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Evaluation of Metropolitan Cities Using Multiple Methods in terms of Healthcare Performance: The Case of Türkiye

(Research Article)

Sağlık Hizmetleri Performansı Açısından Çoklu Yöntemler Kullanılarak Büyükşehirlerin Değerlendirilmesi: Türkiye Örneği

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ABSTRACT

The healthcare sector is one of the most important sectors in a complex situation such as a pandemic, in the treatment of ongoing diseases. This study aims to evaluate healthcare performance of a sample of metropolitan cities in Türkiye. Indicators are divided into various groups, such as healthcare facilities and infrastructure, utilization of healthcare services, human resources for health, and emergency health services. This study used 25 criteria and 30 metropolitan cities to evaluate the 2017-2021 period with the CVM and ELECTRE I method. Comparisons are made using CVM-LOPCOW and ELECTRE I-PROMETHEE II-VIKOR-MCRAT-RAPS-RAMS-RATMI methods. Sensitivity analysis is performed using the weights by the CVM, LOPCOW, CRITIC, SD, Entropy, WENSLO, MEREC, and MEREC-G models. The most important criterion is the average length of stay in hospital (5.6%) among all 25 criteria. Although variables are intended to be used by dividing by population, developed cities stand out depending on their overpopulation. Istanbul has the highest values in many criteria, but it ranks second as it provides health services to more people in terms of population compared to others.

Anahtar Kelimeler:
CVM, ELECTRE I, Sağlık Hizmetleri, ÇKKV

ÖZET

Sağlık sektörü, pandemi gibi karmaşık bir durumda, devam eden hastalıkların tedavisinde en önemli sektörlerden biridir. Bu çalışma, Türkiye'deki büyükehirlerden oluşan bir örneklemin sağlık hizmeti performansını değerlendirmeyi amaçlamaktadır. Göstergeler, sağlık tesisleri ve altyapısı, sağlık hizmetlerinin kullanımı, sağlık için insan kaynakları ve acil sağlık hizmetleri gibi çeşitli gruplara ayrılmıştır. Bu çalışmada 25 kriter ve 30 metropol şehir kullanılarak 2017-2021 dönemi CVM ve ELECTRE I yöntemi ile değerlendirilmiştir. Karşılaştırmalar CVM-LOPCOW ve ELECTRE I-PROMETHEE II-VIKOR-MCRAT-RAPS-RAMS-RATMI yöntemleri kullanılarak yapılmıştır. Duyarlılık analizi, CVM, LOPCOW, CRITIC, SD, Entropy, WENSLO, MEREC ve MEREC-G modelleri ile ağırlıklandırılarak yapılmıştır. 25 kriter arasında en önemli kriter hastanede ortalama kalış süresidir (%5,6). Değişkenlerin nüfusa göre bölünmesi amaçlanmış olsa da, gelişmiş şehirler nüfus fazlalığına bağlı olarak öne çıkmaktadır. İstanbul birçok kriterde en yüksek değerlere sahip olmasına rağmen, diğerlerine kıyasla nüfus bakımından daha fazla kişiye sağlık hizmeti sunduğu için ikinci sırada yer almaktadır.

1. INTRODUCTION

Global life expectancy, which was 46.5 years in 1950, increased to approximately 73.0 years in 2019 and is predicted to reach 77.0 years in 2048, despite the decline caused by the COVID-19 pandemic, as reported by the World Health Organization (WHO, 2023). Providing healthy living conditions for citizens, increasing welfare, enhancing quality health services in a timely and reliable manner, providing access to primary health care services, reducing the risks and costs of services, and improving health outcomes can be counted as some of the leading sustainable development goals considering the contries' long-term plans (Alghawli et al., 2021:81). Ensuring economic development, societies living in prosperity, and a high quality of life of people are related to a healthy population structure of the community (Çağlar and Keten, 2019:43). Health services affect the socio-economic development of society and play an essential role in the lives of people that ensure their existence. The health of society is closely related to the development of the health systems of the countries. Health indicators play a key role in creating health policies and emerge as the basic criteria in performance evaluation (Türkoğlu, 2018:66).

Evaluating the efficiency of health systems is a complex process with some methodological difficulties. The welfare level, socio-economic stability, and productivity level of citizens are constant goals that have become extremely important and necessary in increasing the efficiency of health services for countries with a low or medium human development index. Countries with a high development index are responsible for providing high efficiency and quality in health services (Asandului et al., 2014:262). Health problems, health services, and health possibilities of countries and societies are different from each other. These differences may differ in the countries based on regions, provinces, and smaller settlements. Health services vary by located geography. People with better and worse health tend to cluster in different locations across countries, within countries, and even within local geographies (Murray et al., 2022).

The motivation of this study can be stated as the determination of the metropolitan city to be preferred in a possible health service procurement. This study aimed to investigate healthcare performance at the metropolitan level in Türkiye using the MCDM (Multi Criteria Decision Making) model. The original contributions of this paper to the literature are as follows:

- Evaluating the healthcare performance of metropolitan cities using the large-scale criteria,

- Using the CVM (Coefficient of Variation Method) and ELECTRE I (ÉLimination Et Choix Traduisant la REalité) model,

- CVM-LOPCOW and ELECTRE I-PROMETHEE-VIKOR -MCRAT-RAPS-RAMS-RATMI methods' comparisons,

- Sensitivity analysis used with the ELECTRE I method based on the CVM, LOPCOW, CRITIC, SD, Entropy, WENSLO, MEREC, and MEREC-G models.

The perspective of the study is divided into the following sections: Section 2 reviews the relevant studies through a literature review. Section 3 explained the materials and methods used in the study. In Section 4, the healthcare performance of metropolitan cities is investigated using MCDM methods with a sensitivity analysis. Section 5, presents a discussion and theoretical implications. The conclusion section marked and underlined important implications and suggestions.

2. RELATED WORKS

Healthcare services are vital in people's lives depending on the performance of the facilities offered and the services people receive. Healthcare services may vary depending on the units provided. Various studies have been carried out in the literature in which health services are evaluated according to countries, regions, groups, and cities. Examining these studies contributes to this study.

Tchouaket et al. (2012) evaluated the 27 OECD countries for healthcare system performance and to discern the profiles of the countries by the homogeneity of levels of the performance of their healthcare systems. Şantaş and Şantaş (2018) ranked OECD countries, and regions and provinces of Türkiye into health-related variables, such as health status, healthcare infrastructure, and healthcare utilization. Japan ranks first in health status, use of health services, and in the general category in the ranking of OECD countries in terms of health indicators. Switzerland and Spain follow Japan. Saygın and Kundakcı (2020) evaluated 36 OECD member countries via WASPAS and CODAS methods in terms of health indicators, such as health expenditures, number of hospital beds, number of doctors, number of nurses, life expectancy, infant mortality rates, medical technology, and medical graduates. Murat and Güzel (2023) ranked SAARC and OECD countries according to total, public, and private health expenditures, infant mortality rate, GDP per capita, life expectancy at birth, and mortality rate as the variables affecting health performance.

In the literature, there are studies conducted specifically for the OECD as well as studies conducted specifically for the EU (European Union), G20 (Group of 20), and other countries. Wilkinson et al. (2009) establish the availability of health data and develop a comparison of health indicators in 23 EU member states. Lorcu and Bolat (2012) examined 28 EU candidate, member, and former member countries with logistic regression and discriminant analysis in terms of basic health indicators. Asandului et al. (2014) evaluated the efficiency of public healthcare systems in 30 EU states by DEA. The findings reveal that there are many developed and developing countries at the efficiency frontier, while the majority of the countries in the sample are not efficient. Türkoğlu (2018) ranked 26 EU countries' health indicators for the period 2010-2014 using the TOPSIS method. Norway, Luxembourg, Austria, Sweden, and Germany took the first place in this ranking. Kalhor et al (2016) ranked the countries of the Eastern Mediterranean region according to their health impact indicators with the combination of TOPSIS-AHP. The most important indicator infant mortality rate and, less important than the others, the life expectancy at age 60 indicator were found. Bahrain was found first and Somalia last. Pan et al (2022) used AHP, Entropy, and TOPSIS to determine the performance of the public health system, develop containment policies and recommendations, improve the public health system, and evaluate the performance of governments against COVID-19 using the 15 indicators.

Nasser et al. (2019) ranked 16 selected governorates in Yemen according to health services and availability with 6 criteria and a decision-making system based on Statistical Variance Procedure. Seo and Takikawa (2022) multiple regression analysis was performed and examined the change in national health expenditure and health system performance in central cities and suburbs of Japan. Risk factors for health were high in the central cities while the others were superior in the suburbs. Ritmak et al (2022) examined Khon Kaen, a province in the northeastern part of Thailand, with a combination of AHP-TOPSIS according to 45 indicators in the framework of health, economy, society, and environment.

Çağlar and Keten (2019) developed an index that compares the health indicators of 81 provinces in Türkiye, such as infrastructure, human resources, service, and health indicators. Eren and Ömürbek (2019) divided 81 provinces from Türkiye into regions in terms of 22 health variables and evaluated their performance, and then ranked the clusters with the CRITIC and MULTIMOORA methods. Ömürbek et al (2021) evaluated the efficiency of 81 provinces in Türkiye in terms of health indicators by using the Entropy-based Data Envelopment Analysis method, using nine input and seven output variables for the years 2014-2018. Keleş (2023a) ranked the 81 provinces of Türkiye according to 21 criteria in terms of health services with MCDM methods and found the rate of qualified beds and the number of assistant physicians in the first.

Previous studies differ via regions, countries and groups, and also according to the period in which the data is used. Health services differ not only by countries but also by cities. Cities are in demand by the citizens living in that country according to their size and the accessibility of the services they provide. Along with socio-economic factors, health services have an important place in the lives of citizens. With the revolutionary developments in health services in recent years, Türkiye has started to be preferred more in terms of the health services it offers in the countries of the region, European countries and throughout the world. Health care costs and past health experience play an important role in Türkiye's preference over other countries.

3. MATERIAL AND METHODS

Various MCDM methods can be used to evaluate the healthcare performance and effectiveness of metropolitan cities. The stages followed in the evaluation of healthcare in this study can be expressed simply. The procedure of the study is displayed in the following chart.

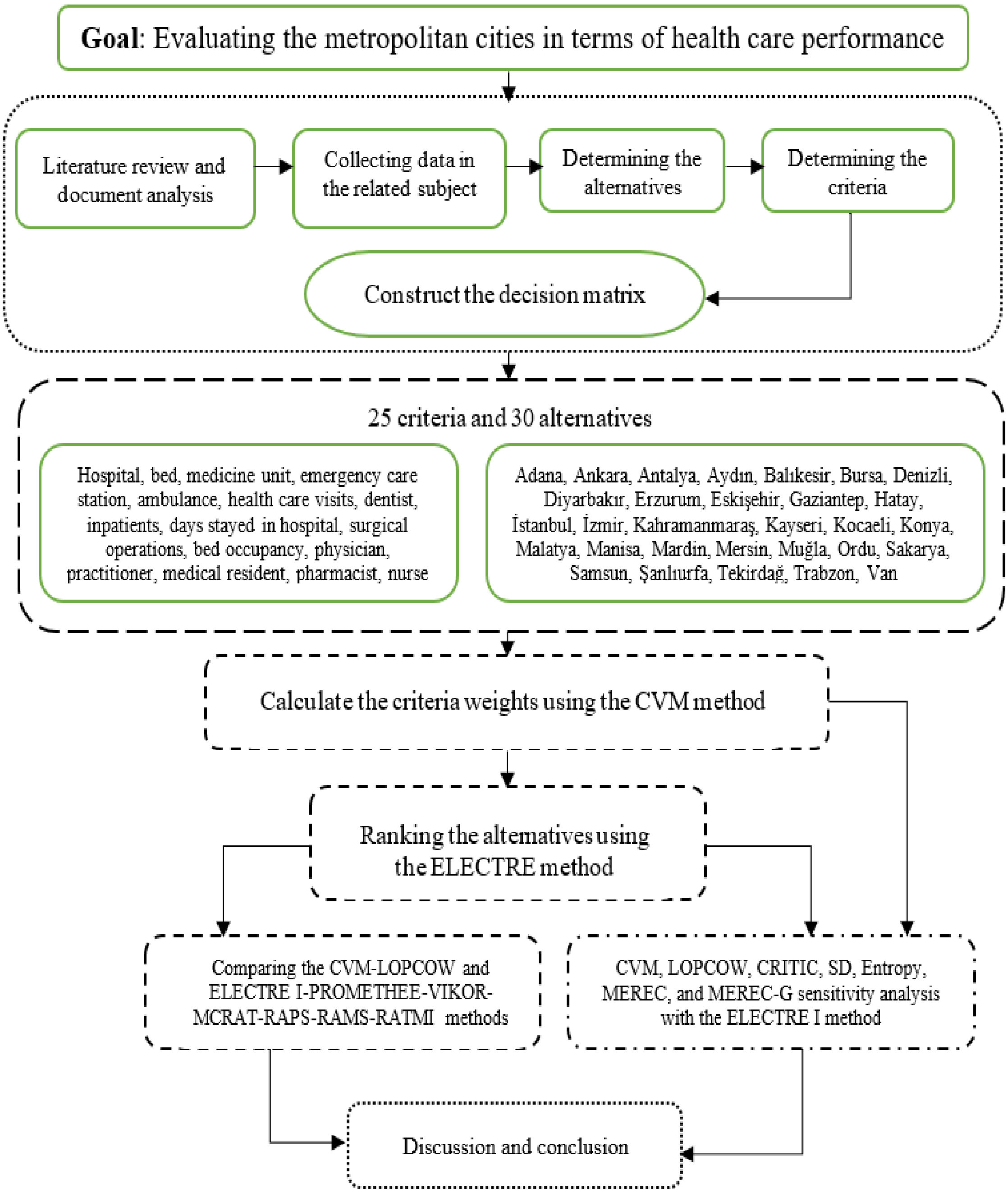

Chart 1. The Flowchart of the Paper

A literature review is made and criteria are defined. This study determined the weights of the healthcare performance criteria and evaluated the alternatives. Legal institutions use indicators divided into various groups to evaluate healthcare services, such as health care facilities and infrastructures, utilization of health care services, human resources for health, emergency health services. Some of these, such as the number of hospitals and beds, are considered to have an important place in health services. Thus, some variables are also affected such as the qualified beds, intensive care unit beds, bed occupancy rates, length of stay in hospital, bed turnover rate, healthcare facility visits, and healthcare personnel per capita in the population. A wide variety of indicators/criteria can be used under the specified groups. These criteria are presented in Table 1.

Table 1. Listed Criteria Related to Health Performance

No	Criterion	Type			Type
C1	Number of Hospital	max.	C11	Number of Inpatients	min.
C2	Number of Bed	max.	C12	Number of Days Stayed in Hospital	min.
	Number of Hospital Bed per 10.000 Population		C13	Number of Surgical Operation	min.

C3	Number of Qualified Bed	max.		C14	Bed Occupancy Rate		min.
C4	Number of Intensive Care Unit Bed	max.		C15	Average Length of Stay in Hospital		min.
	Proportion of Qualified Bed (Intensive care unit beds are not included.)			C16	Bed Turnover Rate in Hospital		min.
	Intensive Care Unit Bed per 10.000 Population			C17	Bed Turnover Interval in Hospital		min.
C5	Number of Family Medicine Unit	max.			Crude Death Rate in Hospital		
	Population per Family Medicine Unit			C18	Specialist Physician	max.	
C6	Number of 112 Emergency Care Station	max.		C19	General Practitioner	max.	
	Population per 112 Emergency Care Station			C20	Medical Resident	max.	
C7	Number of 112 Emergency Care Ambulance	max.		C21	Dentist	max.	
	Population per 112 Emergency Care Ambulance			C22	Pharmacist	max.	
C8	Primary Health Care Facilities Visits		min.	C23	Nurse	max.	
C9	Secondary and Tertiary Health Care Visits		min.	C24	Midwife	max.	
C10	Number of Dentist Visits		min.	C25	Other Health Personnel	max.	

There are a total of 32 variables to be able to evaluated according to various alternatives, but since some of these criteria were derived from other relevant criteria and were similar to each other, only 25 of them were used in this study. In particular, the number of hospitals, beds, and healthcare workers is expected to be the highest to provide more health services. In this case, health services per capita are positively affected and more comprehensive services can be provided. On the other hand, considering that metropolitan cities can benefit more from healthcare services, 81 cities alternatives evaluated within the scope of only 30 metropolitan cities. These 30 metropolitan cities cover approximately 77% of the country's population (TUIK, 2025).

By the way, MCDM occurs when more than one alternative is to be evaluated for more than one criterion. There are various MCDM models in the literature. The CVM method can be used to determine criterion weights as a measure derived from probability theory and statistics. Computational difficulties arising from the sizes of different indexes can be eliminated in order to reduce the influence of subjective factors on decision results by using the fluctuation degree of each index (Wang et al., 2019:624). The CVM method has been used in various studies in the literature and the studies are presented in Table 2.

Table 2. CVM Method Studies

Researcher/s / Year	Method/s	Research subjects
Chen et al., 2019	TOPSIS, CVM	Explained the problems of the TOPSIS method
Sun et al., 2019	CVM	Assessing the influence of land use on groundwater pollution
Wang et al., 2019	The coefficient of variation and composite index method	The status, opportunities, and challenges of China's "going out" of power technology and equipment
Ma et al., 2020	Entropy, CVM	Building forest management decision model
Wu et al., 2020	CVM	Measuring the extent of decentralization for Bitcoin and Ethereum
Chen et al., 2021	Entropy, CVM	Food supply system analysis and information system establishment
Groenendijk et al., 2021	CVM	Multi-loss weighting
Feng et al., 2022	TOPSIS, AHP, CVM	Water allocation model
Long et al., 2022	The coefficient of variation grey correlation method	Urban water environment carrying capacity
Zhou et al., 2023	Entropy, CVM	Risk classification of light pollution in different regions

The basic idea and advantage of the CVM method is to evaluate the mean and standard deviation together, and to assign more weight to the criteria with low variation for criteria that are incomparable or difficult to compare. The CVM method has basic and very short steps. First, construct the decision matrix $R = \{r_{ij}\}$, where, where rij is the value of the jth attribute of the ith alternative; i = 1, 2, … m; j = 1, 2,…, n.

$$CoV_j = \frac{\sqrt{\frac{\sum_{i=1}^{m}(r_{ij}-\overline{r_j})^2}{m-1}}}{\overline{r_{ij}}} 100 \quad \text{(i=1,2,…m; j=1,2…n)} \qquad (1)$$

To assign the highest value to the criterion with the lowest variation, the calculation is made by taking the inverse of the variations.

$$w_j = \frac{\frac{1}{CoV_{ij}}}{\sum_{i=1}^{n} \frac{1}{CoV_{ij}}} \quad (2)$$

The decision matrix is created and the criteria are normalized. Then, the mean and standard deviation of each criterion are calculated and proportioned to each other. Finally, criteria weights are found.

On the other hand, the history of the ELECTRE I (ELECTRE) method dates back almost half a century. It is a very powerful method that compares alternatives in pairs against each other. The ELECTRE method evaluates the alternatives according to their superiority, inferiority, and dominance of each other in pairs. ELECTRE as a ranking MCDM method is a kind of analytical method in limited problems and has a simple and clear logical relation in a decision matrix (Ka, 2011:340). The ELECTRE method facilitates the interpretation of the results for the decision-maker and is advantageous because it is a stable method (Vysochan et al., 2022:447). The ELECTRE method provides the advantage of a robust comparison based on pairwise superiority comparisons between alternative decision points for each evaluation factor (Güler et al., 2023:361). By using the ELECTRE method, decision-makers can include many quantitative and qualitative criteria in the decision-making process (Uysal and Yavuz, 2014:281). The ELECTRE method begins with the creation of a decision matrix expressing the criteria and alternatives. Then, the decision matrix is converted into a utility matrix through utility functions (Carra et al., 2022:451). The ELECTRE method is simply based on pairwise comparison, concordance, discordance, and dominance. ELECTRE method calculation stages can be performed according to Table 3.

Table 3. ELECTRE I Method

No	Process	Description
1	$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{ij}^2}}, i = 1,2,\ldots m; j = 1,2,\ldots n$ $r_{ij} = \frac{\frac{1}{a_{ij}}}{\sqrt{\sum_{k=1}^{m} \left(\frac{1}{a_{ij}}\right)^2}}, i = 1,2,\ldots m; j = 1,2,\ldots n$	a_{ij} is the value of the j_{th} attribute of the i_{th} alternative **(i=1,2,…m; j=1,2…n)** Criteria are normalized.
2	$V = r_{ij}w_j, i = 1,2\ldots, m; j = 1,2,\ldots n$	The weighted decision matrix is created by multiplying the weights (w_j) of the criteria with the normalized matrix (r_{ij}).
3	$C_{kl} = \{j, v_{kj} \geq v_{lj}\}, j = 1,2,\ldots n$ $D_{kl} = \{j, v_{kj} < v_{lj}\}, j = 1,2,\ldots n$	Concordance and discordance sets are created by comparing alternatives.
4	$c_{kl} = \sum_{j \in c_{kl}} w_j$ $d_{kl} = \frac{max_{j \in D_{kl}} \lvert v_{kj} - v_{lj} \rvert}{max_j \lvert v_{kj} - v_{ij} \rvert}$	Concordance and discordance interval/index matrices are calculated.
5	$\underline{c} = \frac{1}{m(m-1)} \sum_{k}^{m} \sum_{l}^{m} c_{kl}$ $\underline{d} = \frac{1}{m(m-1)} \sum_{k}^{m} \sum_{l}^{m} d_{kl}$	Net superiority and net inferior values are created. The rankings of the alternatives are performed by calculating the net superiority and net inferior values. Net superiority values are ranked from largest to smallest, net inferior values are ranked from smallest to largest.

The ELECTRE method has been used in various different studies in the literature. Literature review of the ELECTRE method is presented in Table 4.

Table 4. ELECTRE Method Literature

Researcher/s / Year	Method/s	Research subjects
Ka, 2011	F-AHP, ELECTRE I	Dry port location selection
Uysal and Yavuz, 2014	ELECTRE	Selection of logistics centre location
Kadziński and Ciomek 2016	ELECTRE, PROMETHEE	Preference modeling and robustness analysis
Carra et al., 2022	AHP, ELECTRE	A cycling path selection for sustainable tourism
Orhan et al., 2022	ENTROPY, ELECTRE, TOPSIS	Identification of important areas for rehabilitation in waste-water systems
Vysochan et al., 2022	ELECTRE	Evaluation of innovative projects
Güler et al., 2023	SWARA, ELECTRE	Earthquake risk prioritization

Işık, 2023	AHP, ELECTRE, TOPSIS	Determining alternative crops within the land risk criteria
Kaplan et al., 2023	ELECTRE, TOPSIS	Analysis of financial performances of banks during the Covid-19 pandemic
Rocha, 2023	AHP, ELECTRE I	Health and safety problems

Although there are various methods belonging to the ELECTRE outranking family, only the ELECTRE I method is emphasized in this study since the ELECTRE method offers an effective and robust ranking result.

4. RESULTS WITH EVALUATIONS, AND COMPARISONS

4.1. Evaluating the Metropolitan Cities Using MCDM Methods

The research covers the years 2017-2021, covering the period before and after COVID-19 (HSY, 2023). Criteria weights are presented in table 5 using the CVM method, and differences in the criteria belonging to different years can be examined better in the figure 1.

Table 5. Criteria Weights

	2017	2018	2019	2020	2021		2017	2018	2019	2020	2021
C1	0.036	0.039	0.041	0.040	0.039	C14	0.034	0.035	0.033	0.036	0.036
C2	0.035	0.037	0.038	0.037	0.039	C15	0.057	0.058	0.056	0.055	0.056
C3	0.033	0.034	0.036	0.036	0.035	C16	0.044	0.044	0.045	0.041	0.042
C4	0.042	0.047	0.049	0.047	0.047	C17	0.051	0.047	0.054	0.051	0.049
C5	0.030	0.035	0.030	0.031	0.031	C18	0.032	0.034	0.033	0.035	0.034
C6	0.030	0.033	0.034	0.029	0.029	C19	0.046	0.037	0.033	0.034	0.030
C7	0.032	0.029	0.034	0.034	0.032	C20	0.031	0.032	0.034	0.029	0.029
C8	0.037	0.038	0.035	0.044	0.040	C21	0.034	0.037	0.041	0.040	0.039
C9	0.041	0.037	0.039	0.042	0.041	C22	0.060	0.048	0.047	0.045	0.048
C10	0.042	0.042	0.044	0.058	0.072	C23	0.029	0.038	0.037	0.032	0.035
C11	0.048	0.035	0.035	0.037	0.033	C24	0.034	0.039	0.040	0.039	0.040
C12	0.055	0.058	0.053	0.049	0.048	C25	0.040	0.045	0.045	0.045	0.042
C13	0.047	0.042	0.034	0.036	0.033	Total	1.000	1.000	1.000	1.000	1.000

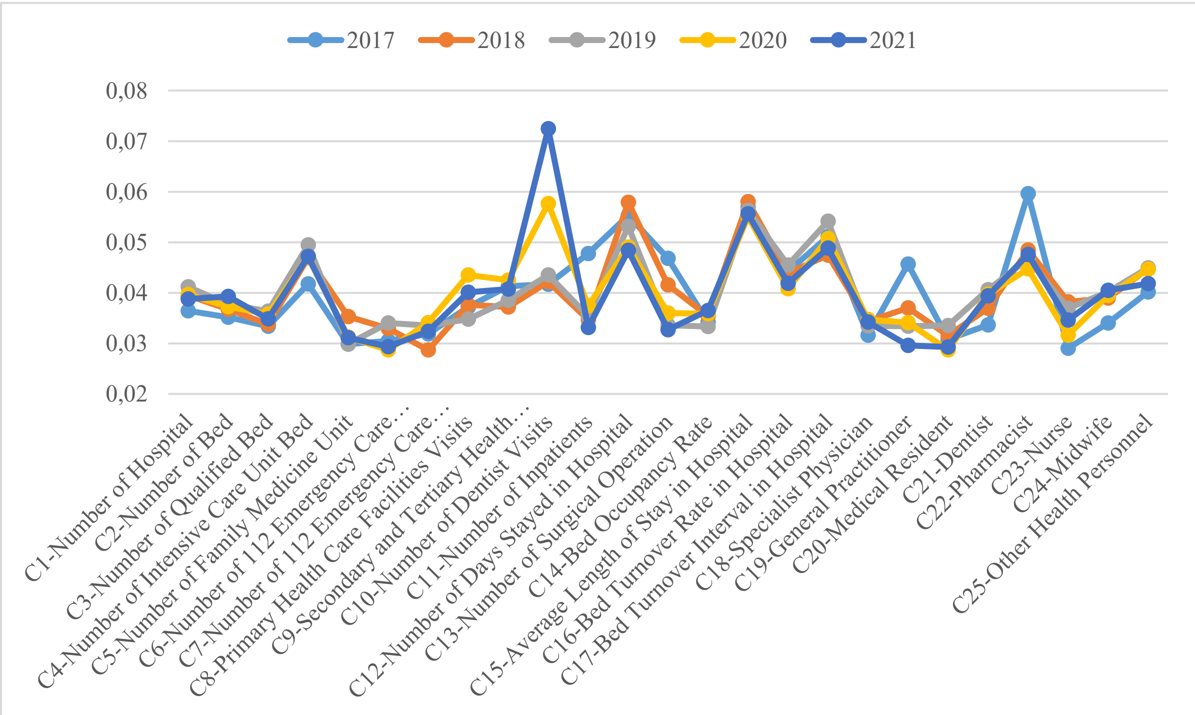

Figure 1. Criteria Weights of Different Years

Among all criteria, the most important criterion is the C15-Average Length of Stay in Hospital (5.6%). Then, C12-Number of Days Stayed in Hospital (5.3%), C10-Number of Dentist Visits (5.1%), C17-Bed Turnover Interval in

Hospital (5.0%) are found, respectively. Indeed, it can be said that the average length of stay and number of days stayed in the hospital have an essential place in the hospital environment for healthy individuals in healthcare services. On the other hand, the less important criterion is the C20-Medical Resident (3.1%) compared to the others. Since the CVM method finds the criterion weights more reasonable, there is little difference between the highest and lowest criterion weights. Although Medical Resident criterion is found to be the least important, this criterion is only about 2% less important than the others. The C12-Number of Days Stayed in Hospital (5.3%) criterion has the least variability (2.039) in the evaluation made among the criteria weights according to the last 5 years. The C10-Number of Dentist Visits (5.1%) criterion has the most variability (26.097), compared to the last 5 years and this criterion ranked first in 2021 with a weight of 7.2%.

The weights of 25 criteria are found using the CVM method, and then the ELECTRE method compares the alternatives with their rank using the properties. When applying the ELECTRE method stages, alternative metropolitan cities are ranked by the 2017-2021 period.

Table 6. Ranked of Alternatives Using ELECTRE

	2017	2018	2019	2020	2021	R		2017	2018	2019	2020	2021	R
Adana	9	10	5	7	5	7	Kayseri	14	7	8	8	12	10
Ankara	1	2	1	1	1	1	Kocaeli	21	28	25	27	29	28
Antalya	3	3	3	3	4	3	Konya	6	8	6	5	7	5
Aydın	11	13	23	29	27	21	Malatya	8	5	6	9	11	8
Balıkesir	13	17	21	18	15	15	Manisa	21	27	28	20	25	25
Bursa	9	11	11	12	13	12	Mardin	28	25	29	24	20	27
Denizli	19	13	18	26	18	18	Mersin	7	6	9	5	6	6
Diyarbakır	20	20	20	13	8	13	Muğla	4	8	10	11	10	9
Erzurum	14	16	13	14	24	13	Ordu	25	29	24	22	23	26
Eskişehir	30	19	14	16	15	18	Sakarya	27	26	27	27	25	29
Gaziantep	26	17	22	24	19	23	Samsun	16	22	19	18	21	20
Hatay	23	24	17	17	27	23	Şanlıurfa	23	22	15	15	14	16
Istanbul	1	1	2	1	2	2	Tekirdağ	29	30	30	30	30	30
Izmir	4	4	4	4	3	4	Trabzon	12	12	12	9	9	11
Kahramanmaraş	18	20	26	23	17	22	Van	17	15	16	20	21	16

Ankara (capital) is always in the first rank, except for 2018. Istanbul, Antalya and Izmir follow respectively. It should be said that the largest cities, compared to the country, have essential contributions to health services. The metropolitan city of Tekirdağ is always in the last rank except for 2017. It is seen that population size is an essential factor in the ranking of alternatives, but it does not exactly affect the ranking.

4.2. Comparisons by Different MCDM Methods

Comparisons and evaluations are performed to test the validity of existing methods by using different MCDM methods, which represents a broad contribution to the relevant literature. Firstly, the CVM and LOPCOW methods were compared for criteria weighting results.

Table 7. Criteria Weights by CVM and LOPCOW Methods-2021

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
CVM	0.039	0.039	0.035	0.047	0.031	0.029	0.032	0.040	0.041	0.072	0.033	0.048	0.033
LOPCOW	0.039	0.040	0.035	0.048	0.031	0.029	0.032	0.041	0.041	0.067	0.033	0.049	0.033
	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	Total
CVM	0.036	0.056	0.042	0.049	0.034	0.030	0.029	0.039	0.048	0.035	0.040	0.042	1.000
LOPCOW	0.037	0.055	0.042	0.049	0.034	0.029	0.029	0.040	0.048	0.035	0.041	0.042	1.000

Very similar weights (correlation r (25) = 0.994 $p<0.01$) are obtained when the CVM method is compared with the LOPCOW method. The same similarity is valid for all years (2017, 2018 and 2020 r=0.998, 2019 r=0.999).

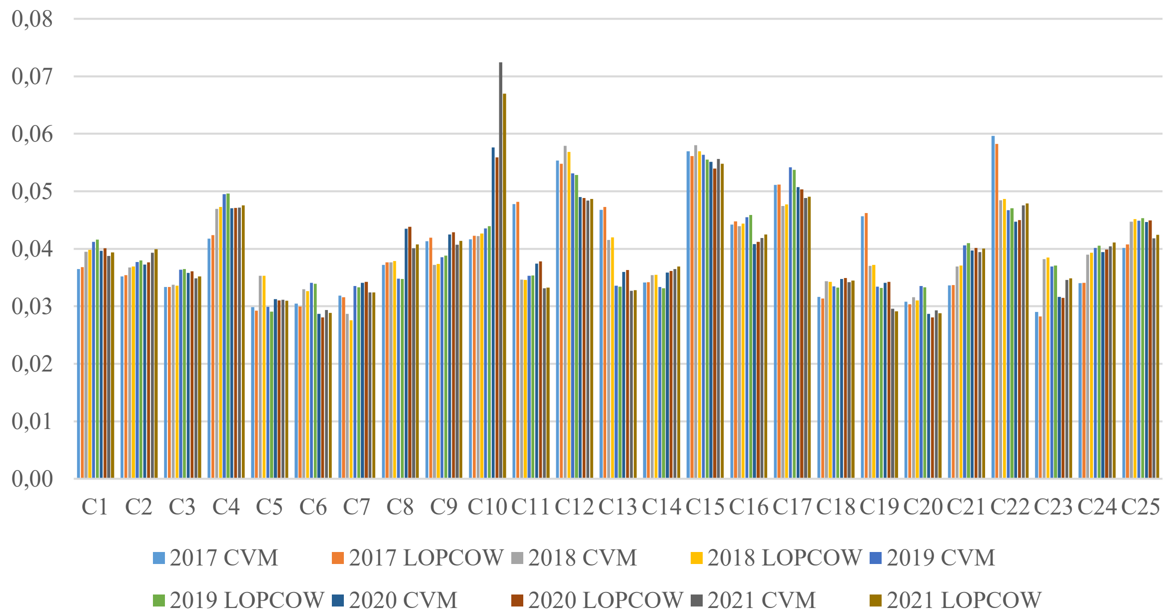

Figure 2. Criteria Weights by CVM and LOPCOW Methods

In the figure, it is seen that the C10-number of dentist visits criterion stands out from the others in 2019, 2020, and 2021, the C22-pharmacist criterion stands out in 2017 and 2018, the C15-average length of stay in hospital and the C12-number of days stayed in hospital criterion always have high levels of criterion weight.

Comparisons can be made with different MCDM methods in the problem where the criteria weights are similar. PROMETHEE-VIKOR-MCRAT-RAPS-RAMS-RATMI methods can be used to compare with the ELECTRE. The PROMETHEE II method can be preferred because it is a powerful and well-known pairwise ranking method. The VIKOR method offers a compromise ranking by including maximum group benefit and individual regret (Wu et al., 2022:560). MCRAT (multiple criteria ranking by alternative trace) and RAPS (ranking the alternatives by perimeter similarity) are two very new methods that rank alternatives (Urošević et al., 2021). Also, RAMS (ranking the alternatives by median similarity) and RATMI (ranking the alternatives using the trace to median index) are newly introduced ranking methods (Abdulaal and Bafail, 2022; Abdulaal et al., 2023).

Table 8. Ranked of Alternatives Using Different MCDM Methods-2021

	ELECTRE	PROMETHEE	VIKOR	MCRAT	RAPS	RAMS	RATMI
A1	5	16	18	10	11	11	11
A2	1	1	1	2	2	2	2
A3	4	3	2	6	7	8	7
A4	27	21	15	24	24	24	24
A5	15	10	7	13	12	12	12
A6	13	12	11	27	27	27	27
A7	18	24	23	22	20	20	20
A8	8	11	12	11	14	14	14
A9	24	18	30	9	8	6	8
A10	15	19	20	14	10	9	9
A11	19	22	19	28	28	28	28
A12	27	13	9	25	26	26	26
A13	2	2	5	1	1	1	1
A14	3	4	3	12	13	13	13
A15	17	20	16	20	21	21	21
A16	12	14	8	21	18	17	18
A17	29	26	22	30	30	30	30
A18	7	7	4	16	16	16	16
A19	11	9	14	7	6	5	6

A20	25	17	10	23	25	25	25
A21	20	30	29	15	15	15	15
A22	6	8	6	4	4	7	4
A23	10	5	17	3	3	3	3
A24	23	15	21	8	9	10	10
A25	25	27	26	18	19	22	19
A26	21	23	25	26	23	18	23
A27	14	29	28	17	17	19	17
A28	30	28	24	29	29	29	29
A29	9	6	13	5	5	4	5
A30	21	25	27	19	22	23	22

Since the most current data is for 2021, only the rankings obtained with different MCDM methods for 2021 are given here. Different alternative ranking methods give different results. This diversity can be explained as a strength of MCDM methods. The ELECTRE method was compared with other (powerful, known, and newest) MCDM methods. The A2 alternative in the ELECTRE method was also found in the first rank with the PROMETHEE and VIKOR methods and was found second rank by the MCRAT, RAPS, RAMS, and RATMI methods. The A13 alternative was found in the second rank in the PROMETHEE method as in the ELECTRE method, but it was found in the first rank in the MCRAT, RAPS, RAMS, and RATMI methods. Similar findings apply not only to 2021 but also to other years. When the relationships of different methods according to different years were examined, mostly moderately significant correlations were detected between the methods.

Table 9. Correlations by Different MCDM Methods-2021

	ELECTRE	PROMETHEE	VIKOR	MCRAT	RAPS	RAMS	RATMI
ELECTRE	1.000						
PROMETHEE	0.765	1.000					
VIKOR	0.643	0.857	1.000				
MCRAT	0.717	0.689	0.359	1.000			
RAPS	0.715	0.675	0.339	0.984	1.000		
RAMS	0.701	0.678	0.322	0.957	0.987	1.000	
RATMI	0.718	0.673	0.340	0.982	1	0.988	1.000

The PROMETHEE method was found to give similar findings to the ELECTRE method. The ELECTRE-PROMETHEE correlation (r=0.765) is moderately strong, significant, and positive. Similar grades of correlations are valid not only for 2021 but also for other years (ELECTRE-PROMETHEE correlation: 2017 r=0.871, 2018 r=0.853, 2019 r=0.793, 2020 r=0.861). Another striking finding here and in other years is that the correlations of the RATMI method with the MCRAT, RAPS, and RAMS methods are quite high.

4.3. Sensitivity Analysis with a Large-Scale Decision Matrix

In the literature, sensitivity analysis models are mostly used in which the criterion weights are changed and the alternatives are ranked accordingly (Liu and Wan, 2019; Uddin et al., 2019; Qu et al., 2020). In this study, sensitivity analysis was carried out using the weights obtained by the LOPCOW method along with the CVM method, as well as different models (CRITIC, SD, Entropy, WENSLO, MEREC, MEREC-G weights).

Different criterion weights were found and presented via the decision matrix for 2021, which has the most up-to-date data according to the scenarios determined at the beginning.

Table 10. Criteria Weights by Determined Scenarios-2021

	CVM	LOPCOW	CRITIC	SD	ENTROPY	WENSLO	MEREC	MEREC-G
C1	0.039	0.039	0.037	0.041	0.024	0.026	0.042	0.027
C2	0.039	0.040	0.034	0.043	0.021	0.024	0.039	0.023
C3	0.035	0.035	0.037	0.040	0.027	0.027	0.039	0.025
C4	0.047	0.048	0.041	0.039	0.016	0.015	0.041	0.023
C5	0.031	0.031	0.042	0.039	0.001	0.001	0.006	0.061
C6	0.029	0.029	0.043	0.037	0.024	0.021	0.029	0.029
C7	0.032	0.032	0.044	0.036	0.031	0.027	0.039	0.031

C8	0.040	0.041	0.045	0.037	0.013	0.013	0.022	0.036
C9	0.041	0.041	0.044	0.039	0.003	0.003	0.011	0.051
C10	0.072	0.067	0.034	0.050	0.025	0.033	0.047	0.027
C11	0.033	0.033	0.056	0.031	0.015	0.012	0.020	0.039
C12	0.048	0.049	0.045	0.040	0.025	0.025	0.035	0.030
C13	0.033	0.033	0.052	0.035	0.021	0.017	0.024	0.040
C14	0.036	0.037	0.044	0.036	0.100	0.078	0.051	0.048
C15	0.056	0.055	0.038	0.043	0.111	0.111	0.070	0.064
C16	0.042	0.042	0.041	0.038	0.110	0.094	0.059	0.052
C17	0.049	0.049	0.043	0.039	0.130	0.109	0.070	0.067
C18	0.034	0.034	0.031	0.044	0.032	0.037	0.042	0.020
C19	0.030	0.029	0.046	0.036	0.007	0.006	0.014	0.046
C20	0.029	0.029	0.029	0.048	0.168	0.218	0.111	0.135
C21	0.039	0.040	0.033	0.042	0.034	0.035	0.054	0.033
C22	0.048	0.048	0.035	0.040	0.011	0.011	0.032	0.017
C23	0.035	0.035	0.035	0.040	0.018	0.018	0.029	0.026
C24	0.040	0.041	0.037	0.043	0.021	0.023	0.041	0.026
C25	0.042	0.042	0.033	0.043	0.014	0.016	0.032	0.022

The CVM method has high correlations with the LOPCOW (r=9.994) and SD (r=0.498) method weights. Although the criterion weights differ, close weights were obtained usually. Sensitivity analysis uses the criteria weights obtained by the determined scenarios for the ELECTRE method and examines the changes in the results of this study.

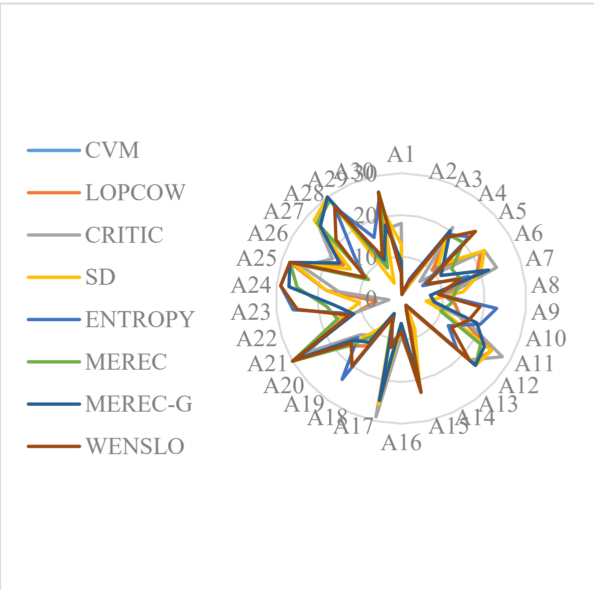

Figure 3.1. ELECTRE Net Superiority Values

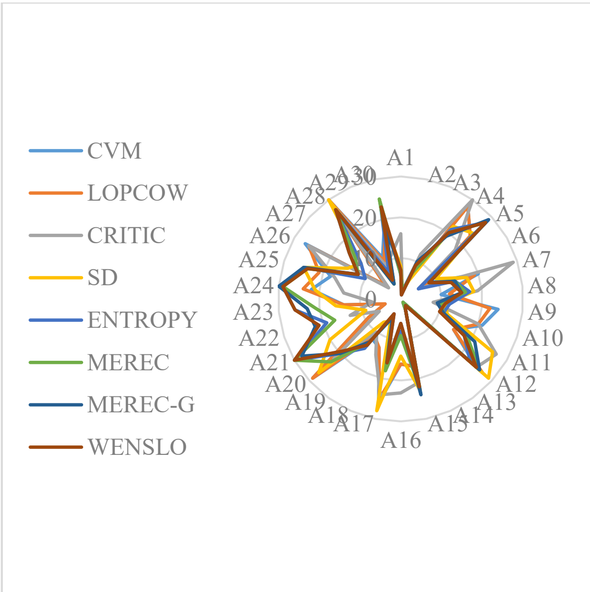

Figure 3.2. ELECTRE Net Inferior Values

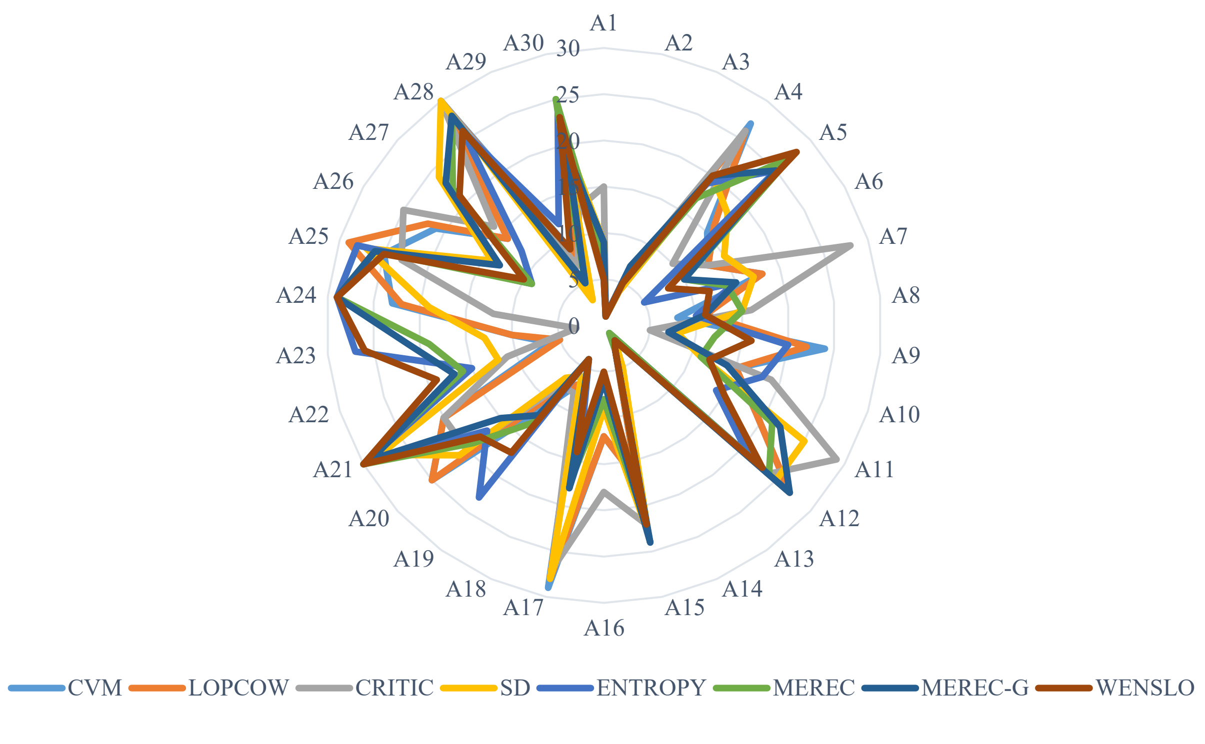

Figure 4. Sensitivity Analysis with Different Models

Sensitivity analysis was performed by eight different criterion weighting models used as data for the ELECTRE method. Even if different criteria weights were used, almost the same ranking was always obtained according to net superior values, and the same is true for net inferior values. Ankara came first, followed by Istanbul, in the net superior in all models. On the other hand, Istanbul came first, followed by Ankara and Izmir, in the net inferior in all models. However, Ankara was ranked first, followed by Istanbul, Izmir, and Antalya when net superior, net inferior, and total dominance scores were used separately. The following rankings differ from each other within themselves. An important finding is that even if the criteria weights change, it doesn't affect the ranking results.

5. DISCUSSION AND THEORETICAL IMPLICATIONS

Comparing this study with some studies investigating health services in the literature adds a difference to the study and literature. There are studies that use different alternatives and evaluate performance using various variables. Wilkinson et al. (2009) made an evaluation based on the presence of only six indicators, Asandului et al. (2014) used three input and three output variables, Kalhor et al (2016) used AHP with only six indicators, Türkoğlu (2018) used only eight criteria without giving their weights, Saygın and Kundakcı (2020) used only eight criteria, Murat and Güzel (2023) used only seven criteria. Şantaş and Şantaş (2018) ranked all provinces in Türkiye with descriptive statistical methods and factor analysis using 14 variables, but although a more limited number of alternatives were used in the current study, it can be said that the opposite ranking was obtained with this study. Although the reason for this was shown as the ratio of health variables to provincial populations in comparison with another study, the current study followed a similar direction. Instead of this, it can be better explained by the methods used causing the difference. Çağlar and Keten (2019) used 23 variables from a similar source with a linear programming-based model in the ranking of 81 provinces, since different evaluation models were used, no similarity was found with the combined ranking. Eren and Ömürbek (2019) used 22 health variables, and a moderate correlation (CVM-CRITIC r=0.385) was found with 16 criteria that were similar to the study. Pan et al. (2022) found hospital beds (per thousand) to be the most important criterion in the AHP and AHP-Entropy combined, and this criterion also has an important place in the current study. Keleş (2023b) used 21 criteria and 81 city alternatives. Although the criteria weights are different, similar alternatives have almost similar rankings, and the BORDA-ELECTRE correlation (r(30)=0.616) is moderately strong. Since the data used in the study is based on the source of the Türkiye Ministry of Health, it is difficult to compare criteria and alternatives with studies conducted in different countries. Therefore, a comprehensive and generalizing comparison could not be made. However, it should be said that partly similar and partly different findings were obtained when the comparison with the existing literature.

On the other hand, since the first cases of COVID-19 appeared three years ago, more than 759 million confirmed cases of COVID-19 and approximately 6.9 million reported COVID-19 deaths worldwide have been reported by the World Health Organization by March 2023. The importance of the health sector's unprecedented necessity and accessibility has been understood even more due to the worldwide pandemic. The actions to be taken against the suddenly emerging COVID-19 have revealed the preparedness of the health system and the adequacy of its capacity. The development of the health system is shaped according to the health indicators presented. The responsibility of the public authority towards its citizens is to build appropriate hospitals and equip hospitals in accordance with health requirements in order to provide the health system in the most appropriate way.

The benefits of health services to individuals and society vary from province to province, but what is expected is to eliminate inequalities in access to health services. Although the variables used are intended to be obtained by dividing the population, developed cities stand out in this study depending on their population levels. However, the public authority must provide health services with similar characteristics to the entire population, taking into account the needs of society. This study, covering the years 2017–2021, provides a comprehensive evaluation of the healthcare service performance of metropolitan cities in Türkiye, encompassing both the pre- and post-COVID-19 periods. The capital, Ankara, ranked first in all years except 2018, followed by Istanbul, Antalya, and Izmir. This outcome highlights the significant role metropolitan cities play in shaping the overall health service landscape in the country. Conversely, Tekirdağ consistently ranked last in almost every year, drawing attention to regional disparities. While population size is an important factor influencing the rankings, it is not the sole determinant. The findings suggest that metropolitan cities hold a stronger position in terms of health system accessibility and adequacy, especially in the aftermath of the pandemic. This situation underscores the responsibility of public authorities to ensure equitable and appropriate healthcare services for all citizens, even though health services in more developed provinces tend to stand out in population-based evaluations.

6. CONCLUSION

Different MCDM models can give different results. This study uses more than one MCDM method in various analyses, and the findings are diversified. In this study, 25 criteria were defined and their weights were found by the CVM method. The CVM-LOPCOW comparison has shown that the methods are interchangeable as similar findings are obtained. 30 metropolitan cities were ranked with the ELECTRE I method and comparisons were made using the PROMETHEE-VIKOR-MCRAT-RAPS-RAMS-RATMI methods. Ankara which is the capital city was found first rank by the ELECTRE, PROMETHEE, and VIKOR methods and was found second rank by the MCRAT, RAPS, RAMS, and RATMI methods. On the other hand, Istanbul was found in the second rank in the PROMETHEE method as in the ELECTRE method, but it was found in the first rank in the MCRAT, RAPS, RAMS, and RATMI methods. The metropolitan city of Tekirdağ was always in the last rank except for 2017. It is understood that population size is an essential factor in the ranking of alternatives, but it does not exactly affect the ranking. Similar and interrelated results were obtained when different methods were used. Sensitivity analysis was performed using the weights by the CVM, LOPCOW, CRITIC, SD, Entropy, WENSLO, MEREC, and MEREC-G models for the ELECTRE I method. The ELECTRE method has been successfully applied to a decision problem where there are many criteria and alternatives (the ELECTRE model has 8x70 decision matrices) and comparisons have been made. Different criteria weights didn't cause changes in the results, as the ELECTRE method evaluates alternatives on the basis of pairwise comparisons. The study contributes to the literature with 15 different methods used in evaluations from different perspectives. Among the 25 criteria, the most important criteria are the average length of stay in the hospital, followed by the number of days stayed in the hospital. In addition, although the indicators were intended to be obtained in proportion to the population, cities with much larger populations still came to the fore.

According to 2023 statistics, while the total number of hospitals in Türkiye was 1156 in 2002, this figure became 1,566 a decade later in 2022. While the total number of hospital beds was 164,471 in 2002, this figure increased by 62% to 266,594 a decade later. There are significant developments in health services in Türkiye, as well as in the rest of the world. However, while the number of hospital beds per 10,000 people is 124.4 in South Korea and 125.9 in Japan, it is 47.5 in EU countries, 42.5 in OECD countries, and 31.2 in Türkiye. The number of hospital beds per capita still lags behind average scores in other countries. On the other hand, while the total number of physicians per 100,000 people was 661 in Greece and 572 in Portugal, Türkiye ranked 41st in the world in the number of physicians with 239. Similarly, the number of physicians remained well below the EU (414) and OECD (377). The statistics presented show that Türkiye attaches more importance to health performance over the years, but the expected increase in importance is not at the desired level. For these reasons, examining the provinces' access to health services, the effectiveness of the services provided, and eliminating various deficiencies will guide decision-makers in developing the right policies in this field.

Achieving socio-economic development, the community's ability to live at a good welfare level, and individuals' high quality of life are directly connected to the society's health structure. Healthcare services provided appropriately contribute to the development of society. It can be proposed to make a slightly more limited but also comparison or benchmarking with cities of different countries in order to reach a more reliable and comprehensive evaluation. In addition, examining the impact of the change in key indicators for alternatives can be developed in future studies to cover the entire period of years in which COVID-19 emerged.

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