Chapter 3

Comparison of Healthcare System Performance in EU Candidate Countries Using an Entropy and TOPSIS-Based Multi-Criteria Decision-Making Approach: Türkiye's Position

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Abstract

This study employs a multi-criteria decision-making (MCDM) approach based on the Entropy and TOPSIS methods to objectively evaluate the relative performance of the healthcare systems of nine European Union candidate and potential candidate countries. The analysis includes Türkiye, Albania, Montenegro, Serbia, North Macedonia, Bosnia and Herzegovina, Moldova, Georgia, and Ukraine.

The performance comparison is based on six key criteria: life expectancy at birth, infant mortality rate, number of physicians per capita, number of hospital beds per capita, health expenditure as a percentage of Gross Domestic Product (GDP), and Diphtheria-Tetanus-Pertussis (DTP3) vaccination coverage rate. The objective weighting of the criteria was determined using the Entropy method, which measures uncertainty. Subsequently, the performance ranking of the countries was established using the TOPSIS technique, which assesses alternatives based on their relative closeness to the ideal solution.

According to the findings, Montenegro, North Macedonia, and Serbia stand out as the countries with the highest-performing healthcare systems. In contrast, Türkiye ranks as the second-lowest performing country, just above Moldova. These results highlight significant improvement needs in Türkiye's healthcare system, particularly in service quality and human resources. The study provides a valuable contribution to the development of evidence-based recommendations for restructuring health policies in these countries.

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1. Introduction

In the 21st century, evaluating the performance of health systems requires a multidimensional approach that extends beyond merely health outcomes. According to the World Health Organization (WHO), the assessment of health systems should be based on the core functions such as governance, financing, and service delivery, as well as the extent to which these functions achieve intermediate and final goals like accessibility, efficiency, fair financing, and quality of care (Papanicolas et al. 2022). In this context, the success level of health systems is associated with their ability to improve the overall health of the population, ensure timely and effective access to services, promote equitable distribution among individuals, and utilize available resources efficiently.

Therefore, evaluating the performance of health systems from a holistic perspective is particularly important in countries undergoing structural transformation, such as candidate countries for European Union (EU) membership. Indeed, Sığırlı et al. (2006), using multidimensional scaling analysis, demonstrated that Türkiye lags behind most EU countries in terms of key health indicators (life expectancy at birth, child mortality rates) and the ratio of health expenditures to GDP. These findings further underscore the significance of conducting comparative analyses of health systems in candidate countries for policymakers.

Comparing health systems across countries enables policymakers to make informed decisions aimed at strengthening their own systems. The HiT (Health Systems in Transition) profiles developed by the European Observatory systematically describe how systems are organized, how funds are allocated, and what types of services are provided using a common template. These profiles allow for an evaluation of countries' health systems both within their historical context and in comparison with other European systems (Rechel et al. 2016).

Over the past two decades, health systems in Southeastern Europe have undergone comprehensive reform processes driven by the pursuit of more effective and efficient service delivery, efforts to ensure the sustainability of health expenditures, financial pressures stemming from technological advancements and an aging population, and the transformative pressures of transitioning from socialist systems to market economies (Bartlett, Bozikov, and Rechel 2012). This historical context reinforces the necessity of comparatively evaluating the performance of health systems in these countries, both from a scientific and structural perspective.

This study aims to systematically evaluate the effectiveness of healthcare services, resource allocation, and investments by conducting a comprehensive analysis of the health systems of Türkiye and other European Union (EU) candidate and potential candidate countries. Using the integrated application of multi-criteria decision-making methods—Entropy and TOPSIS—the study compares health indicators across countries and assesses health system performance within a multidimensional framework. The combined use of these methods provides a more robust and objective analytical foundation while revealing structural differences among countries in greater detail.

At the core of this research lies data obtained from reliable international sources such as the World Bank, with methodological rigor prioritized in the construction of the decision matrix. The six key performance indicators selected for evaluating health systems offer a multidimensional comparison by linking health outcomes with health resources and investments. Life expectancy at birth, which reflects the expected health status of individuals, is considered a critical indicator for assessing a country's overall health conditions. Infant mortality rate, which indicates access to and quality of healthcare services, demonstrates the extent to which populations benefit from essential health services. The number of physicians per 1,000 people reveals the density of health personnel and the capacity for healthcare access, while the number of hospital beds per 1,000 people indicates a country's healthcare infrastructure and service delivery capacity. The share of health expenditures in GDP provides significant insights into the budgeting of health policies by measuring countries' financial investments in the health sector. Lastly, the DTP3 immunization rate reflects the importance placed on preventive healthcare and the effectiveness of basic childhood immunizations in a given country.

These indicators enable cross-country comparisons by objectively evaluating the performance of health systems through data-driven metrics. In the indicator selection process, factors such as data accessibility, international comparability, alignment with EU policies, and the requirements for a structural assessment of health systems were taken into account. The findings of this study will identify Türkiye's position among EU candidate countries, highlighting both the strengths and areas in need of improvement within its health system. In this regard, the research aims to establish an evidence-based framework for the restructuring of health policies and to provide valuable insights for policymakers in enhancing the effectiveness of health investments, improving access to services, and planning reform processes.

Accordingly, the study is structured into five main sections. The introduction presents the conceptual framework and objectives of the research, along with the relevant theoretical background. The literature review section examines existing studies on the evaluation of health systems and discusses findings related to the application of the Entropy and TOPSIS methods in the healthcare field. The methodology section provides a detailed explanation of the implementation steps of these techniques, including data processing procedures and methodological approaches. In the application section, the data collected within the scope of the research are presented, and Türkiye's health system is evaluated comparatively with other EU candidate countries. The conclusion and recommendations section discusses the findings of the study and offers concrete suggestions for restructuring health policies.

The findings clearly reveal Türkiye's position among EU candidate countries by identifying the strengths and areas for improvement in its health system. The study offers a scientific foundation for enhancing health policies and delivers valuable insights for increasing the sustainability and effectiveness of health systems through its methodological approaches and comprehensive data analysis.

2. Literature Review

The health systems of EU candidate countries lag behind the EU average in terms of financial sustainability, service quality, and health outcomes. A comparative study based on EUROSTAT data found that per capita health spending in candidate countries is approximately one-third of the EU average, while infant mortality rates are three times higher. Furthermore, Türkiye has the lowest health expenditure as a share of GDP and ranks lowest in terms of health workforce density (Šantrić Milićević et al. 2020). A report published by the OECD and European Commission (2016) emphasizes significant structural inequalities in the efficiency, accessibility, and sustainability of health systems across EU countries. Notably, there is a life expectancy gap of up to eight years between Western and Central/Eastern European countries, attributed to disparities in access to and quality of healthcare services. The fact that over 550,000 people die prematurely each year due to chronic diseases—resulting in a loss of 3.4 million productive life years—highlights the serious consequences of these inequalities (OECD and EU 2016). Mackenbach and McKee (2013) also note substantial differences in health policy implementation and outcomes across European countries, emphasizing the effectiveness of Northern European countries, while Eastern European nations generally show weak performance. Key determinants of these performance differences include national income, government effectiveness, and societal values.

The evaluation and comparison of health system performance is critically important for policymakers. The European Union (EU) institutionalized this process, which began with the signing of the Tallinn Charter in 2008, through the establishment of the Health Systems Performance Assessment (HSPA) expert group in 2014. Initially focused on sharing best practices, this group has gradually undertaken concrete evaluation studies in areas such as quality of care, integrated service delivery, and primary health care. The group's success lies in its participatory approach, flexible attitude, and effective integration of findings into policymaking (Paoli et al. 2019). The role of primary health care in these evaluations is particularly significant. Barbazza et al. (2019) emphasize that measuring the performance of primary health care in the European region is critical for achieving the goals of health system sustainability and universal health coverage. For this purpose, they developed the comprehensive PHC-IMPACT performance assessment framework, which includes 139 indicators across various domains such as structural characteristics, service delivery models, and health outcomes. Following the COVID-19 pandemic, the concept of "resilience" has come to the forefront. Vainieri, Caputo, and Vinci (2024) assessed the resilience of health systems in EU countries using six key indicators: addressing unmet health needs, protecting vulnerable groups, resource availability and efficiency, trained personnel, digital health, and strengthening primary care. They emphasized that resilience is not only about crisis management but also a fundamental component of sustainable performance.

The multidimensional nature of health systems necessitates the use of composite indices and multi-criteria decision-making (MCDM) methods in performance evaluations. In the literature, multivariate techniques such as factor analysis, cluster analysis, Data Envelopment Analysis (DEA), and Malmquist Total Factor Productivity (TFP) are widely used. For instance, within the EURO-HEALTHY project, numerous indicators were employed based on the core functions defined by the World Health Organization to classify European countries, highlighting similarities and differences in service delivery, financing, and resource generation (Ferreira et al. 2018). Konca and Demirci (2019), in their analysis using the Malmquist TFP method for G20 countries, noted that Türkiye demonstrated a remarkable increase in productivity between 2000 and 2015, attributed to improvements in technical efficiency and technological change, which may be linked to health reforms. Similarly, Teleş, Cakmak, and Konca (2018), in their DEA study on EU-cycle countries, found that Türkiye used its resources relatively more efficiently and was frequently referenced. They emphasized that evaluations should focus more on the effective use of resources rather than merely their availability.

Multi-criteria decision-making (MCDM) methods such as Entropy and TOPSIS are increasingly preferred in the evaluation of health systems due to their capacity to assign objective weights to health indicators and provide comprehensive, impartial analyses for cross-country comparisons. Despite methodological challenges such as indicator selection, weighting, and data quality, these methods facilitate systematic comparisons by integrating diverse indicators related to health expenditures, human resources, and service delivery (Popescu et al. 2018). At the EU level, the 23 headline indicators proposed for comparing the performance of health systems have been found useful by policymakers for general guidance. However, more detailed and explanatory indicators are often preferred in data-driven decision-making processes. Furthermore, the limited adaptability of these indicators to national contexts and the lack of appropriate benchmarks for comparison are among the main barriers to their widespread and effective use (Perić et al. 2020). In this context, MCDM methods such as Entropy and TOPSIS offer a valuable methodological alternative for evaluating health systems in a more objective and comparable manner.

Studies using the TOPSIS method in the context of the European Union provide significant insights into the positioning of candidate countries and Türkiye. Türkoğlu (2018) analyzed 26 European countries for the 2010–2014 period using TOPSIS based on indicators such as life expectancy, health expenditures (as a percentage of GDP and per capita), number of hospital beds, fertility rate, infant mortality, and number of physicians. Countries like Norway and Luxembourg ranked at the top, while Slovakia, Serbia, Latvia, and Türkiye consistently appeared at the bottom of the rankings. Kasman, Kasman, and Gökalp (2019) investigated technical efficiency and productivity convergence—specifically β (beta) and σ (sigma) convergence—in the health systems of EU member and candidate countries between 1995 and 2012. They found that countries (including Türkiye) have converged over time, particularly in terms of life expectancy and infant mortality rates, suggesting that candidate countries are progressively aligning with EU standards.

Multi-criteria decision-making (MCDM) studies with a specific focus on Türkiye's performance generally indicate that the country ranks low among OECD countries. Şahin and Cezlan (2023), using criteria weighted by the Analytic Hierarchy Process (AHP) and ranked via the TOPSIS method, placed Türkiye 29th out of 29 OECD countries, while countries following Beveridge and Bismarck models occupied top positions. Özsarı and Boz (2019) evaluated the health status of 34 OECD countries using TOPSIS and found Japan to have the highest performance, with Türkiye at the lowest rank. Demir Uslu (2021) compared OECD countries using eight health resource indicators from 2019 through TOPSIS and VIKOR methods, ranking Türkiye 25th out of 26 countries in both methods, particularly noting its lag in medical technology. Değirmenci and Yakıcı Ayan (2020), using a combination of Fuzzy Clustering Analysis and TOPSIS, assessed OECD countries based on health resources (e.g., pharmaceutical expenditures, number of doctors, nurses, and beds). They placed Türkiye in the same cluster as Poland, Mexico, and South Korea but in the lowest performance group according to TOPSIS, emphasizing the country's shortage of healthcare personnel. Lastly, Demir Uslu et al. (2023) used TOPSIS to rank OECD countries based on financial indicators such as total, public, and private health expenditures per capita, and health expenditure as a share of GDP. The study ranked the U.S., Switzerland, and Norway at the top, while Türkiye was at the bottom of 35 countries, highlighting its lag relative to economic development and the OECD average.

The composition and structure of health expenditures also provide critical insights for comparative analyses. Boz and Sur (2016), using WHO indicators and Multidimensional Scaling (MDS), analyzed EU member and candidate countries and classified them into two main groups. They found that Türkiye, in terms of health expenditures, was positioned similarly to Poland and Romania, while differing significantly from countries like the Netherlands and Luxembourg. This finding highlights the need to analyze health systems not only by financial magnitude but also by expenditure composition and the public-private balance. Kavas and Ertaş (2023) analyzed 31 OECD countries using the TOPSIS method based on health, economic, and financial indicators. Their study included core health metrics such as life expectancy, health expenditures, and the number of doctors, as well as macro indicators like economic globalization, financial freedom, and GDP per capita. The weights of the criteria were determined according to the principle of intra-group equality and expert opinions. In this multi-criteria decision-making analysis, Türkiye ranked 21st. Such methods enable multidimensional and comparative evaluations of national health system performance and contribute significantly to the policy development process.

The unique contribution of this study to the literature lies in its holistic and objective analysis of the performance of health systems in European Union (EU) candidate and potential candidate countries using Entropy and

TOPSIS-based multi-criteria decision-making (MCDM) approaches. While similar analyses exist in the context of EU member and OECD countries, the literature reveals a notable lack of comprehensive and systematic assessments focused specifically on EU candidate countries. In this regard, the study not only determines Türkiye's comparative position among other candidate countries but also offers decision-makers a data-driven opportunity to analyze the strengths and weaknesses of health systems. By assigning objective weights to indicators through the Entropy method and ranking countries based on their proximity to the ideal solution using TOPSIS, the study stands out methodologically. As such, it contributes to the development of evidence-based health reform recommendations for policymakers.

3. Methodology

3.1. Multi-Criteria Decision-Making Methods and Weighting Approaches

Multi-Criteria Decision-Making (MCDM) methods are analytical tools that enable the systematic evaluation of multiple, and often conflicting, criteria simultaneously. These methods allow for the holistic analysis of both objective and subjective criteria in the decision-making process. The methods used vary depending on whether the criterion weights are known or unknown. Moreover, the literature offers a variety of techniques for determining and comparing criterion weights (Ediz, Altan, and Taşdemir 2025).

3.1.1. Methods Used When Criterion Weights Are Known

In cases where the weights of decision criteria are predetermined, the following methods are commonly used:

DEMATEL (Decision-Making Trial and Evaluation Laboratory): This method analyzes causal relationships among decision criteria to construct a structural influence matrix (Fontela and Gabus 1976).

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution): This method evaluates alternatives based on their distances from the ideal and negative-ideal solutions, identifying the one closest to the ideal as the most appropriate option (Hwang and Yoon 1981).

PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation): A method in which alternatives are assessed in pairs according to preference functions and ranked using net flow values (Brans and Vincke 1985).

ELECTRE (ELimination Et Choix Traduisant la REalité): A method that makes selections based on dominance relations and threshold values between alternatives, incorporating exclusion relationships in the elimination process (Roy 1991).

MAUT (Multi-Attribute Utility Theory): An MCDM method that calculates an overall utility score for each alternative by aggregating weighted utility functions (Keeney and Raiffa 1993).

VIKOR (VlseKriterijumska Optimizacija I Kompromisno Resenje): A method that balances group utility and individual regret measures to determine a compromise solution close to the ideal in multi-criteria problems (Opricovic and Tzeng 2004).

MOORA (Multi-Objective Optimization by Ratio Analysis): An MCDM approach that separately considers benefit and cost criteria and evaluates alternatives using ratio analysis (Brauers and Zavadskas 2006).

ARAS (Additive Ratio Assessment): A method that ranks alternatives based on total performance scores normalized and weighted relative to an ideal solution (Zavadskas and Turskis 2010).

3.1.2. Methods Used When Criterion Weights Are Unknown

When the weights of decision criteria are not predetermined, the following methods are frequently employed:

Borda Count Method: An approach in which alternatives are ranked by each decision-maker and scored based on their position, with the alternative receiving the highest total score being selected (Borda 1781).

Condorcet Method: A method that involves pairwise comparisons between all alternatives, selecting the one that wins the most comparisons (i.e., preferred by the majority) as the overall winner (Condorcet 1785).

Copeland Method: This approach calculates the difference between the number of wins and losses each alternative has in pairwise comparisons, selecting the one with the highest net score (Copeland 1951; Henriet 1985).

Lexicographic Method: A decision-making approach where criteria are ordered by importance. The alternative with the best performance in the most important criterion is selected, and in the case of a tie, the next most important criterion is considered (Fishburn 1974).

3.1.3. Methods for Determining Criterion Weights

The following methods are commonly used for assigning weights to decision criteria:

Entropy Method: An objective weighting method based on the information content (entropy) of criteria, assigning higher weights to those with greater variability (Shannon 1948).

AHP (Analytic Hierarchy Process): A widely used MCDM method in which criteria are evaluated via pairwise comparisons, with a consistency ratio to assess the reliability of comparisons and eigenvalue calculation for determining weights (Saaty 1980).

CRITIC (Criteria Importance Through Intercriteria Correlation): An objective method that considers both the standard deviation (information content) of each criterion and its correlation with others to calculate weights (Diakoulaki, Mavrotas, and Papayannakis 1995).

SWARA (Step-Wise Weight Assessment Ratio Analysis): A step-by-step method where decision-makers rank criteria by importance and assess each one's relative importance compared to the previous criterion (Keršulienė, Zavadskas, and Turskis 2010).

BWM (Best-Worst Method): A method in which the best and worst criteria are identified, and all criteria are compared against them to calculate weights (Rezaei 2015).

FUCOM (Full Consistency Method): A method that determines weights using a minimal number of pairwise comparisons, ensuring high consistency in the process (Pamučar, Stević, and Sremac 2018).

3.2. Entropy Method

Entropy method is a technique that enables the objective determination of criterion weights in multi-criteria decision-making (MCDM) processes. This approach is based on the concept of entropy from information theory, which measures the level of uncertainty. As the amount of information contained in a criterion increases, its significance in the decision-making process—and thus its weight—also increases. The Entropy method, whose steps are outlined below, offers a more impartial weighting mechanism by minimizing potential biases stemming from the subjective assessments of decision-makers (Wang and Lee 2009; Shannon 1948; Zeleny 1982; Wu and Lin 2012).

Step 1: Construct the Decision Matrix of Raw Data

The original decision matrix, in which each alternative is evaluated against various criteria, is defined as follows:

$$X = [x_{ij}]_{nxm} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \quad \begin{matrix} i = 1,2, \ldots, n \\ j = 1,2, \ldots, m \end{matrix}$$

Here, n denotes the number of alternatives, and m represents the number of criteria. The term x_{ij} indicates the value assigned to the i^{th}alternative with respect to the j^{th} criterion.

Step 2: Normalize the Decision Matrix

Due to the fact that criteria may be expressed in different units, the decision matrix must be normalized to ensure comparability. The normalized value r_{ij} is calculated as the ratio of the corresponding cell value to the total of its column:

$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{n} x_{ij}}$$

Step 3: Calculate the Entropy Values of the Criteria

For each criterion, the entropy value $e_j e_j$ is calculated using the following formula:

$$e_j = -k \times \sum_{i=}^{n} r_{ij} \times ln(r_{ij})$$

Here, $k = \frac{1}{\ln(n)}$ is a constant multiplier that ensures the entropy value e_j falls within the range $0 \leq e_j \leq 1$.

Step 4: Calculate the Weights of the Criteria

The deviation d_j in the information content of each criterion and the corresponding weight w_j are determined as follows:

$$d_j = 1 - e_j$$

$$w_j = \frac{d_j}{\sum_{i=1}^{m} d_j}$$

With this method, criteria with lower information diversity (entropy)—meaning they contribute more significantly to the decision-making process—are assigned higher weights.

3.3. TOPSIS Method

The TOPSIS method is a widely used technique for ranking alternatives in multi-criteria decision-making problems. It is based on the principle that the chosen alternative should be closest to the ideal solution and farthest from the negative ideal solution. The steps of the TOPSIS method, outlined below, take into account the decision-maker's preferences and the weights of the criteria to rank the alternatives accordingly (Behzadian et al. 2012; Hwang and Yoon 1981).

Step 1: Constructing the Decision Matrix

The decision matrix X , consisting of n alternatives and m criteria, is formed as follows:

$$X = [x_{\mathrm{ij}}]_{\mathrm{nxm}} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \qquad \begin{matrix} i = 1,2,\dots,n \\ j = 1,2,\dots,m \end{matrix}$$

Here, x_{ij} represents the performance of the i^{th} alternative with respect to the j^{th} criterion.

Step 2: Normalization

The decision matrix is normalized using the vector normalization method. The normalized value r_{ij} is calculated as:

$$r_{\mathrm{ij}} = \frac{x_{\mathrm{ij}}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \qquad \begin{matrix} i = 1,2,\dots,n \\ j = 1,2,\dots,m \end{matrix}$$

Step 3: Construct the Weighted Normalized Decision Matrix

$$v_{ij} = w_j . r_{ij}$$

$$V = [v_{\mathrm{ij}}]_{\mathrm{nxm}} = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1m} \\ v_{21} & v_{22} & \cdots & v_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ v_{n1} & v_{n2} & \cdots & v_{nm} \end{bmatrix} = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & \cdots & w_m r_{1m} \\ w_1 r_{21} & w_2 r_{22} & \cdots & w_m r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ w_1 r_{n1} & w_2 r_{n2} & \cdots & w_m r_{nm} \end{bmatrix} \qquad \begin{matrix} i = 1,2,\dots,n \\ j = 1,2,\dots,m \end{matrix}$$

Here, w_j represents the weight of the j^{th} criterion, and it must satisfy the condition:

$$\sum_{j=1}^{m} w_{\mathrm{j}} = 1$$

Step 4: Determining the Ideal and Negative-Ideal Solutions

The ideal solution $A^{+}$is formed by selecting the maximum values for benefit criteria and the minimum values for cost criteria. Conversely, the negative-ideal solution A^{-} is defined by selecting the minimum values for benefit criteria and the maximum values for cost criteria.

$$A^{+} = \left\{ \max_{i} v_{ij} \ \ (j \in benefit), \min_{i} v_{ij} \ \ (j \in cost) \ \ \right\}$$

Step 5: Calculate the Separation Measures

The distances of each alternative from the ideal and negative-ideal solutions are calculated using the Euclidean distance metric:

$$S_i^{+} = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^{+})^2}$$

$$S_i^{-} = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^{-})^2}$$

Step 6: Calculate the Relative Closeness to the Ideal Solution

The relative closeness C_i of each alternative to the ideal solution is calculated using the following formula:

$$C_i = \frac{S_i^{-}}{S_i^{+} + S_i^{-}} \ \ , \ \ 0 \leq \ C_i \leq \ 1$$

Step 7: Ranking

The alternatives are ranked in descending order based on their C_i values. The alternative with the highest C_i value is considered the most preferred option:

$C_i \uparrow \Rightarrow$ Higher preference

This final step provides a clear and data-driven ranking of all alternatives, guiding decision-makers toward the optimal choice.

4. Application

This study was conducted to compare the relative performance of the health systems of nine countries that are candidates or potential candidates for European Union membership. The countries included in the analysis are Türkiye, Albania, Montenegro, Serbia, North Macedonia, Bosnia and Herzegovina, Moldova, Georgia, and Ukraine. These countries were selected because they are undergoing health sector reforms within the framework of the EU's enlargement policy and because their health systems exhibit structurally distinct characteristics. Kosovo was excluded from the analysis due to the unavailability of up-to-date and reliable data for the relevant criteria.

In the decision-making process, six key performance criteria were identified to represent health systems in a multidimensional manner. The criteria used in the evaluation include: life expectancy at birth (LEB), infant mortality rate (IMR), number of physicians per 1,000 people (PhysD), number of hospital beds per 1,000 people (HospBeds), current health expenditure as a percentage of GDP (CHE%GDP), and DTP3 immunization coverage (DTP3).The selection of these indicators was influenced by their frequent use in the literature (e.g., Türkoğlu, 2018; Demirci, Konca, and İlgün, 2020) and their ability to enable a comprehensive assessment that encompasses health system outputs, resources, and investments. Moreover, these indicators were chosen based on the most recent data available from the World Bank databases. Although the data may not pertain to the exact same year for all countries, a complete and comparable decision matrix was constructed in accordance with the principle of comparability.

After constructing the decision matrix, the Entropy method was employed in the criterion weighting stage. The Entropy method enables the calculation of objective weights by analyzing the level of uncertainty among criteria, without requiring input or judgment from the decision-maker. Unlike subjective methods such as the Analytic Hierarchy Process, the Entropy method assigns weights directly based on the variability of the data, which is why it is widely used in multi-criteria decision-making applications.

After the criterion weights presented in Table 1 were determined using the Entropy method, the TOPSIS method was applied based on these weights to calculate the relative health performance of the countries. This method identifies the best alternative as the one closest to the ideal solution and farthest from the negative-ideal solution. Accordingly:

- First, the decision matrix was normalized (Table 2),
- Then, the normalized values were multiplied by the weights obtained through the Entropy method to form the weighted normalized matrix (Table 3),
- Next, for each criterion, the positive ideal (best) and negative ideal (worst) values were determined (Table 4),
- The distances of each country from these ideal points were calculated, and the closeness coefficients (C_i) were computed using the resulting values (Table 5),
- Finally, the countries' overall health system performance levels were ranked based on their C_i values, revealing their relative health performance (Table 6).

Table 1. Criterion Weights Obtained Using the Entropy Method

LEB	IMR	PhysD	HospBeds	CHE%GDP	DTP3
0,002	0,474	0,197	0,179	0,133	0,015

Table 2. Normalization of the Decision Matrix

Countries	LEB	IMR	PhysD	HospBeds	CHE%GDP	DTP3
Türkiye	0.33880	0.39930	0.23000	0.22320	0.15550	0.37590
Albania	0.34950	0.36420	0.19930	0.21720	0.25760	0.36830
Montenegro	0.34070	0.09210	0.29150	0.28440	0.45890	0.30760
Serbia	0.33470	0.19750	0.30110	0.39940	0.40600	0.35320
N. Macedonia	0.33070	0.12290	0.31380	0.31500	0.32020	0.32660
Bosnia-Herzegovina	0.34180	0.23260	0.24590	0.17470	0.36650	0.27720
Moldova	0.31260	0.59240	0.34450	0.42250	0.29250	0.33040
Georgia	0.32710	0.35100	0.59470	0.36880	0.30470	0.33420
Ukraine	0.32240	0.34230	0.31700	0.46730	0.34460	0.31520

Table 3. Weighted Normalized Decision Matrix

Countries	LEB	IMR	PhysD	HospBeds	CHE%GDP	DTP3
Türkiye	0.00068	0.18943	0.04536	0.03986	0.02070	0.00556
Albania	0.00070	0.17277	0.03930	0.03880	0.03429	0.00545
Montenegro	0.00068	0.04371	0.05749	0.05080	0.06108	0.00455
Serbia	0.00067	0.09367	0.05937	0.07133	0.05404	0.00523
N. Macedonia	0.00066	0.05829	0.06188	0.05626	0.04262	0.00483
Bosnia-Herzegovina	0.00068	0.11033	0.04850	0.03120	0.04878	0.00410
Moldova	0.00063	0.28102	0.06794	0.07546	0.03893	0.00489
Georgia	0.00065	0.16653	0.11727	0.06586	0.04055	0.00495
Ukraine	0.00064	0.16237	0.06250	0.08346	0.04587	0.00466

Table 4. Positive and Negative Ideal Solutions

Ülke	LEB	IMR	PhysD	HospBeds	CHE%GDP	DTP3
Positive A^+	0.00070	0.04371	0.11727	0.08346	0.06108	0.00556
Negative A^-	0.00063	0.28102	0.03930	0.03120	0.02070	0.00410

Table 5. Distances of Countries to Positive and Negative Ideals and Closeness Coefficient (C_i)

Countries	S_i^+	S_i^-	C_i
Türkiye	0.17300	0.09200	0.34800
Albania	0.16000	0.10900	0.40700
Montenegro	0.06800	0.24200	0.78000
Serbia	0.07800	0.19600	0.71500
N. Macedonia	0.06600	0.22600	0.77400
Bosnia-Herzegovina	0.11000	0.17300	0.61200
Moldova	0.24400	0.05600	0.18600
Georgia	0.12600	0.14400	0.53400
Ukraine	0.13200	0.13400	0.50500

Table 6. Ranking of Countries Based on Closeness Coefficient

Rank	Countries	Closeness Coefficient (C_i)
1	Montenegro	0.780
2	N. Macedonia	0.774
3	Serbia	0.715
4	Bosnia-Herzegovina	0.612
5	Georgia	0.534
6	Ukraine	0.505
7	Albania	0.407
8	Türkiye	0.348
9	Moldova	0.186

5. Conclusion and Recommendations

The integrated analysis model developed using the Entropy and TOPSIS methods has provided a multidimensional and objective evaluation of the health system performances of European Union candidate countries. In the resulting ranking, Montenegro, North Macedonia, and Serbia occupied the top three positions, while Türkiye was ranked eighth, and Moldova demonstrated the lowest performance. Türkiye's low ranking highlights significant shortcomings in terms of health infrastructure, service delivery capacity, and resource management. Particularly, low physician and hospital bed density, limited health expenditures, and a high infant mortality rate are identified as key weaknesses. On the other hand, Türkiye's high DTP3 immunization coverage and relatively favorable life expectancy compared to some other countries are considered strengths.

To close the performance gap in Türkiye's health system, it is essential to first ensure the effective planning and management of resources. Health workforce recruitment should be increased and medical education capacity expanded to balance the growing workload. Infrastructure deficiencies in rural areas must be addressed, and regional inequalities in access to healthcare should be reduced. Financially, the share of health expenditures in GDP should be increased, with a focus on directing resources toward primary care and preventive services. To lower infant mortality rates, the quality of perinatal care must be improved, and digital monitoring systems should be more widely implemented. In the context of EU harmonization, the integration of digital health systems should be accelerated, and resilience indicators should be aligned with EU standards. Additionally, cooperation with high-performing countries such as Montenegro and North Macedonia should be pursued to develop joint projects in areas such as health technology and workforce training.

The primary limitation of this study stems from the lack of complete data synchronization across countries, which resulted in some indicators reflecting different years. Additionally, the limited number of criteria included in the model and the exclusion of qualitative data—such as quality of healthcare services or patient satisfaction—have narrowed the scope of the evaluation. Future research should consider integrating environmental and socioeconomic factors that influence health systems, such as air pollution and income inequality. To test the model's robustness under uncertainty, sensitivity analyses using methods like Fuzzy TOPSIS or Grey Relational Analysis may also be employed. Particularly in the post-COVID-19 era, examining the resilience performance of health systems within the same methodological framework would contribute meaningfully to the literature. In conclusion, this study objectively identifies Türkiye's position among EU candidate countries and offers a scientific foundation for decision-makers in restructuring health policies, planning infrastructure investments, and allocating resources.

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