenesis, 25*(5), 891-900. https://doi.org/10.1093/carcin/bgh089
[38]- Cohen, S. M., Shirai, T., & Steineck, G. (2000). Epidemiology and etiology of premalignant and malignant urothelial changes. *Scandinavian Journal of Urology and Nephrology, 34*(203), 105-115.
[39]- Reinert, T., Modin, C., Castano, F. M., Lamy, P., Wojdacz, T. K., Hansen, L. L., ... & Ørntoft, T. F. (2011). Comprehensive genome methylation analysis in bladder cancer:

Identification and validation of novel methylated genes and application of these as urinary tumor markers. *Clinical Cancer Research, 17*(17), 5582-5592.
[40]- Wang, P., Ye, D., Guo, J., Liu, F., Jiang, H., Gong, J., ... & Xu, J. (2014). Genetic score of multiple risk-associated single nucleotide polymorphisms is a marker for genetic susceptibility to bladder cancer. *Genes, Chromosomes and Cancer, 53*(1), 98-105.
[41]- Czerniak, B., Dinney, C., & McConkey, D. (2016). Origins of bladder cancer. *Annual Review of Pathology: Mechanisms of Disease, 11*, 149-174.
[42]- Figueroa, J. D., Ye, Y., Siddiq, A., Garcia-Closas, M., Chatterjee, N., Prokunina-Olsson, L., ... & Rothman, N. (2014). Genome-wide association study identifies multiple loci associated with bladder cancer risk. *Human Molecular Genetics, 23*(5), 1387-1398.
[43]- Ordway, J. M., Bedell, J. A., Citek, R. W., Nunberg, A., Garrido, A., Kendall, R., ... & Jeddeloh, J. A. (2006). Comprehensive DNA methylation profiling in a human cancer genome identifies novel epigenetic targets. *Carcinogenesis, 27*(12), 2409-2423.
[44]- Zheng, Q., Zhou, F., Cui, X., Liu, M., Li, Y., Liu, S., ... & Yan, Q. (2018). Novel serum biomarkers detected by protein array in polycystic ovary syndrome with low progesterone level. *Cellular Physiology and Biochemistry, 46*(6), 2297-2310.
[45]- Di Fiore, R., D'Anneo, A., Tesoriere, G., & Vento, R. (2013). RB1 in cancer: Different mechanisms of RB1 inactivation and alterations of pRb pathway in tumorigenesis. *Journal of Cellular Physiology, 228*(8), 1676-1687.
[46]- Guo, G., Sun, X., Chen, C., Wu, S., Huang, P., Li, Z., ... & Cai, Z. (2013). Whole-genome and whole-exome sequencing of bladder cancer identifies frequent alterations in genes involved in sister chromatid cohesion and segregation. *Nature Genetics, 45*(12), 1459-1463.
[47]- Chesi, M., Brents, L. A., Ely, S. A., Bais, C., Robbiani, D. F., Mesri, E. A., ... & Bergsagel, P. L. (2001). Activated fibroblast growth factor receptor 3 is an oncogene that contributes to tumor progression in multiple myeloma. *Blood, The Journal of the American Society of Hematology, 97*(3), 729-736.
[48]- Mittal, R. D., Mandal, R. K., & Gangwar, R. (2012). Base excision repair pathway genes polymorphism in prostate and bladder cancer risk in North Indian population. *Mechanisms of Ageing and Development, 133*(4), 127-132.
[49]- Allory, Y., Beukers, W., Sagrera, A., Flandez, M., Marques, M., Marquez, M., ... & Real, F. X. (2014). Telomerase reverse transcriptase promoter mutations in bladder cancer: High frequency across stages, detection in urine, and lack of association with outcome. *European Urology, 65*(2), 360-366.
[50]- Cavalieri, E. L., Rogan, E. G., & Zahid, M. (2017). Critical depurinating DNA adducts: Estrogen adducts in the etiology and prevention of cancer and dopamine adducts in the etiology and prevention of Parkinson's disease. *International Journal of Cancer, 141*(6), 1078-1090.
[51]- Basma, H. A., Kobeissi, L. H., Jabbour, M. E., Moussa, M. A., & Dhaini, H. R. (2013). CYP2E1 and NQO1 genotypes and bladder cancer risk in a Lebanese population. *International Journal of Molecular Epidemiology and Genetics, 4*(4), 207.
[52]- Androutsopoulos, V. P., Spyrou, I., Ploumidis, A., Papalampros, A. E., Kyriakakis, M., Delakas, D., ... & Tsatsakis, A. M. (2013). Expression profile of CYP1A1 and CYP1B1 enzymes in colon and bladder tumors. *PLOS ONE, 8*(12), e82487.
[53]- Zhou, S. F. (2008). Drugs behave as substrates, inhibitors and inducers of human cytochrome P450 3A4. *Current Drug Metabolism, 9*(4), 310-322.
[54]- Grando, J. P. S., Kuasne, H., Losi-Guembarovski, R., Sant'Ana Rodrigues, I., Matsuda, H. M., Fuganti, P. E., ... & de Syllos Colus, I. M. (2009). Association between polymorphisms in the biometabolism genes CYP1A1, GSTM1, GSTT1 and GSTP1 in bladder cancer. *Clinical and Experimental Medicine, 9*, 21-28.
[55]- Yin, X., Xiong, W., Wang, Y., Tang, W., Xi, W., Qian, S., & Guo, Y. (2018). Association of CYP2E1 gene polymorphisms with bladder cancer risk: A systematic review and meta-analysis. *Medicine, 97*(39).
[56]- Al-Saraireh, Y. M., Alshammari, F. O., Youssef, A. M., Al-Sarayreh, S., Almuhaisen, G. H., Alnawaiseh, N., ... & Alrawashdeh, H. M. (2021). Profiling of CYP4Z1 and CYP1B1 expression in bladder cancers. *Scientific Reports, 11*(1), 5581.

[57]- Okubo, K., Ressing, N., Schulz, W. A., Hansen, F. K., Asano, T., & Sato, A. (2021). The dual histone deacetylase-proteasome inhibitor RTS-V5 acts synergistically with ritonavir to induce endoplasmic reticulum stress in bladder cancer cells. *Anticancer Research, 41*(12), 5987-5996.
[58]- Stern, M. C., Umbach, D. M., van Gils, C. H., Lunn, R. M., & Taylor, J. A. (2001). DNA repair gene XRCC1 polymorphisms, smoking and bladder cancer risk. *Cancer Epidemiology, Biomarkers & Prevention, 10*(2), 125-131.
[59]- Wu, Y., & Yang, Y. (2014). ERCC2 gen polimorfizmleri, cinsiyet, sigara içme ve mesane kanserine yatkınlık arasındaki karmaşık ilişki: bir meta-analiz. *Tumor Biology, 35*, 5245-5257.
[60]- Cartwright, R. A., Glashan, R. W., Rogers, H. J., Ahmand, R. A., Barham-Hall, D., & Higgins, E. (1982). [Title in original language]. *Lancet, 2*, 842-845.
[61]- Salagovic, J., Kalina, I., Habalova, V., Hrivnak, M., Valansky, L., & Biros, E. (1999). The role of human glutathione S-transferases M1 and T1 in individual susceptibility to bladder cancer. *Physiological Research, 48*, 465-471.
[62]- [Eksik]
[63]- Sankhwar, M., & Sankhwar, S. N. (2014, January). Variations in CYP isoforms and bladder cancer: A superfamily paradigm. In *Urologic Oncology: Seminars and Original Investigations* (Vol. 32, No. 1, pp. 28-e33). Elsevier.
[64]- Go, R. E., Hwang, K. A., & Choi, K. C. (2015). Cytochrome P450 1 family and cancers. *The Journal of Steroid Biochemistry and Molecular Biology, 147*, 24-30.
[65]- Arayıcı, M. E., Başbınar, Y., & Ellidokuz, H. (2021). İnsan kanserlerinin etiyolojisinde gen-çevre etkileşiminin rolü. *ERÜ Sağlık Bilimleri Fakültesi Dergisi, 8*(2), 30-37.
[66]- Kamat, A. M., Hahn, N. M., Efstathiou, J. A., Lerner, S. P., Malmström, P. U., Choi, W., ... & Kassouf, W. (2016). Bladder cancer. *The Lancet, 388*(10061), 2796-2810.
[67]- Yin, X., Xiong, W., Wang, Y., Tang, W., Xi, W., Qian, S., & Guo, Y. (2018). Association of CYP2E1 gene polymorphisms with bladder cancer risk: A systematic review and meta-analysis. *Medicine, 97*(39).
[68]- Burger, M., Catto, J. W., Dalbagni, G., et al. (2013). Epidemiology and risk factors of urothelial bladder cancer. *European Urology, 63*, 234-241.
[69]- Gültekim, M. H., Şimşekoğlu, M. F., & Önal, M. (2020). Yaşlılıkta üriner sistem kanserleri-mesane kanseri. In A. Döventaş (Ed.), *Geriatrik Üroloji* (pp. 59-64). Türkiye Klinikleri.
[70]- Fulop, T., Larbi, A., & Hirokawa, K., et al. (2007). Immunosupportive therapies in aging. *Clinical Interventions in Aging, 2*, 33-54.
[71]- Değer, D., Aslan, Ö. D., Çömez, K., Eren, F., Adırbelli, S., & Aslan, G. (2017). Mesane kanseri erken tanı ve tedavisinde toplumsal farkındalık: Yaş ve eğitim düzeyinin önemi. *Üroonkoloji Bülteni, 16*(1).
[72]- Fajkovic, H., Halpern, J. A., Cha, E. K., Bahadori, A., Chromecki, T. F., Karakiewicz, P. I., & Shariat, S. F. (2011). Impact of gender on bladder cancer incidence, staging, and prognosis. *World Journal of Urology, 29*, 457-463.
[73]- Lutz, C. T., Livas, L., Presnell, S. R., Sexton, M., & Wang, P. (2021). Gender differences in urothelial bladder cancer: Effects of natural killer lymphocyte immunity. *Journal of Clinical Medicine, 10*(21), 5163.
[74]- Ergün, D., Savaş, İ., Ergün, R., Kaya, A., & Gülhan, M. (2009). Akciğer kanseri ve ailesel kanser hikâyesi. *Tuberk Toraks, 57*(3), 251-258.
[75]- Memiş, B. (2015). Mesane kanserinde peritümöral ve intratümöral immün cevabın, tümör nüksü ve prognostik faktörlerle ilişkisi= Peritumoral and intratumoral immune response in bladder cancer and its relationship with tumor recurrence and prognostic factors (Yayınlanmamış yüksek lisans tezi). Marmara Üniversitesi.
[76]- de Maturana, E. L., Rava, M., Anumudu, C., Sáez, O., Alonso, D., & Malats, N. (2018). Bladder cancer genetic susceptibility: A systematic review. *Bladder Cancer, 4*(2), 215-226.
[77]- Akarsu, S. (2013). Koroner arter bypass cerrahisi uygulanan hastalarda vücut kitle indeksinin mortalite ve morbidite üzerine etkisi (Yayınlanmamış yüksek lisans tezi). Bursa Uludağ Üniversitesi.

[78]- Freedman, N. D., Silverman, D. T., Hollenbeck, A. R., et al. (2011). Association between smoking and risk of bladder cancer among men and women. *JAMA, 306*(7), 737-745.
[79]- van Osch, F. H., Jochems, S. H., van Schooten, F. J., et al. (2016). Quantified relations between exposure to tobacco smoking and bladder cancer risk: A meta-analysis of 89 observational studies. *International Journal of Epidemiology, 45*(3), 857-870.
[80]- İrer, B., Dağ, F., & Aslan, G. (2017). Sigara kullanım süresinin mesane kanserinin tanı anındaki klinik ve patolojik özellikleriyle olan ilişkisinin değerlendirilmesi. *Üroonkoloji Bülteni, 16*(4).
[81]- Malats, N., & Real, F. X. (2015). Epidemiology of bladder cancer. *Hematology/Oncology Clinics, 29*(2), 177-189.
[82]- Eren, A. E., & Taş, S. (2021). Bladder cancer and genetic background in young patients. *Endoüroloji Bülteni, 13*(1), 29-31.
[83]- Jemal, A., Bray, F., Center, M. M., Ferlay, J., Ward, E., & Forman, D. (2011). Global cancer statistics. *CA: A Cancer Journal for Clinicians, 61*(2), 69-90.
[84]- Dueñas, M., Martínez-Fernández, M., et al. (2015). PIK3CA gene alterations in bladder cancer are frequent and associate with reduced recurrence in non-muscle invasive tumors. *Molecular Carcinogenesis, 54*(6), 566-576.
[85]- Zeng, W., Li, Y., Lu, E., & Ma, M. (2016). CYP1A1 rs1048943 and rs4646903 polymorphisms associated with laryngeal cancer susceptibility among Asian populations: A meta-analysis. *Journal of Cellular and Molecular Medicine, 20*(2), 287-293.
[86]- Wrensch, M. R., Miike, R., Sison, J. D., Kelsey, K. T., Liu, M., McMillan, A., Quesenberry, C., & Wiencke, J. K. (2005). CYP1A1 varyantları ve San Francisco Körfez bölgesi Latinoları ve Afrikalı Amerikalılarda sigarayla ilişkili akciğer kanseri. *International Journal of Cancer, 113*(1), 141-146.
[87]- Sivaraman, L., Leatham, M. P., Yee, J., Wilkens, L. R., Lau, A. F., & Le Marchand, L. (1994). CYP1A1 genetik polimorfizmleri ve yerinde kolorektal kanser. *Cancer Research, 54*(15), 3692-3697.
[88]- Daly, A. K. (2015). Sitokrom P450'nin polimorfik varyantları: Kanser ve diğer hastalıklarla ilgisi. *Advances in Pharmacology, 74*, 85-111.
[89]- Hussein, A. G., Pasha, H. F., El-Shahat, H. M., Gad, D. M., & Toam, M. M. (2014). CYP1A1 gen polimorfizmleri ve sigara içme durumu akciğer kanseri riski için değiştirici faktörler olarak. *Gene, 541*, 26-30.
[90]- Ma, C., Lu, X. C., Fan, L., Luo, Y., Yang, B., Gao, Y., Liu, X. F. (2011). Irbesartan, EA'da aterosklerozla ilişkili inflamatuar gen ifadelerini düzenler. hy926 hücreleri [Çince makale]. *Nan Fang Yi Ke Da Xue Xue Bao, 31*, 1835-1839.
[91]- Buyukgoze, O., Osmanoglu, N., Arslan, S., & Sen, A. (2013). Ülseratif kolit ile CYP1A12*A, GSTT1 null, GSTM1 null, mEPHX*3 ve XRCC1-399 genetik polimorfizmlerinin ilişkisi. *International Journal of Colorectal Disease, 28*(5), 593-595.
[92]- Hamachi, T., Tajima, O., Uezono, K., Tabata, S., Abe, H., Ohnaka, K., & Kono, S. (2013). Japon erkeklerde CYP1A1, GSTM1, GSTT1 ve NQO1 polimorfizmleri ve kolorektal adenomlar. *World Journal of Gastroenterology, 19*(28), 4023-4030.
[93]- Li, H., Xiao, D., Hu, L., & He, T. (2012). Association of CYP1A1 polymorphisms with prostate cancer risk: An updated meta-analysis. *Molecular Biology Reports, 39*(12), 10273-10284.
[94]- Öztürk, T., Kahraman, Ö. T., Toptaş, B., Kisakesen, H. I., Cakalir, C., Verim, L., ... & Isbir, T. (2011). The effect of CYP1A1 and GSTM1 gene polymorphisms in bladder cancer development in a Turkish population. *In Vivo, 25*(4), 663-668.
[95]- Liu, G., Ghadirian, P., Vesprini, D., Hamel, N., Paradis, A. J., Lal, G., ... & Foulkes, W. D. (2000). Polymorphisms in GSTM1, GSTT1 and CYP1A1 and risk of pancreatic adenocarcinoma. *British Journal of Cancer, 82*(10), 1646-1649.
[96]- Chen, C., Huang, Y., Li, Y., Mao, Y., & Xie, Y. (2007). Cytochrome P450 1A1 (CYP1A1) T3801C and A2455G polymorphisms in breast cancer risk: A meta-analysis. *Journal of Human Genetics, 52*(5), 423-435.
[97]- Mrozikiewicz, P. M., Grześkowiak, E., Seremak-Mrozikiewicz, A., Bogacz, A., Barlik, M., Semczuk, A., ... & Drews, K. (2011). Importance of CYP1A1 polymorphism and its transcriptional regulation in ovarian and endometrial cancer. *Ginekologia Polska, 82*(12).

[98]- Kumar, V., Yadav, C. S., Singh, S., Goel, S., Ahmed, R. S., Gupta, S., ... & Banerjee, B. D. (2010). CYP1A1 polymorphism and organochlorine pesticides levels in the etiology of prostate cancer. *Chemosphere, 81*(4), 464-468.
[99]- Cordero, K., Espinoza, I. R., Caceres, D., Roco, A., Miranda, C., Squicciarini, V., ... & Quinones, L. (2010). Oral cancer susceptibility associated with the CYP1A1 and GSTM1 genotypes in Chilean individuals. *Oncology Letters, 1*(3), 549-553.
[100]- Lu, Y., Zhang, X. L., Xie, L., Li, T. J., He, Y., Peng, Q. L., ... & Li, S. (2014). Lack of association between CYP1A1 polymorphisms and risk of bladder cancer: A meta-analysis. *Asian Pacific Journal of Cancer Prevention, 15*(9), 4071-4077.
[101]- Wang, Y., Kong, C. Z., Zhang, Z., Yang, C. M., & Li, J. (2014). CYP1A1 genetic polymorphisms and bladder cancer risk: A meta-analysis. *DNA and Cell Biology, 33*(2), 171-181.
[102]- Srivastava, D. S., Mandhani, A., & Mittal, R. D. (2008). Genetic polymorphisms of cytochrome P450 CYP1A1 (*2A) and microsomal epoxide hydrolase gene, their interactions with tobacco users and susceptibility to bladder cancer: A study from North India. *Archives of Toxicology, 82*(9), 633-639.
[103]- Hoidy, W. H., Jaber, F. A., & Al-Askiry, M. A. (2019). Association of CYP1A1 rs1048943 polymorphism with prostate cancer in Iraqi men patients. *Asian Pacific Journal of Cancer Prevention, 20*(12), 3839.
[104]- Abbas, M., Srivastava, K., Imran, M., & Banerjee, M. (2014). CYP1A1 gene variants rs4646903 (T> C) and rs1048943 (A> G) and their association with cervical cancer in North Indian population. *European Journal of Obstetrics & Gynecology and Reproductive Biology, 176*, 68-74.
[105]- Cao, D., Ren, Z., & Li, D. (2019). Association between CYP1A1 rs4646903 T>C genetic variations and male infertility risk: A meta-analysis. *Medicine, 98*(31), e16543.
[106]- Altunkol, A., Savaş, M., Dilmeç, F., Utanğaç, M. M., Abat, D., Gümüş, K., ... & Yeni, E. (2018). Detection of CYP1A1 and GSTP1 gene polymorphisms in bladder cancer patients in a Turkish population using a polymerase chain reaction-restriction fragment length polymorphism method. *Turkish Journal of Urology, 44*(2), 125.
[107]- Kogevinas, M., Zock, J. P., Jarvis, D., Kromhout, H., Lillienberg, L., Plana, E., ... & Antó, J. M. (2007). İşyerinde maddelere maruz kalma ve yeni başlayan astım: Uluslararası prospektif popülasyona dayalı bir çalışma (ECRHS-II). *The Lancet, 370*(9584), 336-341.
[108]- Dörrenhaus, A., Müller, T., & Roos, P. H. (2007). Increased CYP1A1 expression in human exfoliated urothelial cells of cigarette smokers compared to non-smokers. *Archives of Toxicology, 81*(1), 19-25.
[109]- Lu, Y., Zhang, X. L., Xie, L., Li, T. J., He, Y., Peng, Q. L., ... & Li, S. (2014). Lack of association between CYP1A1 polymorphisms and risk of bladder cancer: A meta-analysis. *Asian Pacific Journal of Cancer Prevention, 15*(9), 4071-4077.
[110]- Berber, U., Yilmaz, I., Yilmaz, O., Haholu, A., Kucukodaci, Z., Ates, F., & Demirel, D. (2013). CYP1A1 (Ile462Val), CYP1B1 (Ala119Ser and Val432Leu), GSTM1 (null), and GSTT1 (null) polymorphisms and bladder cancer risk in a Turkish population. *Asian Pacific Journal of Cancer Prevention, 14*(6), 3925-3929.
[111]- Hirvonen, A., Husgafvel-Pursiainen, K., Karjalainen, A., Anttila, S., & Vainio, H. (1992). CYP1A1 geninde yakından bağlantılı nokta mutasyonlu MspI ve Ile-Val polimorfizmleri: Finlandiyalı bir çalışma popülasyonunda akciğer kanserine duyarlılık ile ilişki eksikliği. *Cancer Epidemiology, Biomarkers & Prevention, 1*(6), 485-489.Naccarati, A., Soucek, P., Stetina, R., Haufroid, V., Kumar, R., Vodickova, L., ... & Vodicka, P. (2006). Genetic polymorphisms and possible gene-gene interactions in metabolic and DNA repair genes: Effects on DNA damage. *Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis, 593*(1-2), 22-31.

Relationship of Physiological Curvatures of the Spine with Demographic Characteristics, Balance, Postural Habit and Postural Awareness

Omurganın Fizyolojik Eğriliklerinin Demografik Özellikler, Denge, Postural Alışkanlık ve Postural Farkındalık ile İlişkisi

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Abstract

Purpose: This preliminary study aims to determine the relationship between physiologic curvatures of the spine and demographic characteristics, balance, postural habits and postural awareness.

Method: Forty-five female university students, aged between 18 and 27 years, were included in the study. In the sagittal alignment assessment, the angles of kyphosis and lordosis were measured using a Bubble inclinometer. Balance parameters were evaluated statically and dynamically with the Corebalance device. The Postural Habit and Awareness Scale was used to determine postural behaviors. Pearson correlation analysis was used to determine the relationships between these parameters.

Result: There was no significant correlation between the physiological curvatures of the spine and balance parameters, as well as postural behaviors. However, a moderate positive correlation was found between kyphosis and lordosis angles (r:0.314,p:0.035). In addition, a moderate significant relationship was found between the body mass index of the participants and their postural awareness (r:0.322,p:0.031), static (r:0.435,p:0.003) and dynamic balance parameters (r:-0.386,p:0.009).

Conclusion: The results of this preliminary study revealed no significant correlation between the physiological curvatures of the spine and balance parameters,

as well as postural behaviors, in young female university students. There is a need for further studies with a large sample group in which the parameters affecting the physiologic curvatures of the spine will be examined more extensively.

Keywords: Spinal curvatures, Balance, Postural Habit , Postural Awareness

Özet

Amaç: Bu ön çalışma, omurganın fizyolojik eğrilikleri ile demografik özellikler, denge, postural alışkanlıklar ve postural farkındalık arasındaki ilişkiyi belirlemeyi amaçlamaktadır.

Yöntem: Çalışmaya yaşları 18-27 arasında değişen 45 kadın üniversite öğrencisi dahil edilmiştir. Sagittal düzlem değerlendirmesinde kifoz ve lordoz açıları Bubble inklinometre ile ölçülmüştür. Denge parametreleri Corebalance cihazı ile statik ve dinamik olarak değerlendirilmiştir. Postural davranışların belirlenmesinde Postural Alışkanlık ve Farkındalık Ölçeği kullanılmıştır. Parametreler arasındaki ilişkilerin belirlenmesinde Pearson korelasyon analizi uygulanmıştır.

Bulgular: Omurganın fizyolojik eğrilikleri ile denge parametreleri ve postural davranışlar arasında anlamlı bir korelasyon saptanmamıştır. Bununla birlikte, kifoz ve lordoz açıları arasında orta düzeyde pozitif bir korelasyon bulunmuştur (r:0,314, p:0,035). Ayrıca, katılımcıların vücut kitle indeksi ile postural farkındalık (r:0,322, p:0,031), statik (r:0,435, p:0,003) ve dinamik denge parametreleri (r:-0,386, p:0,009) arasında orta düzeyde anlamlı bir ilişki tespit edilmiştir.

Sonuç: Bu ön çalışmanın sonuçlarına göre, genç kadın üniversite öğrencilerinde omurganın fizyolojik eğrilikleri ile denge parametreleri ve postural davranışlar arasında anlamlı bir ilişki bulunmamıştır. Omurganın fizyolojik eğriliklerini etkileyen parametrelerin daha kapsamlı inceleneceği, geniş örneklem gruplu ileri çalışmalara ihtiyaç duyulmaktadır.

Anahtar Kelimeler: Omurga eğrilikleri, Denge , Postural alışkanlık ,Postural farkındalık

Giriş

İnsan omurgasının servikal ve lomber lordoz ile torakal/sakral kifoz gibi fizyolojik eğrilikleri, postüral stabilite, hareket kabiliyeti ve biomekanik stres dağılımında kritik rol oynar. Bu eğriliklerdeki değişimler, yaş ve cinsiyet gibi demografik faktörlerden önemli ölçüde etkilenir:

Omurganın Yaşam Boyu Değişimi ve Klinik Sonuçları

Omurganın yapısal özellikleri, yaşam boyunca dinamik bir değişim sürecinden geçer. Çocukluk döneminde servikal ve lomber lordoz gelişimi motor becerilerle ilişkilendirilirken (1), ileri yaşlarda dejeneratif süreçler torasik kifozda artışa neden olmaktadır. Özellikle 50 yaş üzeri bireylerde intervertebral disk dejenerasyonu ve vertebral morfometrik değişiklikler, sagittal düzlemde eğrilik artışıyla sonuçlanabilir (2). Bu süreçte, kadınlarda osteoporoz kaynaklı deformiteler daha belirgin hale gelirken, erkeklerde disk dejenerasyonuna bağlı değişimler ön plana çıkmaktadır (3,4). Yaşlanma ile ilişkili spinal deformitelerin patofizyolojisini inceleyen güncel çalışmalar, dejeneratif skolyoz insidansının yaşla birlikte arttığını ortaya koymaktadır (5).

Cinsiyete Bağlı Spinal Adaptasyonlar

Lomber lordoz açısı ve pelvik parametrelerde gözlenen cinsiyete bağlı farklılıklar, biyomekanik adaptasyonlarla ilişkilidir. Kadınlarda daha belirgin olan lomber eğrilik, pelvik pozisyona ve pelvik açısal farklılıklara bağlı artan postüral yüklenmelere karşı gelişen fonksiyonel bir adaptasyon olarak yorumlanabilir (6). Sakral eğim ve pelvik tilt açılarındaki cinsiyet farklılıkları, spinal mobilite paternlerinde de varyasyonlara yol açmaktadır (7).

Postüral Denge ve Spinal Deformitelerin Etkisi

Torakolomber bölgedeki eğrilik değişimleri, postüral kontrol mekanizmalarını önemli ölçüde etkilemektedir. Dejeneratif spinal deformitesi olan bireylerde yapılan stabilometrik analizler, lomber kifoz artışı ile postüral salınım parametreleri arasında anlamlı korelasyonlar olduğunu göstermektedir (8). Skolyoz gibi spinal deformiteler, özellikle sagital ve koronal düzlemde postüral instabiliteye yol açarak düşme riskini artırmaktadır (9,10). Adolesan idiyopatik skolyozlu bireylerde sagittal dengesizliğin denge performansını olumsuz etkilediği bildirilmiştir (11).

Postüral Alışkanlıkların Omurga Üzerindeki Etkileri

Uzun süreli statik postürler, omurga segmentleri üzerinde yük dağılımını değiştirerek eğrilik modifikasyonlarına neden olabilmektedir. Dinamik manyettik rezonans görüntüleme teknikleriyle yapılan çalışmalar, farklı oturma pozisyonlarının lomber segmental hareketliliği önemli ölçüde etkilediğini ortaya koymuştur (12). Pediatrik popülasyonda ise torakal kifotik pozisyonda oturma alışkanlığının lomber hiperkifoz ile ilişkili olduğu gösterilmiştir (13).

Postüral Farkındalık ve Rehabilitasyon Yaklaşımları

Kronik muskuloskeletal ağrılı bireylerde postüral farkındalık düzeyi ile ağrı şiddeti arasında ters orantı bulunmaktadır (14). Postür farkındalığının artırılması, yoga ve Pilates gibi egzersizlerle spinal hizalanmayı iyileştirerek ağrıyı azaltmaktadır. Zihin-beden tekniklerine dayalı müdahalelerin postüral kontrolü iyileştirerek spinal sağlık parametrelerini olumlu yönde etkileyebileceği öne sürülmektedir (14,15).

Sonuç olarak, spinal sağlık; demografik özelliklerden postüral davranışlara kadar çok yönlü bir etkileşim ağına bağlıdır ve bu faktörlerin bütüncül bir yaklaşımla ele alınması, klinik müdahalelerin etkinliğini artırabilir.

Yöntem

Çalışma Tasarımı ve Katılımcılar

Bu çalışmada 18–27 yaş aralığındaki 45 kadın üniversite öğrencisiyle bir analiz gerçekleştirilmiştir. Spinal cerrahi öyküsü, nöromüsküler bozukluklar veya akut kas-iskelet yaralanmaları olan bireyler çalışma dışı bırakılmıştır.

Demografik Veriler

Demografik bilgi formu kapsamında katılımcıların yaş, cinsiyet, kilo, boy, vücut kitle indeksi sorgulanmıştır.

Postural Davranışlar

Katılımcıların genel vücut postürü New York Postür Değerlendirme Ölçeği (NYPD) ile değerlendirilmiştir. NYPD, anatomik pozisyonda çeşitli vücut bölümlerinin doğru ve yanlış hizalanmasını değerlendirmek amacıyla geliştirilmiştir. NYPD; baş, boyun, omuzlar, bel ve sırt, kalça, diz ve ayak bilekleri dâhil olmak üzere 13 vücut bölümünde meydana gelebilecek muhtemel postür bozukluklarının resim yoluyla değerlendirilmesini sağlayan bir ölçektir (16).

Postüral Alışkanlık ve Farkındalık Ölçeği

19 madden oluşan bu anket postüral farkındalık (12) ve postüral alışkanlık (7) alt maddeleri olmak üzere toplam 19 maddeden oluşan anket Bayar ve ark. tarafından Türkçe geçerlilik ve güvenirlik çalışması yapılmıştır. Ölçek her bir madde için 5'li likert tipinde olup (Hiç Katılmıyorum=1, Katılmıyorum=2, Kararsızım=3, Katılıyorum=4, Tamamen Katılıyorum=5) katılımcı tarafından işaretlenen maddenin ilgili puanı toplanarak ölçekten alınan toplam skor elde edilmiştir. Yüksek puan, iyi bir postürü ve farkındalığı gösterir (17).

Sagital Dizilimin Değerlendirilmesi

Bu çalışmada, üniversite öğrencilerinin sagital omurga dizilimi, Baseline® marka yerçekimi tabanlı *bubble inklinometre* (Fabrication Enterprises Inc., ABD) ile değerlendirilmiştir. Bu cihaz, eklem hareket açıklığını ölçen, kalibrasyon gerektirmeyen ve düşük maliyetli bir gonyometredir (18).

Ölçüm Protokolü

Katılımcılar, standart platform üzerinde çıplak ayakla, ayakları omuz genişliğinde açık ve kolları serbest pozisyonda durmuştur. Baş pozisyonu, Frankfort

düzlemi yere paralel olacak şekilde standardize edilmiş, ölçüm öncesi 1 saatlik fiziksel aktivite kısıtlaması uygulanmış ve oda sıcaklığı 24°C'de sabitlenmiştir.

- **Torasik Kifoz Ölçümü**

  Clarkson (19) protokolüne uygun olarak, inklinometrenin üst ucu C7 spinöz çıkıntısına, alt ucu T12 seviyesine yerleştirilmiştir. Cihaz göz hizasında tutularak okuma hataları minimize edilmiştir. Kifoz açısı, iki vertebral seviyeden alınan açısal değerlerin farkı hesaplanarak belirlenmiştir.

- **Lomber Lordoz Ölçümü**

  Lomber lordoz açısı için inklinometre, L1 ve S1 spinöz çıkıntılarına yerleştirilmiş ve bu iki seviyeden elde edilen değerlerin toplamı kullanılmıştır (20). Tüm ölçümler nötral ayakta duruş pozisyonunda gerçekleştirilmiş olup, bu yöntem sagital eğrilik değerlendirmelerinde yüksek tekrarlanabilirlik sağlamaktadır.

Denge Değerlendirmesi

Statik ve dinamik denge performansının belirlenmesi için birçok yöntem ve cihaz bulunmaktadır. Bu yöntemler manuel ve elektronik sistemlerle yapılan ölçümler olarak iki sınıfta değerlendirilmektedir. Çalışmamızda statik ve dinamik denge parametrelerinin objektif olarak değerlendirilmesinde geçerli bir bilgisayar destekli cihaz olan Corebalance kullanılmştır (21-23).

İstatistiksel Analiz

Spinal eğrilikler, denge parametreleri, PAFÖ skorları ve BKİ arasındaki ilişkiler Pearson korelasyon katsayıları ile incelenmiştir. Anlamlılık düzeyi $p < 0.05$ olarak belirlenmiştir.

Sonuç

Tablo 1'de katılımcıların demografik özellikleri ile araştırmada incelenen değişkenlere ait betimsel istatistikler yer almaktadır. Tabloda, her bir değişken için ortalama ve standart sapma değerlerini içermektedir.

Tablo 1. Katılımcıların demografik özellikleri ve sonuç ölçümleri değerleri

Değişken	Ortalama±Standart Sapma
Postüral Alışkanlık	22.98±3.35
Postüral Farkındalık	41.04±4.77
Dinamik Denge	1738.49±701.45
Statik Denge Gözler Açık	292.80±200.93
Statik Denge Gözler Kapalı	807.73±462.82
Torasik Kifoz Açısı	30.89±10.51
Lumbal Lordoz Açısı	26.11±10.87
Boy (cm)	165.47±6.20
Kilo (kg)	64.38±12.19
Beden Kitle İndeksi (BKİ)	23.52±4.27

Tablo 2, bu araştırmada incelenen değişkenler arasındaki ilişkileri incelemek üzere yapılan Pearson korelasyon analizi sonuçlarını sunmaktadır. Korelasyon analizi, değişkenler arasındaki doğrusal ilişkinin yönünü ve gücünü -1 ile +1 arasında değişen katsayılarla ifade etmektedir. Pozitif korelasyon değerleri (+), bir değişkendeki artışın diğer değişkende de artışa eşlik ettiğini gösterirken, negatif değerler (-) bir değişkendeki artışın diğerinde azalmayla ilişkili olduğunu ifade etmektedir. Analiz sonuçlarının istatistiksel anlamlılığı $p<0.05$ düzeyinde (*) ve $p<0.01$ düzeyinde (**) olmak üzere iki farklı seviyede değerlendirilmiştir. Bu tablo, postural özellikler, denge performansı ve antropometrik ölçümler arasındaki karmaşık ilişkiler ağını ortaya koymakta ve araştırma bulgularının yorumlanması için bir çerçeve sunmaktadır.

Analiz sonuçlarına göre, vücut ağırlığı ile beden kitle indeksi (VKİ) arasında güçlü pozitif korelasyon saptanmıştır ($r=0.921$, $p<0.001$). Postüral farkındalık ile vücut ağırlığı ($r=0.332$, $p=0.026$) ve VKİ ($r=0.322$, $p=0.031$) arasında ise zayıf pozitif korelasyonlar mevcuttur (Tablo 2).

Denge parametreleri açısından bakıldığında, vücut ağırlığı ve VKİ'nin gözler kapalı statik denge ile orta düzeyde pozitif korelasyon göstermektedir (sırasıyla $r=0.488$, $p=0.001$ ve $r=0.435$, $p=0.003$). Buna karşılık, aynı parametrelerin dinamik denge ile orta düzeyde negatif korelasyon göstermektedir (sırasıyla $r=-0.392$, $p=0.008$ ve $r=-0.386$, $p=0.009$). Spinal eğrilikler arasındaki ilişkiler incelendiğinde, torasik kifoz ile lumbal lordoz arasında zayıf pozitif yönde anlamlı bir ilişki belirlenmiştir ($r=0.314$, $p=0.035$) (Tablo 2).

Çalışmada, postüral alışkanlık ile diğer tüm değişkenler arasında istatistiksel olarak anlamlı bir ilişki tespit edilememiştir ($p>0.05$). Benzer şekilde, postüral farkındalık ile dinamik denge, statik denge (gözler açık/kapalı), torasik kifoz, lumbal lordoz ve boy uzunluğu arasında da anlamlı korelasyon bulunamamıştır ($p>0.05$) (Tablo 2).

Dinamik denge ile statik denge parametreleri (gözler açık/kapalı), torasik kifoz, lumbal lordoz ve boy uzunluğu arasındaki ilişkiler istatistiksel olarak anlamlı değildir ($p>0.05$). Statik denge (gözler açık) ile diğer değişkenler arasında da anlamlı bir korelasyon gözlemlenmemiştir ($p>0.05$) (Tablo 2).

Antropometrik ölçümlerden boy uzunluğu ile vücut ağırlığı (r=0.270, p=0.073) ve boy uzunluğu ile VKİ (r=-0.120, p=0.431) arasındaki ilişkiler anlamlı bulunmamıştır. Ayrıca, torasik kifoz ve lumbal lordozun boy uzunluğu, vücut ağırlığı ve VKİ ile olan ilişkileri de istatistiksel olarak anlamlı değildir (p>0.05) (Tablo 2).

Tablo 2. Omurganın fizyolojik eğriliklerinin diğer parametreler ile ilişkisi

	Postural Alışkanlık	Postural Farkındalık	Dinamik Denge	Statik Denge Gözler Açık	Statik Denge Gözler Kapalı	Torasik Kifoz	Lumbal Lordoz	Boy	Kilo	VKI
Postural Alışkanlık	1.000	-0.014	-0.088	-0.126	-0.253	0.172	0.038	-0.003	-0.192	-0.189
Postural Farkındalık	-0.014	1.000	-0.172	-0.048	0.101	0.278[a]	0.245	0.035	0.332[a]	0.322[a]
Dinamik Denge	-0.088	-0.172	1.000	0.149	-0.284	0.025	-0.165	-0.023	-0.392[b]	-0.386[b]
Statik Denge Gözler Açık	-0.126	-0.048	0.149	1.000	0.058	-0.066	0.137	0.119	-0.082	-0.139
Statik Denge Gözler Kapalı	-0.253	0.101	-0.284	0.058	1.000	-0.136	0.010	0.141	0.488[b]	0.435[b]
Torasik Kifoz	0.172	0.278[a]	0.025	-0.066	-0.136	1.000	0.314[a]	0.246	0.144	0.052
Lumbal Lordoz	0.038	0.245	-0.165	0.137	0.010	0.314[a]	1.000	-0.042	0.115	0.119
Boy	-0.003	0.035	-0.023	0.119	0.141	0.246	-0.042	1.000	0.270	-0.120
Kilo	-0.192	0.332[a]	-0.392[b]	-0.082	0.488[b]	0.144	0.115	0.270	1.000	0.921[b]
VKI	-0.189	0.322[a]	-0.386[b]	-0.139	0.435[b]	0.052	0.119	-0.120	0.921[b]	1.000

[a] Correlation is significant at the 0.05 level (2-tailed).
[b] Correlation is significant at the 0.01 level (2-tailed).

Tartışma

Bu ön çalışmanın sonuçları, genç kadın üniversite öğrencilerinde omurganın fizyolojik eğrilikleri ile denge parametreleri ve postüral davranışlar arasında anlamlı bir korelasyon olmadığını ortaya koymuştur.

Postüral farkındalık ve BKİ arasındaki ilişkiyi inceleyen çalışmalar sınırlı olup, elde edilen bulgular farklılık göstermektedir. Literatürde (24), genel popülasyonda BKİ ile postüral farkındalık arasında anlamlı bir korelasyon bulamamıştır. Bununla birlikte, bariatrik cerrahi hastalarında yapılan bir çalışmada vücut farkındalığı ile BKİ arasında pozitif bir ilişki olduğu bildirilmiştir (25). Yapılan bir çalışmada (26) ise normal kilolu bireylerin, fazla kilolu olanlara kıyasla daha yüksek postüral farkındalığa sahip olduğunu belirtmiştir. Diğer taraftan, bazı çalışmalar postüral farkındalık ile vücut ağırlığı ve BKİ arasında pozitif bir korelasyon olduğunu ortaya koymaktadır. Bu durum, yüksek vücut kütlesine sahip bireylerin postürlerine daha fazla dikkat ediyor olabileceği şeklinde yorumlanabilir. Artan postüral farkındalık, fazla kilolu bireylerde postüral rahatsızlıkların veya sağlık kaygılarının bir sonucu olarak gelişebilir. Nitekim, yapılan araştırmalar yüksek BKİ'nin fiziksel rahatsızlıklar veya sağlık motivasyonları nedeniyle postüral farkındalığı artırabileceğini desteklemektedir (27).

Güncel çalışmalar, dinamik denge ile vücut ağırlığı ve beden kitle indeksi (BKİ) arasında negatif bir korelasyon olduğunu göstermektedir. Bu bulgu, yüksek vücut kütlesinin denge performansını olumsuz yönde etkilediğine işaret etmektedir. Artan

vücut ağırlığının, ağırlık merkezini değiştirerek ve çekirdek stabiliteyi azaltarak denge mekanizmalarını bozduğu öne sürülmektedir (28,29). Ancak bu çalışmada gözler kapalı yapılan statik denge testlerinde vücut ağırlığı ve BKİ ile pozitif bir ilişki gözlemlenmiştir. Normalde yüksek vücut kütlesinin dengeyi bozması beklenirken, bu sonuç, fazla kilolu bireylerin görsel uyaranlar olmadığında propriyosepsiyon ve kinestetik geri bildirim mekanizmalarını daha iyi kullanarak dengeyi koruyabildiğini düşündürmektedir. Bu bulgu, mevcut literatürle kısmen çelişse de, statik dengede henüz tam anlaşılmamış kompanzasyon stratejilerinin varlığına işaret ediyor olabilir (29).

Çalışmamızdaki torasik kifoz ile lumbal lordoz arasındaki pozitif korelasyon, omurganın farklı bölgelerindeki eğriliklerin birbirini etkilediğini göstermektedir. Artan torasik kifozun, lumbal lordozda kompansatuvar değişikliklere yol açarak genel postüral dengeyi korumaya yardımcı olduğu düşünülmektedir. Bu da postür düzeltme çalışmalarında omurganın bütüncül bir yaklaşımla ele alınması gerektiğini vurgulamaktadır. Torasik kifoz ve lumbal lordoz arasındaki ilişki özellikle adolesan idiyopatik skolyoz (AIS) hastalarında belirgin olarak gözlemlenmektedir (30). Çalışmalar, bu iki spinal eğrilik arasında anlamlı bir bağlantı olduğunu ortaya koymaktadır. Yaşlı bireylerde ise lumbal lordoz ile torasik kifoz arasındaki farkın (LL-TK), sagittal dengeyi değerlendirmede klinik açıdan önemli bir parametre olduğu bildirilmiştir (31). Ancak sağlıklı yetişkin popülasyonda bu ilişkinin daha az belirgin olduğu görülmektedir. Legaye ve arkadaşlarının çalışması, pelvis parametreleri ile spinal eğrilikler arasındaki korelasyonları vurgularken, torasik kifoz ve lumbal lordoz arasında doğrudan bir ilişki tespit edememiştir (32). Mevcut bulgular, sağlıklı bireylerde sagittal dengenin korunmasında bu eğriliklerin uyumlu şekilde çalıştığını düşündürmekle birlikte, doğrudan korelasyonların sınırlı olduğunu göstermektedir.

Bu çalışmanın bulgularına göre, genç kadın üniversite öğrencilerinde omurganın fizyolojik lordoz ve kifoz eğrilikleri ile denge parametreleri ve postür arasında anlamlı bir ilişki tespit edilmemiştir. Bu durum, çalışma popülasyonunun sağlıklı bireylerden oluşması ve patolojik spinal eğriliklerin (hiperlordoz veya hiperkifoz) bulunmaması ile açıklanabilir. Spinal deformitelerin daha belirgin olduğu klinik popülasyonlarda bu ilişkiler farklılık gösterebilir.

Bu ön çalışmanın sonuçları, omurga eğriliklerinin postüral kontrol ve denge üzerindeki potansiyel etkilerinin daha kapsamlı bir şekilde incelenmesi gerektiğini ortaya koymaktadır. İleriki araştırmalarda, daha geniş örneklem büyüklükleri, farklı yaş grupları ve klinik popülasyonların dahil edilmesiyle spinal eğriliklerin postüral davranışlar üzerindeki rolünün daha detaylı değerlendirilmesi önerilmektedir.

KAYNAKÇA

1. Cramer, G. D., & Darby, S. A. (2014). Clinical anatomy of the spine, spinal cord, and ANS (3rd ed.). Elsevier. Clinical Anatomy of the Spine
2. Singer, K. P. (2002). Influence of age on cervicothoracic spinal curvature: An ex vivo radiographic survey. Clinical Biomechanics, 17(5), 361-367. Age and Cervicothoracic Curvature
3. Kado, D. M., Prenovost, K., & Crandall, C. (2010). Narrative review: Hyperkyphosis in older persons and its association with adverse health outcomes. *Journal of Orthopaedic & Sports Physical Therapy*, 40(6), 324-333. https://doi.org/10.2519/jospt.2010.3099
4. Parvez, M. S., Islam, M. S., Hasan, M. M., Islam, M. N., & Islam, M. S. (2023). Age- and gender-related radiological changes of the cervical spine: A study with largest magnetic

resonance imaging database of 5672 consecutive patients. *Journal of Craniovertebral Junction & Spine*, 14(2), 127-137. https://doi.org/10.4103/jcvjs.jcvjs_9_23
5. SSR. (2024). Coping with an ageing spine. Scoliosis Support & Research. Ageing Spine
6. Hay, O., Dar, G., Abbas, J., Stein, D., May, H., Masharawi, Y., Peled, N., & Hershkovitz, I. (2015). The lumbar lordosis in males and females, revisited. PLOS ONE, 10(8), e0133685. Lumbar Lordosis in Males and Females
7. Yamada, T., Yamato, Y., Hasegawa, T., Yoshida, G., Yasuda, T., Banno, T., Arima, H., Oe, S., Mihara, Y., Ushirozako, H., Ide, K., Watanabe, Y., Nakai, K., & Matsuyama, Y. (2024). Gender differences in spinal mobility during postural changes: A detailed analysis using upright CT. Scientific Reports, 14(1), 59840. Gender Differences in Spinal Mobility
8. Ishikawa, Y., Miyakoshi, N., Kasukawa, Y., Hongo, M., & Shimada, Y. (2009). Spinal curvature and postural balance in patients with osteoporosis. Osteoporosis International, 20(12), 2049-2053. Spinal Curvature and Balance
9. Yilmaz, H., Zateri, C., Kusvuran Ozkan, A., Kayalar, G., & Berk, H. (2019). Evaluation of balance in young adults with idiopathic scoliosis. *Turkish Journal of Physical Medicine and Rehabilitation*, 65(3), 233-239. https://doi.org/10.5606/tftrd.2019.2825
10. Şahin, F., Urak, Ö., & Akkaya, N. (2019). Evaluation of balance in young adults with idiopathic scoliosis. *Turkish Journal of Physical Medicine and Rehabilitation, 65*(3), 236–243. https://doi.org/10.5606/tftrd.2019.2825
11. Yagci, G., Yakut, Y., & Simsek, E. (2019). Evaluation of balance in young adults with idiopathic scoliosis. PLOS ONE, 14(10), e0223744. Balance in Scoliosis
12. Baumgartner, D., Zemp, R., List, R., Stoop, M., Naxera, M., Elsig, J. P., & Lorenzetti, S. (2012). The spinal curvature of three different sitting positions analysed in an open MRI scanner. *The Scientific World Journal*, 2012, 184016. https://doi.org/10.1100/2012/184016
13. Santonja-Medina, F., Collazo-Diéguez, M., Martínez-Romero, M. T., Rodríguez-Ferrera, M. L., Aparicio-Sarmiento, A., Cejudo, A., & Sainz de Baranda, P. (2020). Sitting posture, sagittal spinal curvatures and back pain in 8 to 12-year-old children from the Region of Murcia (Spain): ISQUIOS Programme. *International Journal of Environmental Research and Public Health*, 17(7), 2578. https://doi.org/10.3390/ijerph17072578
14. Cramer, H., Mehling, W. E., Saha, F. J., Dobos, G., & Lauche, R. (2018). Postural awareness and its relation to pain: Validation of an innovative instrument measuring awareness of body posture in patients with chronic pain. *BMC Musculoskeletal Disorders*, 19, 109. https://doi.org/10.1186/s12891-018-2031-9
15. Kado, D. M., Prenovost, K., & Crandall, C. (2010). Narrative review: Hyperkyphosis in older persons and its association with adverse health outcomes. *Journal of Orthopaedic & Sports Physical Therapy*, 40(6), 324-333. https://doi.org/10.2519/jospt.2010.3099
16. Öztürk, S. A., Kıyak, G., Arslan, E., Acar, H. T., Ercan, S., & Çetin, C. (2021). Cerrahlardaki egzersiz alışkanlığının kas-iskelet sistemi ağrısına ve postüre etkisi [The effect of exercise habits on musculoskeletal pain and posture in surgeons]. Pamukkale Medical Journal [Pam Tıp Dergisi], 15(1), 117-123.
17. Bayar, B., Güp, A. A., Özen Oruk, D., İpek Dongaz, Ö., Doğu, E., & Bayar, K. (2023). Development of the postural habits and awareness scale: a reliability and validity study. *International Journal of Occupational Safety and Ergonomics*, *29*(2), 815-820.
18. Işık, H., Koç, G. G., Öğüt, E., & Işık, E. İ. (2022). Columna Vertebralis Hareketlerinin Değerlendirilmesinde İnklinometre ve Radyolojik Ölçümün Karşılaştırılması [Comparison of Inclinometer and Radiological Measurement in the Evaluation of Columna Vertebralis Movements]. Arşiv Kaynak Tarama Dergisi [Archives Medical Review Journal], 31(4), 243-248. doi:10.17827/aktd.1186684
19. Clarkson HM. Musculoskeletal Assessment: Joint Motion and Muscle Testing. 3rd ed. Philadelphia, USA: Lippincott Williams & Wilkins; 2013.
20. - [The reliability, minimal detectable change and concurrent validity of a gravity-based bubble inclinometer and iPhone application for measuring standing lumbar lordosis](https://pubmed.ncbi.nlm.nih.gov/23862655/)

21. Platzer, H. P., Raschner, C., & Patterson, C. (2009). Performance-determining physiological factors in the luge start. Journal of sports sciences, 27(3), 221-226.
22. Malliou, P., Ispirlidis, I., Beneka, A., Taxildaris, K., & Godolias, G. (2003). Vertical jump and knee extensors isokinetic performance in professional soccer players related to the phase of the training period. Isokinetics and exercise science, 11(3), 165-169
23. Asseman, F. B., Caron, O., & Crémieux, J. (2008). Are there specific conditions for which expertise in gymnastics could have an effect on postural control and performance?. Gait & posture, 27(1), 76-81.
24. Da Costa Silva, L., Beltran, G. A., Gomes da Silva, D. F., Han, J., de Araujo, G. G., Vancini, R. L., & Andreasi, V. (2022). Self-reported body awareness: Validation of the Postural Awareness Scale and the Multidimensional Assessment of Interoceptive Awareness-2 in a non-clinical adult sample. *Frontiers in Psychology*, 13, 946271. https://doi.org/10.3389/fpsyg.2022.946271
25. Vancini, R. L., Seffrin, A., de Lira, C. A. B., Knechtle, B., Nikolaidis, P. T., de Almeida, A. A., & Andreasi, V. (2022). Body awareness in patients who underwent bariatric surgery: A preliminary study. *Frontiers in Psychology*, 12, 768986. https://doi.org/10.3389/fpsyg.2021.768986
26. Topino, E., Gori, A., & Cacioppo, M. (2020). Mind and body: Italian validation of the Postural Awareness Scale. *Frontiers in Psychology, 11*, Article 827. https://doi.org/10.3389/fpsyg.2020.00827
27. Greve, J., Alonso, A., Bordini, A. C. P. G., & Camanho, G. L. (2007). Correlation between body mass index and postural balance. *Clinics (São Paulo), 62*(6), 717-720. https://doi.org/10.1590/s1807-59322007000600010
28. Hue, O., Simoneau, M., Marcotte, J., Berrigan, F., Doré, J., Marceau, P., Marceau, S., Tremblay, A., & Teasdale, N. (2006). Body weight is a strong predictor of postural stability. *Gait & Posture, 24*(2), 169-175. https://doi.org/10.1016/j.gaitpost.2006.07.005
29. Ku, P. X., Abu Osman, N. A., Yusof, A., & Wan Abas, W. A. B. (2016). Effects of body mass index on foot posture alignment and core stability in a healthy adult population. *International Journal of Sports and Exercise Medicine*, 2(3). https://doi.org/10.23937/2469-5718/1510040
30. Ohrt-Nissen, S., Kamper, S. J., Dahl, B., & Gehrchen, M. (2014). Thoracic hypokyphosis in the young patient is associated with a high degree of lumbar lordosis. *Spine Deformity, 2*(1), 38–42. https://doi.org/10.1016/j.jspd.2013.09.004
31. Yang, S. H., Park, Y. S., Cho, J. H., Sung, D. H., & Moon, S. H. (2016). Lumbar lordosis minus thoracic kyphosis: A novel parameter of sagittal balance in elderly populations. *Global Spine Journal, 6*(7), 667–673. https://doi.org/10.1055/s-0035-1566543
32. Legaye, J., Hecquet, J., & Marty, C. (2005). Sagittal plane alignment of the spine and gravity: A radiological and clinical evaluation. *Acta Orthopaedica Belgica, 71*(2), 213–220. https://pubmed.ncbi.nlm.nih.gov/16152857/

Nursing Approaches in Diabetic Foot Wounds

Diyabetik Ayak Yaralarında Hemşirelik Yaklaşımları

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Abstract

Diabetes mellitus develops when the pancreas is unable to secrete sufficient amounts of insulin or when the body is unable to use the available insulin effectively. This impairment leads to an increase in blood glucose levels (hyperglycaemia) and can cause serious damage to many organs and systems, especially the blood vessels and nervous system. Diabetes is a chronic health problem with high morbidity and mortality rates, which is encountered more and more frequently both in Turkey and worldwide. Diabetic foot; It usually occurs as a result of nerve injuries caused by peripheral neuropathy and circulatory disorders due to atherosclerosis in the lower extremity vessels. This condition, which often begins after minor trauma, is characterised by ulcer formation, infection development and deep tissue damage. Classification of diabetic foot infections is extremely important in terms of assessing the severity of the ulcer, determining the risk factors and establishing an effective treatment plan. The main classification systems used for this purpose include Meggitt-Wagner, University of Texas, DIAFORA, PEDIS, WIfI and SINBAD classifications. Self-care of the individual has an important place in the successful control of diabetes. However, many individuals have difficulty in implementing lifestyle changes and this may negatively affect both physical and mental well-being. In this context, interventions applied by nurses and health professionals in the process of disease management are among the main goals.

Keywords: Diabetic foot ulcer, diabetic wound management, nursing approach, nursing.

Özet

Diabetes mellitus, pankreas yeterli miktarda insülin salgılayamadığında veya vücut mevcut insülini etkili bir şekilde kullanamadığında gelişir. Bu bozukluk kan glikoz seviyelerinde artışa (hiperglisemi) yol açar ve başta kan damarları ve sinir sistemi olmak üzere birçok organ ve sistemde ciddi hasara neden olabilir. Diyabet, hem Türkiye'de hem de dünyada giderek daha sık karşılaşılan, yüksek morbidite ve mortalite oranlarına sahip kronik bir sağlık sorunudur. Diyabetik ayak; genellikle periferik nöropatinin neden olduğu sinir yaralanmaları ve alt ekstremite damarlarındaki ateroskleroza bağlı dolaşım bozuklukları sonucu ortaya çıkar. Sıklıkla minör travma sonrası başlayan bu durum ülser oluşumu, enfeksiyon gelişimi ve derin doku hasarı ile karakterizedir. Diyabetik ayak enfeksiyonlarının sınıflandırılması ülserin ciddiyetinin değerlendirilmesi, risk faktörlerinin belirlenmesi ve etkin bir tedavi planının oluşturulması açısından son derece önemlidir. Bu amaçla kullanılan başlıca sınıflandırma sistemleri Meggitt-Wagner, Teksas Üniversitesi, DIAFORA, PEDIS, WIfI ve SINBAD sınıflandırmalarıdır. Diyabetin başarılı bir şekilde kontrol altına alınmasında bireyin öz bakımı önemli bir yere sahiptir. Ancak birçok birey yaşam tarzı değişikliklerini uygulamakta güçlük çekmekte ve bu durum hem fiziksel hem de ruhsal iyilik halini olumsuz etkileyebilmektedir. Bu bağlamda hastalık yönetimi sürecinde hemşireler ve sağlık profesyonelleri tarafından uygulanan müdahaleler temel hedefler arasında yer almaktadır.

Anahtar Kelimeler: Diyabetik ayak ülseri, diyabetik yara yönetimi, hemşirelik yaklaşımı, hemşirelik.

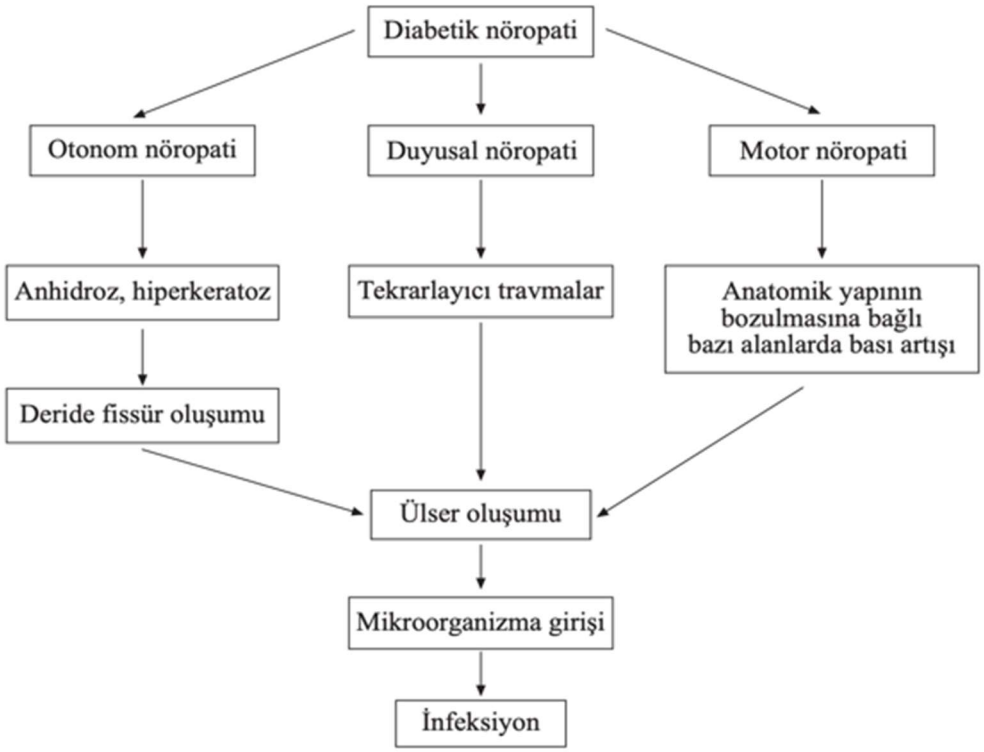
GİRİŞ

Diyabet, dünya genelinde yaygın bir sağlık sorunudur. Diabetes mellitus olarak da bilinen bu hastalık, pankreasın yeterli miktarda insülin üretememesi veya vücudun üretilen insülini etkin bir şekilde kullanamaması sonucu ortaya çıkan kronik bir rahatsızlıktır. Bu durum, kan şekeri seviyesinin yükselmesine (hiperglisemi) yol açarak özellikle kan damarları ve sinirler başta olmak üzere birçok vücut sisteminde ciddi hasarlara neden olabilir (Akıllı ve ark., 2022). Diyabetik yara, diyabet hastalarında vücudun herhangi bir bölgesinde gelişebilen açık bir yaradır. Bu tür yaralar**, Staphylococcus aureus, Pseudomonas aeruginosa, Klebsiella pneumoniae, Escherichia coli, Vibrio vulnificus, Acinetobacter baumannii** ve **Citrobacter freundii** gibi mikroorganizmaların varlığı nedeniyle enfeksiyona yatkın hale gelir. Bu bakteriler yara iyileşmesini geciktirerek enfeksiyonun ilerlemesine ve kangren oluşumuna sebep olabilir. (Kamal ve ark., 2024). Dünya genelinde her 11 yetişkinden biri diyabet hastasıdır ve bu bireylerin yaklaşık %90'ı Tip 2 diyabetle yaşamaktadır

(Dong ve ark., 2024). Diyabet hem Türkiye'de hem de dünya genelinde görülme sıklığı giderek artan, yüksek morbidite ve mortalite oranlarına sahip kronik bir hastalıktır (Yavuz Batmaz ve Katran, 2024).

DİYABETİK AYAK YARALARININ OLUŞUM MEKANİZMASI

Diyabetik ayak ülserlerinin gelişiminde; periferik nöropati, damar yapısındaki bozulmalar, enfeksiyonlar ve bağışıklık sistemi düzensizlikleri tek başına ya da birlikte etkili olabilir. Bu komplikasyonlar arasında, periferik duyu kaybıyla birlikte görülen periferik nöropati en yaygın ve en kritik olanıdır (Demir ve ark., 2004).



Diyabetik ayakta nöropatiye bağlı enfeksiyon gelişim mekanizması (Demir ve ark., 2004).

Diyabetik ayak, periferik nöropatiye bağlı sinir hasarı ve alt ekstremite damarlarında ateroskleroza bağlı dolaşım bozukluğu sonucu, genellikle küçük travmalar sonrasında gelişen ülser, enfeksiyon ve derin doku hasarını tanımlar. Diyabetik ayak yaralarının yaklaşık %60'ı nöropatik kökenlidir. Bu durum, özellikle erkeklerde ve Tip 2 diyabetli bireylerde daha sık gözlenmektedir. Diyabetli hastalarda nöropati, iskemi ve bağışıklık sisteminde zayıflamaya bağlı olarak dirençli enfeksiyonlar ortaya çıkabilmekte, bu enfeksiyonlar ise sıklıkla kemiğe kadar ilerleyerek amputasyon ya da ölümle sonuçlanabilmektedir. Amputasyonlarda en sık karşılaşılan nedenler arasında iyileşmeyen yaralar, enfeksiyonlar ve gangren yer almaktadır. Türkiye'de, travmaya bağlı olmayan amputasyonların yaklaşık %50'si diyabete bağlı olarak gerçekleşmekte ve Sağlık Bakanlığı verilerine göre yılda ortalama 12.000 amputasyon

yapılmaktadır. Bu amputasyonların %45 ila %85'inin aslında önlenebilir nedenlere dayandığı bildirilmiştir. Diyabetik bireylerde nöropati, enfeksiyon ve iskeminin etkili şekilde yönetilememesi, ayak yaralarının oluşmasına ve bu durumun %80 oranında majör ampütasyonla sonuçlanmasına yol açabilmektedir (Ceyhan ve Akutay, 2019).

DİYABETİK AYAK YARALARINDA EVRELEME VE KLİNİK DEĞERLENDİRME

Diyabetik ayak enfeksiyonlarının sınıflandırılması, ülserin ciddiyetinin derecelendirilmesi, risk faktörlerinin belirlenmesi ve uygun tedavi stratejisinin seçimi açısından büyük önem taşır. Diyabetik hastalarda ayak yaralarının analizi için literatürde çeşitli sınıflama sistemleri geliştirilmiştir. Bu sistemlerin bir kısmı yara, enfeksiyon ve dolaşımı ayrı ayrı ele alırken, diğerleri bu parametreleri kombine bir şekilde değerlendirmektedir. Öne çıkan sınıflama sistemleri şunlardır:

Meggitt-Wagner Sınıflaması: Ülser ve gangren durumunu temel alır.

Texas Üniversitesi Sınıflaması: Ülser, enfeksiyon ve iskemi varlığını inceler.

DIAFORA (Diabetic Foot Risk Assessment): Nöropati, ayak deformitesi, geçmiş ülser/ampütasyon öyküsü, gangren, enfeksiyon ve osteomyelit gibi parametreleri değerlendirir.

PEDIS Sınıflaması: Perfüzyon, yara boyutu, enfeksiyon şiddeti ve duyu kaybı üzerine odaklanır.

WIfI (Wound, Ischemia, foot Infection): Yara, iskemi ve enfeksiyon bileşenlerini analiz eder.

SINBAD (Site, Ischemia, Neuropathy, Bacterial Infection, Area, Depth): Ülserin lokalizasyonu, iskemi, nöropati, bakteriyel enfeksiyon ve derinlik gibi kriterleri puanlayarak değerlendirir.

PEDIS sınıflaması, detaylı bir değerlendirme sunmasına rağmen klinik pratikte uygulanması zordur. İdeal bir sınıflama sistemi; basit, ek ekipman gerektirmeyen, acil triyajda hızlı karar vermeyi kolaylaştıran ve sağlık çalışanları arasında standart iletişimi sağlayan bir yapıda olmalıdır. Ancak günümüzde bu özelliklerin tamamını karşılayan tek bir sistem bulunmamaktadır. Bu nedenle farklı klinik senaryolara göre farklı sınıflamaların kullanılması önerilmektedir (Kadanalı ve ark., 2024).

IWGDF 2019 Kılavuzu, uluslararası iletişim ve pratik uygulanabilirlik açısından **SINBAD** sistemini önermiştir. Bu sistemde her bir parametre (yara boyutu, iskemi, nöropati, enfeksiyon, lokalizasyon ve derinlik) 0-1 puanla skorlanır ve toplam 6 puan üzerinden değerlendirme yapılır. SINBAD'ın basit ve ekipmansız uygulanabilir olması, acil servislerde hızlı triyaja imkân tanıması ve sağlık çalışanları arasında ortak bir dil oluşturması avantajlarıdır.

2023 IWGDF Güncellemesi, ülser özelliklerinin değerlendirilmesinde **SINBAD**'ı güçlü öneri (düşük kanıt düzeyi) ile önermiştir. Ek uzmanlık ve kaynak varlığında

ise **WIfI** sisteminin koşullu olarak kullanılabileceği belirtilmiştir. WIfI, periferik arter hastalığı ve iskemi değerlendirmesinde etkili olsa da transkutanöz oksijen ölçümü gibi teknik gereksinimler nedeniyle acil kullanımı sınırlıdır.

Öneriler:

Acil Değerlendirme: Hızlı triyaj için ekipman gerektirmeyen ve kolay uygulanabilen SINBAD sistemi tercih edilmelidir.

Enfeksiyon Değerlendirmesi: 2023 IWGDF/IDSA sınıflaması kullanılmalıdır.

İleri İnceleme: Periferik dolaşım değerlendirmesi gereken durumlarda WIfI sistemi düşünülebilir.

Sonuç olarak, diyabetik ayak ülserlerinde prognozu öngören evrensel bir sınıflama bulunmamakla birlikte, klinik ihtiyaca göre SINBAD (pratiklik) veya WIfI (dolaşım odaklı) sistemleri kullanılabilir. Bu uzlaşı raporunda, enfeksiyon değerlendirmesi için IWGDF/IDSA, yara analizi içinse SINBAD sınıflaması önerilmektedir (Kadanalı ve ark., 2024).

Tablo 1. IWGDF 2023 Risk Düzeyi Sistemi ve karşılık gelen tarama sıklığı

Kategori	Yara riski	Özellikleri	Sıklık*
0	Çok düşük	KDK yok, PAH yok	Yılda bir
1	Düşük	KDK veya PAH	Her 6-12 ayda bir
2	Orta	KDK + PAH, *veya* KDK + ayakta şekil bozukluğu *veya* PAH + ayakta şekil bozukluğu	Her 3-6 ayda bir
3	Yüksek	KDK veya PAH, *ve* aşağıdakilerden en az biri: - Ayak yarası öyküsü - Alt ekstremite ampütasyonu (minor veya major) - Son evre böbrek hastalığı	Her 1-3 ayda bir

Not: KDK=Koruyucu Duyu Kaybı; PAH= Periferik Arter Hastalığı; *Tarama sıklığı uzman görüşlerine dayanmaktadır. Bu süreleri öneren bir yayın bulunmamaktadır.

(IWGDF Guidelines, 2023)

DİYABETİK AYAK YARALARINDA HEMŞİRELİK YAKLAŞIMLARI

Diyabetin etkili bir şekilde kontrol altına alınmasında öz yönetim temel bir rol oynar. Bu sürecin yaklaşık %98'i; kan şekeri takibi, düşük yağ içeren beslenme, düzenli fiziksel aktivite ve ayak ülserlerini önlemeye yönelik bilinçli uygulamaları içeren kişisel bakım faaliyetlerini kapsamaktadır. Ancak diyabetle başa çıkmak sadece teknik olarak karmaşık değil, aynı zamanda oldukça zorlayıcıdır. Bu nedenle birçok hasta yaşam tarzını değiştirme konusunda güçlük yaşar ve hem fiziksel hem de psikolojik anlamda istenilen sonuçlara ulaşmakta zorlanır (Wuri ve ark., 2021). Hastalığın etkin bir şekilde

yönetilmesi, hemşireler ve sağlık ekibi tarafından yürütülen müdahalelerin temel amaçları arasında yer almaktadır. Diyabetik ayak ülseri ile yaşamak, bu alanda görev yapan hemşireler ve hastalar için genellikle alışılmadık ve stresli bir deneyim olup, multidisipliner bakım sürecinde önemli bir zorluk oluşturmaktadır (Nayeri ve ark., 2020). Diyabetik ayak ülserleri; enfeksiyon gelişimi, hastaneye yatış ve ampütasyon gibi ciddi komplikasyonlara neden olabileceğinden, ülser nükslerinin önlenmesi, iyileşme sürecindeki bireylerin etkin yönetiminde kritik bir öneme sahiptir (Guo ve ark., 2023).

Diyabete bağlı ayak ülserlerinde hemşirelik bakımının temel hedefi; doku bütünlüğünü muhafaza etmek, yeni ülserlerin oluşmasını engellemek, mevcut dokularda meydana gelebilecek yıkımı ve enfeksiyon riskini en aza indirgemek ve etkili yara bakımı sağlamaktır. Diyabetli bireylerde hemşirelik uygulamaları; hastanın risk düzeyinin belirlenmesi, yara bakımı yapılması, özellikle ayak sağlığının korunması ve kan şekeri düzeyinin dengede tutulmasına yönelik eğitim ve danışmanlık hizmetlerini içermelidir (Eraydın ve Avşar, 2019).

Diyabetli bireylerde ayakta ülser gelişimini önleyebilmek için riskli ayakların erken dönemde belirlenmesi ve düzenli aralıklarla yapılan ayak muayeneleri büyük önem taşımaktadır. Uygun ayakkabı kullanımının sağlanması ve yara gelişimine zemin hazırlayan faktörlerin ortadan kaldırılması, koruyucu bakımın temel basamaklarını oluşturur. Bu süreçte sağlık profesyonelleri, diyabetli bireylerin ve ailelerinin ayak bakımı konusundaki bilgi düzeylerini düzenli olarak değerlendirerek farkındalık kazandırmaya yönelik eğitimler düzenlemelidir (Özgürsoy ve ark., 2024).

Hemşireler, diyabetin ve diyabetik ayağın yönetimine ilişkin eğitim programlarının planlanması ve uygulanmasında temel sorumluluğa sahiptir. Aynı zamanda bireyin terapötik öz bakım becerilerini destekleyerek, hastalığa ve bakım süreçlerine dair bilgileri davranış değişikliğine dönüştürmesini sağlarlar. Bu şekilde hastanın yaşam kalitesini artırmada önemli bir rol üstlenirler. Hemşireler ayrıca, toplum içinde risk altındaki bireyleri tespit ederek diyabetin gelişimini önleyebilir ya da geciktirebilir (Özgürsoy ve ark., 2024).

Diyabetik ayak ülseri gelişen bireylerde karşılaşılan sorunların büyük bir kısmı önlenebilir nitelikte olup, tanı konulduğu andan itibaren düzenli takiplerin yapılması ve koruyucu yaşam tarzı davranışlarının kazandırılması gerekmektedir. Diyabet bakım ekibinin etkin bir üyesi olan hemşireler, koruyucu sağlık hizmetlerinin planlanması ve sürdürülmesinde kilit konumdadır. Diyabetli bireyler için birincil hemşirelik yaklaşımı eğitimdir. Bu nedenle hemşirelerin yeterli bilgi ve beceriye sahip olmaları, bu bilgi ve deneyimi hastalara etkili bir biçimde aktarabilmeleri, kaliteli ve konforlu bakım sunumu açısından büyük önem taşır (Özgürsoy ve ark., 2024).

Hemşirelerin diyabetli bireylerde üstlendiği başlıca roller arasında; riskli ayakların değerlendirilmesi, yara ve ülser bakımının uygulanması, ayak sağlığını koruyucu yaklaşımlar ve glisemik kontrolün sağlanmasına yönelik danışmanlık ve eğitim hizmetleri sunulması yer almaktadır (Özgürsoy ve ark., 2024).

SONUÇ

Hemşireler, diyabete bağlı ayak ülseri gelişimini tetikleyen etkenleri belirleyerek, risk grubundaki hastaları erken dönemde saptayıp uygun önlemleri alarak hastalara bu konuda bilinç kazandırabilir. Bu sayede olası ayak problemleri henüz başlangıç aşamasında fark edilip önlenebilir. Hemşireler, diyabet bakım ekibinin aktif üyeleri olarak; hastaların ayak bakımına dair eğitimi, ülser takibi, yara bakımı ve komplikasyonların önlenmesine yönelik faaliyetlerde etkili biçimde yer almalıdır. Özellikle tekrar eden ülserlerin önlenmesinde hemşirenin eğitici ve koruyucu rolü büyük önem taşımaktadır.

KAYNAKÇA

Akıllı, B., Koluman, A., & Abban Mete, G. (2022). Diyabetik Yaralara Elektriksel Stimülasyon Uygulamaları. International Journal of Innovative Engineering Applications, 6(2), 189-198. https://doi.org/10.46460/ijiea.1063953

Ceyhan, Ö., & Akutay, S. (2019). Diyabetik hastalarda amputasyon sonrası yara iyileşmesi ve bakım. *Sakarya Tıp Dergisi, 9*(1), 11–15. https://doi.org/10.31832/smj.496098

Demir, Y., Demir, S., & Gökçe, Ç. (2004). Diabetik ayak: Fizyopatolojisi, tanısı ve rekonstrüksiyon öncesi tedavisinde güncel yaklaşımlar. *Kocatepe Tıp Dergisi*, *5*(3).

Dong, Y., Wang, M., Wang, Q., Cao, X., Chen, P., & Gong, Z. (2024). Single-cell RNA-seq in diabetic foot ulcer wound healing. *Wound repair and regeneration: official publication of the Wound Healing Society [and] the European Tissue Repair Society*, *32*(6), 880–889. https://doi.org/10.1111/wrr.13218

Eraydın, Ş., & Avşar, G. (2019). Diyabetik ayak ülserinde fiziksel muayene ve hemşirelik bakımı. *Journal of Anatolia Nursing and Health Sciences, 22*(4), 306–312.

Guo, Q., Ying, G., Jing, O., Liu, Y., Zhang, Y., & Li, J. (2023). Influencing factors for the recurrence of diabetic foot ulcers: A meta-analysis. *International Wound Journal, 20*(5), 1762–1775. https://doi.org/10.1111/iwj.14017

Kadanalı, A., Saltoğlu, N., Ak, Ö., ve diğerleri. (2024). Diyabetik ayak ülseri ve enfeksiyonlarının tanı, tedavi, korunma ve rehabilitasyonu: Türkiye uzlaşı raporu, 2024 [Diagnosis, treatment, prevention, and rehabilitation of diabetic foot ulcers and infections: Turkish Consensus Report, 2024]. *Klimik Dergisi, 37*(1), 1-43.

Kamal, R., Awasthi, A., Pundir, M., & Thakur, S. (2024). Healing the diabetic wound: Unlocking the secrets of genes and pathways. *European journal of pharmacology*, *975*, 176645. https://doi.org/10.1016/j.ejphar.2024.176645

Nayeri, N. D., Samadi, N., Mehrnoush, N., Allahyari, I., Bezaatpour, F., & NaseriAsl, M. (2020). Experiences of nurses within a nurse-led multidisciplinary approach in providing care for patients with diabetic foot ulcer. *Journal of family medicine and primary care*, *9*(6), 3136–3141. https://doi.org/10.4103/jfmpc.jfmpc_1008_19

Özgürsoy Uran, B. N., Bulut, A., Sofulu, F., Konakçı, G., et al. (2024). Diyabetik Ayak Bakımına Yönelik Hemşire Tutum Ölçeği'nin Türkçe'ye Uyarlanması ve Psikometrik Özelliklerinin İncelenmesi. Turkish Journal of Diabetes and Obesity, 8(1), 19-26. https://doi.org/10.25048/tudod.1400243

Schaper, N. C., et al. (2023). *IWGDF Guidelines on Diabetes-Related Foot Disease*. *Diabetes/Metabolism Research and Reviews*, **39**(S1). https://iwgdfguidelines.org/wp-content/uploads/2024/10/Turkish-IWGDF-Guidelines-2023-IWGDF-Diyabetle-Iliskili-Ayak-Hastaliginn-Onlenmesi-ve-Yonetimi-Rehberleri.pdf

Yavuz Batmaz, Ç., & Katran, H. B. (2024). Diyabetik Yara Polikliniğine Başvuran Hastaların Öz Bakım Gücünün Ayak Bakım Davranışlarına Etkisi. Fenerbahçe University Journal of Health Sciences, 4(2), 325-337. https://doi.org/10.56061/fbujohs.1400794

Wuri Kartika, A., Widyatuti, W., & Rekawati, E. (2021). The effectiveness of home-based nursing intervention in the elderly with recurrent diabetic foot ulcers: A case report. *Journal of Public Health Research, 10*(2), Article 2162. https://doi.org/10.4081/jphr.2021.2162

Nasotreachal Intubation

Nazotrakeal Entübasyon

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Abstract

Intubation is the process of inserting a tube called an endotracheal tube (ET) through the mouth or nose and then into the airway (trachea). Endotracheal intubation is performed in patients with airway obstruction, cardiac arrest, trauma or injury to the neck, abdomen, or chest affecting the airway, loss of consciousness or decreased level of consciousness, during general anesthesia, respiratory failure or apnea, and in patients at risk of aspiration.

The intubation procedure can be performed via either the oral or nasal route.

Endotracheal Intubation via the Oral Route:This is intubation through the mouth. Due to its quicker application, it is especially preferred over nasotracheal intubation in emergency situations.

Nasotracheal Intubation:This is intubation through the nasal passage. The nasotracheal intubation process is similar to endotracheal intubation, but the tube is passed through the nose and then advanced into the trachea.

Nasotracheal intubation is preferred in cases where orotracheal intubation cannot be performed due to intraoral space-occupying lesions, structural abnormalities, or trismus; in cervical instability or degenerative cervical diseases; in head and neck surgeries (intraoral and oropharyngeal surgeries such as segmental mandibulectomy, mandibular osteotomy, mandibular reconstructive surgery, etc.); in tonsillectomies to provide the surgeon with a better working area and in intensive care unit patients requiring long-term ventilation, as an alternative to tracheostomy.

Keywords: Intubation, Nasotracheal Intubation

Özet

Entübasyon endotrakeal tüp (ET) adı verilen bir tüpün ağız veya buruna, daha sonra da hava yoluna (trakea) yerleştirilme işlemidir.

Hava yolu tıkanıklığı, kalp durması, boyun, karın ve göğüste hava yolunu etkileyen yaralanma veya travma, bilinç kaybı veya düşük bilinç düzeyi, genel anestezi işlemi sırasında, solunum yetmezliği veya apne ve aspirasyon riski olan hastalarda endotrakeal entübasyon işlemi uygulanmaktadır.

Entübasyon işlemi oral veya nazal yoldan uygulanabilmektedir.

Oral yol ile Endotrakeal Entübasyon: Ağız yoluyla entübasyondur. Daha hızlı olması nedeniyle özellikle acil durumlarda nazotrakeal entübasyona tercih edilir.

Nazotrakeal Entübasyon: Burun yolu ile entübasyondur. Nazotrakeal entübasyon süreci endotrakeal entübasyona benzer, ancak burada tüp burun içinden geçirilir ve ardından trakeaya ilerletilir.

Ağız içi yer kaplayan lezyonlar, yapısal anormallikler, trismus nedeniyle orotrakeal entübasyonun gerçekleştirilemeyeceği olgularda, Servikal instabilite, servikal dejeneratif hastalıklarda, baş ve boyun cerrahisinde (intraoral ve orofaringeal cerrahiler; segmental mandibulektomi, mandibuler osteotomi, mandibular rekonstruktif cerrahi vb) , tonsillektomilerde nazotrekeal entübasyon cerraha rahat çalışılacak alan sağlanması açısından ve yoğun bakım ünitesinde uzun ventilasyon gerektiren olgularda trakeostomiye alternatif olarak tercih edilmektedir.

Anahtar Kelimeler: Entübasyon, Nazotrekeal Entübasyon

GİRİŞ:

Entübasyon endotrakeal tüp (ET) adı verilen bir tüpün ağız veya buruna, daha sonra da hava yoluna (trakea) yerleştirilme işlemidir.

Entübasyon Gerektiren Durumlar:

- Hava yolu tıkanıklığı
- Kalp durması
- Boyun, karın ve göğüste hava yolunu etkileyen yaralanma veya travma
- Bilinç kaybı veya düşük bilinç düzeyi
- Genel anestezi işlemi sırasında
- Solunum yetmezliği veya apne
- Aspirasyon riski

Entübasyon Nasıl Uygulanır?

Entübasyon işlemini farklı yöntemlerle uygulamak mümkündür. Bu yöntemler şu şekildedir.

Oral yol ile Endotrakeal Entübasyon : Ağız yoluyla entübasyondur. Daha hızlı olması nedeniyle özellikle acil durumlarda nazotrakeal entübasyona tercih edilir.

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NAZOTREKEAL ENTÜBASYON

Kuhn F1 1902 yılında Nazotrakeal entübasyonu (NE) ilk kez tanımlamıştır. Daha sonra, 1920 li yıllarda bu teknik intraoral, faringeal ve laringeal ameliyatlar için anestezi indüksiyonunda ve boyun ameliyatları sırasında cerrahi sahada daha iyi görüş alanı sağlanması için popülerlik kazanmıştır Günümüzde ise uygulama başta diş hekimlikleri olmak üzere iyice yaygınlaşmıştır. [1-3]

Nazotrakeal entübasyon orotrakeal entübasyona göre daha travmatiktir ve postoperatif morbiditede artışa neden olmaktadır[4-7]. Bu travmaya katkıda bulunan faktörler arasında uygulayıcının deneyimsizliği ve gözetim eksikliğinin yanı sıra hasta anatomik varyasyonları, orofasiyal bölgede geçmiş rekonstrüktif cerrahi ve nasotrakeal tüpün geçişini bozabilecek yarık damak veya yüz kemiği kırığı yer alır. [8-9-10]

Nazotrakeal entübasyon uygulayacağımız olguların preanestezik değerlendirilmesinde detaylı bir anamnez sonrası tek tek nazal kavitelerini kapatıp, rahat hava geçişi olan nazal kaviteyi tespit etmemizin, nazotrakeal entübasyon başarısını arttırdığı bilinmektedir.Çünkü burun boşluğundaki anatomik varyasyonlar (ör., septal deviasyon veya konka hipertrofisi) yaygındır ve hastalarda asemptomatik olabilir.[10, 11] Bu nedenle, hem nazotrakeal entübasyondan önce hem de orotrakeal entübasyondan önce burun boşluğunun dikkatli bir şekilde değerlendirilmesi gerekir.

Nazotrakeal entübasyon da önce tüp dar ve uzun burun boşluğundan geçirilmelidir.[12] Nasotrakeal entübasyon sırasında, burun deliğindeki endotrakeal tüpün geçebileceği iki yol vardır.Bunlardan birincisi orta ve alt konkalar arasındaki üst yol diğeri ise alt konka ile burun boşluğunun tabanı arasındaki alt yoldur.[13] Güvenlik açısından değerlendirilir ise Alt yol daha güvenlidir çünkü orta konka ve kribriform plakadan daha uzakta bulunur.

Endotrekeal tüp ön-arka yönde yüz düzlemine dik olarak yerleştirilir; Böylece alt konka ile burun boşluğunun tabanı arasındaki alt yoldan geçirilmiş olur.[14]

Nazotrakeal entübasyon öncesi nazal mukozanın hazırlanması gerekmektedir.Bu sebeple lubrikan jeller, topikal lokal anestezik yada vazokonstrüktörler yaygın olarak kullanılmaktadır.[4]

Bir çok klinisyen düşük konsantrasyonda adrena- lin (1:200000 veya daha az) yada fenilefrin (%0.05) içeren lokal anestezik (lidokain) kullanmayı tercih etmektedir. Buna alternatif olarak öncesinde vazokonstrüktör nazal sprey (oxymetazoline) kullanımının, travmayı ve burun mukozasındaki kanamayı azaltıp mekanik genişleme oluşturduğu kanısında olanlarda vardır.[5,15,16]

Nazotrakeal entübasyon tercih edilen cerrahi işlemler [4,5]:

-Ağız içi yer kaplayan lezyonlar, yapısal anormallikler, trismus nedeniyle orotrakeal entübasyonun gerçekleştirilemeyeceği olgularda,

-Servikal instabilite, servikal dejeneratif hastalıklar,

-Baş ve boyun cerrahisinde (intraoral ve orofaringeal cerrahiler; segmental mandibulektomi, mandibuler osteotomi, mandibular rekonstruktif cerrahi vb)

-Obstrüktif uyku apne sendromu bulunanlarda,

-Yoğun bakım ünitesinde uzun ventilasyon gerektiren olgularda trakeostomiye alternatif olarak

-Tonsillektomiler

Nazotrekeal entübasyonun kontrendike olduğu durumlar[4,5]:

- Kanama diyatezi,

-Antikoagulan kullanımı,

- Kafa tabanı kırığı,

- Alt hava yolunda yabancı cisim öyküsü olanlarda,

-Bakteremi riskinin yüksek olduğu kalp kapakçık anomalileri ile protez kalp kapağı bulunanlarda.

Nazotrakeal entübasyonun komplikasyonları[4,5,7,17,18,19,20,21,22]:

- Burun kanamasıdır. genellikle nazal septumun anteriorunda yer alan Kisselbach's plexusunun tahribi yol açmaktadır

-Dental girişimlerde gözlenen, alfa hemolitik streptokoklar ve Corynibakterium'un etken olarak saptandığı bakteriyemidir.

-Tüpün lokal ya da yabancı cisimlerle parsiyel ya da tam obstrükte olmasıdır. Obstrüksiyona en sık yol açan; kopan nazal polip, alt konka, sublükse diş, bant ya da kan pıhtısıdır. En belirgin tanı end tidal CO2 monitörizasyonuyla konur.

- Atrofik mukoza,

- Siliyer fonksiyonda azalma, kuru ve fonksiyonu azalmış havayolu sonrası ortaya çıkabilen submukozal laserasyondur.

- Retrofaringeal perforasyon

- Priform fossanın perforasyonu sonrası subkutanöz/mediastinal amfizem ortaya çıkabi- lir.

- Sinüzittir.

KAYNAKÇA

1- Kuhn F. Die pernasale tubage. Munchen Medizinisch Wochenschrift 1902; 49: 1456.

2- Magill IW. Technique in endotracheal anaesthesia. Br Med J 1930; 2: 817-19.

3- Aldrete JA. Nasotracheal intubation. Surg Clin North Am 1969; 49: 1209-15.

4- Hall CEJ, Shutt LE. Nasotracheal intubation for head and neck surgery. Anaesthesia 2003; 58:249 56.

5- Prasanna D, Bhat S. Nasotracheal Intubation: An Overview. J Maxillofac Oral Surg 2014; 13:366-72.

6- Morgan GE, Mikhail MS, Murray MJ, Larson CP. Airway Management. Clinical Anesthesiology. In: Morgan GE, Mikhail MS, Murray MJ, Larson CP, eds. Clinical Anesthesiology. 3th ed. New York: McGraw-Hill Companies 2002. p. 59-86.

7- Kwon MA, Song J, Kim S, Ji SM, Bae J . Inspection of the nasopharynx prior to fiberoptic-guided nasotracheal intubation reduces the risk epistaxis. J Clin Anesth. 2016; 32: 7-11.

8 -Bell CN, Macintyre DR, Ross JW, Pigott RW, Weller RM. Faringoplasti: nazotrakeal entübasyon için bir tehlike. Bri J Oral Maksillofasiyal Cerrahi 1986; 24(3):212–216. doi: 10.1016/0266-4356(86)90077-X. [DOI] [PubMed] [Google Akademik]

9-Tintinalli JE, Claffey J. Nasotrakeal entübasyonunun komplikasyonları. Ann Emerg Med. 1981; 10(3):142–144. doi: 10.1016/S0196-0644(81)80379-4. [DOI] [PubMed] [Google Akademik]

10-Smith JE, Reid AP. Nazotrakeal entübasyon için burun deliği seçimini etkileyen asemptomatik intranazal anormallikler. Bri J Anaesth. 1999; 83(6):882–886. doi: 10.1093/bja/83.6.882. [DOI] [PubMed] [Google Akademik]

11-Smith JE, Reid AP. Nazotrakeal entübasyondan önce daha fazla patent burun deliğinin belirlenmesi. Anestezi. 2001; 56(3):258–262. doi: 10.1046/j.1365-2044.2001.01717-3.x. [DOI] [PubMed] [Google Akademik]

12-Holzapfel L. Nazal ve oral entübasyon. Minerva Anestesiol. 2003; 69(5):348–352. [PubMed] [Google Akademik]

13-Ahmed-Nusrath A, Maşa JL, Smith JE. Nazal entübasyon için burundan geçen yollar: üç endotrakeal tüpün karşılaştırılması. Br J Anaesth. 2008; 100(2):269–274. doi: 10.1093/bja/aem350. [DOI] [PubMed] [Google Akademik]

14-Prasanna D, Bhat S. Nazotrakeal Entübasyon: Genel Bir Bakış. J Maxillofac Oral Cerrahi 2014; 13(4):366–372. doi: 10.1007/s12663-013-0516-5. [DOI] [PMC ücretsiz makale] [PubMed] [Google Akademik]

15- Williamson R. Nasal intubation and epistaxis. Anaesthesia 2002; 57: 1033-4.

16- Kay J, Bryan R, Hart HB, Minkel DT, Munshi C. Sequential dilation: A useful adjunct in reducing blood loss from nasotracheal intubation. Anesthesiology 1985; 63: A259.

17- Lee JH, Kim CH, Bahk JH, Park KS. The influence of endotracheal tube tip design on nasal trauma during nosotracheal intubation: magill-tip versus murpy-tip. Anesth Analg 2005; 101: 1226-9.

18- Berry FA. Blankenbaker WL, Ball CG. Comparison of bacteremia occurring with nasotracheal and orotracheal intubation. Anaesth Analg 1973; 52: 873-6.

19- Valdes C, Tomas I, Alvarez M, Limeres J, Medina J, Diz P. The incidence of bacteraemia associated with tracheal entubation. Anaesthesia. 2008; 63: 588-92.

20- Chait DH, Poulton TJ. Case report: retropharyngeal perforation, a complication of nasotracheal intubation. Nebr Med J. 1984; 69: 68-9.

21- Blanc VF, Tremblay NA. The complications of tracheal intubation: a new classification with a review of the literatüre. Anesth Analg 1974; 53: 202-13.

22- Heuer JF, Heitmann S, Crozier TA, Bleckmann A, Quintel M, Russo SG. A comparison between the GlideScope® classic and GlideScope® direct video laryngoscopes and direct laryngoscopy for nasotracheal intubation. J Clin Anesth 2016; 33: 330-6.