

EVALUATION OF THE CRITERIA AFFECTING THE DEATH RATE UNDER-5 BY THE ENTROPY-BASED TOPSIS METHOD

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Abstract:

Introduction and Aim: One of the criteria used in determining the health levels of countries, planning health services and determining priorities is the under-5 mortality rate. The aim of this study is to weight the criteria that may affect the under-5 mortality rate and to compare the countries in the WHO Europe region in line with these criteria.

Material and methods: The criteria have been obtained as a result of literature review. These; Conjugated pneumococcal, hepatitis B and measles vaccination rates in children under 1 year of age, percentage of children 0-14 years of age with tuberculosis, adolescent pregnancy, percentage of premature deaths among the causes of death under the age of 5, crude birth rate, country's exposure to air pollution, current health expenditure as percentage of gross domestic product, current health expenditure per capita in US\$, domestic general government health expenditure as percentage of current health expenditure, domestic private health expenditure as percentage of current health expenditure, out-of-pocket expenditure as percentage of current health expenditure.

The data was obtained from WHO. The Entropy Weighting Method was used to obtain the objective weights of the criteria that affect the under-5 mortality rate, and the TOPSIS method was used to rank the countries."

Results and discussion: When the criteria affecting under-5 mortality rate were evaluated, it was found that the highest level of importance was percentage of children with tuberculosis. This is followed by the variables 'current health expenditure per capita in US\$' and 'adolescent pregnancy', respectively. Relatively less important among the criteria was rate of children with 2 doses of measles vaccine. When the ranking of countries was made analysis, it was determined that "Switzerland" was in the best condition. "Slovakia" ranked last.

Conclusion: In order to reduce the mortality rate under 5 years of age, it is recommended to plan interventions to reduce tuberculosis rates first.

Keywords: *Under-5 Mortality Rate, Entropy, TOPSIS, Europe*

Introduction: Health indicators are essential criteria in demonstrating the quality of the health system used in a country and determining the factors affecting health. There are many health indicators showing the development level of a country [1]. One of them is the under-5 mortality rate. According to the report published by the World Health Organization (WHO), the under-5 mortality rate is among the 100 fundamental health indicators [2]. The under-5 mortality rate is the ratio of the number of deaths recorded from 1000 live births by the age of five to the under-5 population [3].

As part of the sustainable development goals for 2030, the United Nations aims to reduce the deaths of children under the age of 5 to 25 per 1000 live births [4]. The under-5 mortality rate is 38 per thousand globally, 7.53 per thousand in the WHO European region, and 8.37 per thousand in Turkey

[5]. WHO states that most under-5 deaths are preventable or treatable with cost-effective interventions in health and sanitation [6].

A qualified examination of the causes of child death is essential in planning public health interventions to reduce and prevent deaths. This can be done objectively with the entropy-based Topsis. The method ensures that the rates affected by several criteria are evaluated objectively with multi-criteria decision-making processes [7]. This study was conducted to weigh (prioritize) the criteria that may affect the under-5 mortality rate and to compare the countries in the WHO Europe region in line with these criteria.

Material and Methods: The population of the study covered 53 countries in the WHO Europe region. The reason for choosing the Europe region is that Turkey is located in this region. No sample selection was made, and it was tried to reach the data of all countries. Nineteen countries were excluded as they did not have data on some variables, thus, a total of 34 countries were included in the study.

Variables: The criteria affecting the under-five mortality rate were obtained as a result of the national and international literature review [8-12]. A total of 13 criteria were included in the analysis (Table 1): conjugated pneumococcal, hepatitis B and measles vaccination rates in children under one year of age, percentage of children 0-14 years of age with tuberculosis, adolescent pregnancy, percentage of premature deaths among the causes of death under the age of 5, crude birth rate, country's exposure to air pollution, current health expenditure as percentage of gross domestic product, current health expenditure per capita in US dollars, domestic general government health expenditures as a percentage of current health expenditures, domestic private health expenditures as a percentage of current health expenditures, and out-of-pocket expenditures as a percentage of current health expenditures. Research data were obtained from WHO's 2020 data.

Table 1. The criteria used in the study

Criteria Code	Criteria	Topsis Values (Min-Max)*
K1	Conjugated pneumococcal vaccination rates in children under 1 year of age (%)	Max
K2	Hepatitis B vaccination rates in children under 1 year of age (%)	Max
K3	Two doses of measles vaccination rates in children under 1 year of age	Max
K4	Percentage of children 0-14 years of age with tuberculosis (%)	Min
K5	Adolescent pregnancy	Min
K6	Percentage of premature deaths among the causes of death under the age of 5	Min
K7	Crude birth rate	Min
K8	Country's exposure to air pollution	Min
K9	Current health expenditure as percentage of gross domestic product (%)	Max
K10	Current health expenditure per capita in US\$	Max
K11	Domestic general government health expenditure as percentage of current health expenditure (%)	Max

K12	Domestic private health expenditure as percentage of current health expenditure (%)	Min
K13	Out-of-pocket expenditure as percentage of current health expenditure (%)	Min

* Max: criteria for which a high value is desirable

Min: criteria for which a low value is desirable

Data Analysis: The Entropy Weighting Method was used to obtain the objective weights of the criteria affecting the under-5 mortality rate, and the TOPSIS method was used to rank the countries in the study.

Entropy Weighting Method: Entropy Weighting Method, a criterion weighing method in multi-criteria decision-making, only weighs the values derived from the data set. Since the subjective preferences of individuals are not included in this method, it is considered an objective weighing method [13, 14].

In this study, 'entropy' and ' d_j ' values were calculated after the entropy-normalized decision matrix was created. The weight (w_j) of each variable was then determined.

TOPSIS Method (Technique for Order Preference by Similarity to Ideal Solution)

The TOPSIS method is a multi-criteria decision-making method and is based on the assumption that the chosen alternative should have the closest distance to the positive ideal solution and the farthest distance from the negative ideal solution [15-17].

In this study, the weights obtained with the Entropy Weighting Method for the variables were used in the TOPSIS method. A weighted normalized decision matrix was created, and ideal and negative ideal solution values, distance values, and relative closeness values were calculated with this method.

Results

The entropy values and weights of the variables are given in Table 2. The order of the criteria according to the degree of importance is shown in Table 3.

Table 2. Entropy and weight values for the variables

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13
Entropy (E_j)	0.998	0.999	1.000	0.858	0.918	0.979	0.984	0.964	0.987	0.871	0.985	0.967	0.951
d_j	0.002	0.001	0.000	0.142	0.082	0.021	0.016	0.036	0.013	0.129	0.015	0.033	0.049
Weight (w_j)	0.003	0.001	0.001	0.264	0.151	0.040	0.030	0.066	0.025	0.238	0.028	0.061	0.091
Ranking	11	12	13	1	3	7	8	5	10	2	9	6	4

Table 3. Ranking the criteria in order of importance

Ranking	Criteria Code	Criteria
1	K4	Percentage of children 0-14 years of age with tuberculosis
2	K10	Current health expenditure per capita in US\$
3	K5	Adolescent pregnancy
4	K13	Out-of-pocket expenditure as percentage of current health expenditure (%)
5	K8	Country's exposure to air pollution
6	K12	Domestic private health expenditure as percentage of current health expenditure (%)
7	K6	Percentage of premature deaths among the causes of death under the age of 5
8	K7	Crude birth rate
9	K11	Domestic general government health expenditure as percentage of current health expenditure (%)
10	K9	Current health expenditure as percentage of gross domestic product (%)
11	K1	Conjugated pneumococcal vaccination rates in children under 1 year of age (%)
12	K2	Hepatitis B vaccination rates in children under 1 year of age (%)
13	K3	2 doses measles vaccination rates in children under 1 year of age

It was determined that the most critical criterion affecting the under-5 mortality rate was the 'percentage of children 0-14 years of age with tuberculosis' (0.264). This was followed by the 'Current health expenditure (CHE) per capita in US\$' (0.238) and 'adolescent pregnancy' (0.151) criteria, respectively. Among the criteria, the relatively less important one was '2 doses measles vaccination rates in children under 1 year of age' (0.001).

Ranking the countries with the TOPSIS method demonstrated that the top three countries in terms of under-5 mortality rate were Switzerland, Norway and Luxembourg. Türkiye ranks 24th on the list. Slovakia, on the other hand, took the last place when all criteria were considered (Table 4).

Table 4. S+, S- and C* values for countries and ranking results

	S+	S-	C*	Ranking
Andorra	0.0806	0.2241	0.7354	9
Armenia	0.1248	0.1781	0.5879	30
Azerbaijan	0.1333	0.1891	0.5866	31
Belgium	0.0666	0.1958	0.7461	7
Bulgaria	0.1232	0.1909	0.6078	28

Croatia	0.1042	0.2192	0.6779	16
Cyprus	0.0929	0.2192	0.7023	12
France	0.0658	0.2011	0.7536	6
Georgia	0.1220	0.1913	0.6107	27
Germany	0.0583	0.2036	0.7774	5
Greece	0.1001	0.2044	0.6714	18
Israel	0.0869	0.1826	0.6774	17
Italy	0.0843	0.2028	0.7063	11
Kazakhstan	0.1208	0.1923	0.6142	25
Kyrgyzstan	0.1320	0.1762	0.5718	32
Lithuania	0.1019	0.2044	0.6673	20
Luxembourg	0.0417	0.2331	0.8483	3
Malta	0.0842	0.2059	0.7097	10
Norway	0.0344	0.2173	0.8632	2
Poland	0.1052	0.2116	0.6678	19
Portugal	0.0916	0.2064	0.6927	14
Moldova	0.1192	0.1876	0.6114	26
Romania	0.1220	0.1860	0.6040	29
Russia	0.1130	0.1951	0.6333	22
Serbia	0.1118	0.2024	0.6442	21
Slovakia	0.2350	0.0463	0.1646	34
Slovenia	0.0909	0.2085	0.6964	13
Spain	0.0885	0.1953	0.6881	15
Sweden	0.0558	0.2061	0.7869	4
Switzerland	0.0219	0.2367	0.9154	1
Türkiye	0.1169	0.1894	0.6184	24
Turkmenistan	0.1203	0.2049	0.6299	23
United Kingdom	0.0698	0.2044	0.7453	8
Uzbekistan	0.1564	0.1176	0.4293	33

Discussion

The causes of death for children under the age of five can guide the evaluation of the health status of a society and many services that are directly or indirectly related to health. Although the mortality rates of children under the age of five worldwide and in Turkey have decreased rapidly in recent years, they still have not fallen to the desired figures. It is estimated that 50% of these deaths are preventable [18].

Knowing the causes of death is essential in planning the corresponding measures. According to our research results, the most crucial variable among the criteria evaluated that affect under-5 mortality rate was the 'percentage of children 0-14 years of age with tuberculosis'. Although tuberculosis is a treatable and preventable disease today, it is still among the 10 most common causes of death in children [19]. Tuberculosis can remain asymptomatic for a long time and has non-specific findings in children. For these reasons, timely diagnosis is essential as the disease can lead to disability and death due to

complications when the diagnosis is delayed [20]. Children usually get tuberculosis from adults, and the risk of developing the disease increases as the infected child ages. The greater the number of untreated adult cases in a country, the higher the likelihood of TB in children [21]. Therefore, early diagnosis and treatment of adult cases are essential in reducing tuberculosis-related deaths in children under 5 years old. The World Health Organization aims to reduce the incidence of tuberculosis cases by 80% and related deaths by 90% by 2030 [22]. Immunization is a vital preventive health service in protecting and improving child health [23]. Countries should focus on increasing BCG vaccination rates to prevent tuberculosis and reduce tuberculosis-related deaths. It is recommended to continue mandatory BCG vaccination, especially in societies with poor health and economic conditions and where the probability of encountering tuberculosis bacillus is high. It can therefore be concluded that the countries in the Europe region should prioritize reducing the tuberculosis rate in children aged 0-14 in reducing the under-5 mortality rate.

The second most important criterion affecting the under-5 mortality rate in the study is 'current health expenditure per capita'. Although increased health expenditures are associated with health outcomes, especially in low-income countries, there is no recommended amount of expenditure. In general, as per capita income increases, health expenditure also increases. Universal Health Coverage is possible if the society can access health services without financial difficulties. The increase in public health expenditures contributes positively to the community's access to health services [24]. There are various relevant studies confirming the positive effect of the increase in health expenditures on health outcomes [25-27]. There are also studies that have found a negative relationship between the increase in total health expenditure, per capita health expenditure and public health expenditures and the under-5 mortality rate. Evirgen [28] found a significant negative relationship between out-of-pocket health expenditures and public health expenditures and under-5 mortality rates in Turkey. They found that a 1-unit increase in out-of-pocket health expenditures reduces the under-5 child mortality rate by 0.09 percent. In contrast, a 1-unit increase in public health expenditures reduces the under-5 child mortality rate by 0.20%. Rezapur et al. [29] found that the increase in public health expenditures decreased the under-5 mortality rates in their study covering middle and high-income countries. Karyani et al. [30] found that increased health expenditures per capita and public health expenditures among OECD countries decreased the under-5 mortality rates. Anyanwu and Erhijakpor [31] found that a 10% increase in the total health expenditure per capita causes a 21% decrease in the under-5 mortality rate and a 22% decrease in the infant mortality rate, contributing positively to health outcomes. The relationship between increased health expenditures and different primary health indicators, including under-5 mortality rates, is noteworthy. However, the regular increase in health expenditures raises concerns about the financial sustainability of health systems in the long run. In line with this information, it can

be suggested that policymakers take measures to improve socio-economic and environmental factors, which are included in the social determinants of health, as well as health expenditures.

As a result of the study, it was found that the third variable affecting the under-5 mortality rate was the 'adolescent pregnancy rate'. A major social health problem in both developed and developing countries, adolescent pregnancies represent high-risk pregnancies and can cause serious health problems for both mother and baby [32]. Problems that increase the risk of neonatal death, such as prematurity, low birth weight and asphyxia, are more common in infants of adolescent mothers [33]. Neonatal deaths account for approximately 47% of all child deaths under the age of 5 [34]. Therefore, neonatal health is key to reducing deaths under 5 years of age. To prevent adolescent pregnancies, it can be recommended that countries prevent early marriages, increase the school attendance rate of girls, support pregnancy prevention programs among adolescents, and plan trainings on sexuality and contraception use for girls and boys.

In line with these results, it can be concluded that the countries in the Europe region should consider the most effective criteria determined by this study when developing policies to reduce the under-5 mortality rate. This way, a faster improvement can be achieved in reducing the mortality rate under the age of 5 years.

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