Hacettepe Sağlık İdaresi Dergisi, 2025; 28(1), 65-80
https://doi.org/10.61859/hacettepesid.1581132

RESEARCH ARTICLE

EVALUATION OF OECD COUNTRIES IN TERMS OF HUMAN DEVELOPMENT INDEX, MORTALITY RATES AND HEALTH EXPENDITURES WITH CLUSTER ANALYSIS

Nazan KARTAL *

ABSTRACT

The objective of this study is to apply cluster analysis to OECD countries in order to identify country groups with similar Human Development Index (HDI), mortality and health expenditure profiles. In order to achieve the aforementioned aim, the research employed a correlation analysis and K-means clustering method to analyse a number of variables for 38 OECD Countries with 2020 data. These included the HDI, maternal, infant and under-five child mortality rates, the share of total health expenditure and the share of public health expenditure. The results demonstrated a significant and positive correlation between HDI and total health expenditure, as well as public health expenditure. Additionally, a negative and strong relationship was observed between HDI and maternal, infant and child mortality rates. The cluster analysis yielded the following results: 13 countries were assigned to cluster 1, 3 to cluster 2, and 13 to cluster 3. Furthermore, it was observed that Colombia, Mexico and Turkey, which are situated within the same cluster, exhibited the lowest HDI and the lowest proportion allocated to health expenditures with the highest maternal, infant and under-five child mortality rates. The results of this study demonstrate that health expenditure is a crucial factor in the progression of the HDI. It is thought that countries with a low HDI can enhance health outcomes by reducing mortality rates and increasing health expenditure.

Keywords: *Human development ındex, health expenditure, mortality, clustering, OECD.*

ARTICLE INFO

* *Research Assisstant, PhD., Çankırı Karatekin University, Faculty of Health Sciences Health Management, nazankartal@karatekin.edu.tr*
https://orcid.org/0000-0002-5416-7952

Received: 07.11.2024
Accepted: 01.03.2025

Cite This Paper:

Kartal, N. (2025). Evaluation of OECD countries in terms of human development index, mortality rates and health expenditures with cluster analysis. Hacettepe Sağlık İdaresi Dergisi, 28(1), 65-80. https://doi.org/10.61859/hacettepesid.1581132

ARAŞTIRMA MAKALESİ

OECD ÜLKELERİNİN İNSANİ GELİŞME ENDEKSİ, ÖLÜM ORANLARI VE SAĞLIK HARCAMALARI AÇISINDAN KÜMELEME ANALİZİ İLE DEĞERLENDİRİLMESİ

Nazan KARTAL †

ÖZ

Bu çalışmanın amacı, OECD ülkelerine kümeleme analizi uygulayarak İnsani Gelişme Endeksi (HDI), ölüm oranı ve sağlık harcamaları profilleri benzer olan ülke gruplarını belirlemektir. Araştırma kapsamında 38 OECD ülkesi için 2020 yılına ait verilerle HDI, anne, bebek ve beş yaş altı çocuk ölüm oranları, toplam sağlık harcaması payı ve kamu sağlık harcaması payı değişkenleri korelasyon analizi ve K-ortalamalar kümeleme yöntemi kullanılarak analiz edilmiştir. HDI ile toplam sağlık harcamaları ve kamu sağlık harcamaları arasında anlamlı ve pozitif ilişki; HDI ile anne, bebek ve çocuk ölüm oranları arasında ise negatif ve güçlü ilişki olduğu belirlenmiştir. Kümeleme analizi sonucunda küme 1'de 13 ülke, küme 2'de 3 ülke ve küme 3'te 13 ülke olduğu belirlenmiştir. Aynı kümede yer alan Kolombiya, Meksika ve Türkiye'nin en düşük HDI ve sağlık harcaması ile en yüksek anne, bebek ve beş yaş altı çocuk ölüm oranlarına sahip olduğu görülmüştür. Çalışma sonuçları sağlık harcamalarının HDI gelişimine önemli bir katkısı olduğunu göstermiştir. HDI skoru düşük olan ülkelerin sağlık harcamalarını artırarak ve ölüm oranlarını azaltarak sağlık sonuçlarını iyileştirebileceği düşünülmektedir.

Anahtar Kelimeler: *İnsani gelişme endeksi, sağlık harcaması, mortalite, kümeleme, OECD.*

MAKALE HAKKINDA

Arş.Gör.Dr., Çankırı Karatekin Üniversitesi sağlık Bilimleri Fakültesi Sağlık yönetimi Bölümü, nazankartal@karatekin.edu.tr
https://orcid.org/0000-0002-5416-7952

Gönderim Tarihi: 07.11.2024
Kabul Tarihi: 01.03.2025

Atıfta Bulunmak İçin:

Kartal, N. (2025). Evaluation of OECD countries in terms of human development index, mortality rates and health expenditures with cluster analysis. Hacettepe Sağlık İdaresi Dergisi, 28(1), 65-80. https://doi.org/10.61859/hacettepesid.1581132

I. INTRODUCTION

Human development is thought to have emerged after the 1950s as a result of discussions on the relationship between economic growth and the development of social welfare (Reyes and Useche, 2019). A significant number of international organisations and scholars have articulated the necessity to supplement existing well-being measures with solutions that will facilitate more effective assessment and evaluation of countries' policy responses to diverse challenges. The Human Development Index (HDI) is an index often used to classify countries. It plays two important roles in this process. Firstly, it enables a more comprehensive examination of the concept of well-being by popularising the concept of a standard measure of human development. Secondly, it offers a viable alternative to GDP per capita, which is regarded as the benchmark for measuring human development (Babiarz et al. 2018; Stanton, 2007).

The HDI is a statistical measure devised by the United Nations to assess the level of socio-economic developmental progress achieved by countries. The HDI is a composite indicator that synthesises three fundamental dimensions of human development: health, education and income. The HDI is calculated by combining three key indicators: life expectancy at birth for a healthy life, education indicators (literacy and schooling) for access to information, and per capita income for average purchasing power. This formulation permits the HDI to account for well-being in addition to health and education (Reyes and Useche, 2019; Prados de la Escosura, 2015; UNDP, 2001; Anand and Sen, 2000). The HDI is scored on a scale of 0 to 1, with 1 representing the highest level of human development. The 2014 Human Development Report delineates four levels of human development: very high, high, medium, and low. Countries with an HDI below 0.550 are classified as low, those between 0.550 and 0.699 as medium, those between 0.700 and 0.799 as high, and those above 0.800 as very high (UNDP, 2014).

The available evidence indicates a positive correlation between the ratio of health expenditures to gross domestic product and health outcomes (Nixon and Ulmann, 2006; Crémieux et al., 1999). In particular, countries that allocate a greater proportion of their gross domestic product (GDP) to healthcare have been demonstrated to exhibit comparatively superior health outcomes in comparison to countries that allocate less of their GDP to healthcare (Nuhu et al., 2018). A study examining the effect of public health expenditure on HDI in Turkey based on data between 1991 and 2013 found a positive and significant relationship (Yalçın and Çakmak, 2016).

It is essential for health policymakers to assess the trends in reproductive health indicators, such as infant and maternal mortality rates, and their communication and interaction with development indicators. This will ensure a regular and accurate assessment of the health system's performance and facilitate more effective risk factor management strategies (Rohani et al., 2018; Khosravi and Rahbar, 2009). The infant mortality rate is a principal indicator used to assess the health status and socioeconomic well-being of a country (Alijanzadeh et al., 2016). The infant mortality rate serves as a key indicator in gauging the standards of healthcare and social equality (Alijanzadeh et al., 2016; Hakobyan et al., 2006; Arntzen et al., 2004).

The OECD offers the privilege of facilitating the collaboration of essential global affairs among its esteemed member countries and a variety of valued partners at national, regional and local levels. The OECD has a membership of 38 countries worldwide. The data and analysis produced by the organisation are utilised by member countries as a basis for informing their policy decisions, and they also assume a pivotal role in the country reviews (OECD, 2024).

The objective of this study is to apply a cluster analysis to a set of OECD countries, with the aim of identifying groups of countries that exhibit similar characteristics with respect three key indicators: the HDI, mortality rates and health expenditures. The literature shows that there are studies using the HDI in cluster analysis. These include the studies by Fahmiyah and Ningrum (2023), Repiská et al. (2022), Polat (2021), Krylovas et al. (2020), Güloğlu et al. (2018), Altaş and Arikan (2017), Mylevaganam (2017), and Sulkowski and White (2016). However, it was observed that the cluster analysis studies did not incorporate the variables evaluated in cluster analysis with HDI within the scope of this research. It is thus anticipated that the present study will make a notable contribution to the existing literature.

II. METHODS

2.1. Aim of the Research

The aim of this research was to determine the most appropriate method for classifying OECD member countries according to their human development index, mortality rates, and health expenditure data. To this end, cluster analysis was conducted, and the differences between the clusters in which the countries were located were evaluated.

2.2. Study Population

The countries participating in this analysis are those belonging to the OECD. The research encompassed a total of 38 countries.

2.3. Data Collection

In this study, the use of secondary data was employed. The data used in this study were obtained from open access sources. Ethics committee approval is not required because secondary data has been used in the study. Table 1 below provides details of the variables included in the research and their sources.

Table 1. Variables and Sources

Variables	Description	Source
THE- Total healthcare expenditure as a share of GDP, 2020	The total expenditure on healthcare as a percentage of the gross domestic product (GDP).	World Health Organization - Global Health Observatory (2024)
PHE- Public expenditure on healthcare as percent of total healthcare expenditure, 2020	The proportion of current health expenditures financed by domestic public sources for health.	
MMR-Maternal mortality rate, 2020	The estimated number of maternal deaths per 100,000 live births is based on data from death certificates, large-scale surveys, and statistical modelling.	
IMR-Infant mortality rate, 2020	The estimated number of deaths of children under one year of age per 100 live births, in deaths per 100 live births.	
CMR-Child mortality rate, 2020	The estimated proportion of infants who die before reaching the age of five.	
HDI-Human Development Index, 2020	The HDI is a summary measure of key dimensions of human development, including a long and healthy life, a good education, and a decent standard of living. A higher value indicates a higher level of human development.	

2.4. Statistical Analysis

In this study, the cluster analysis method was employed. A review of the literature reveals the existence of numerous cluster analysis methods. Clustering methods can be classified into two main categories: stepwise (also known as stage-ordered or hierarchical clustering) and non-stepwise (also known as non-stage-ordered or non-hierarchical) cluster methods (Alpar, 2013). In this study, hierarchical and non-hierarchical clustering analyses were conducted in accordance with the prescribed methodology.

The steps for the Clustering algorithm process are as follows:

Since the units of the variables are different, the data were standardized with z transformation and the standard data matrix was used in the cluster analysis study.

The standardised data were subjected to analysis using Ward's technique, which is one of the hierarchical cluster analysis methods. The appropriate number of clusters was then determined.

Once the optimal number of clusters had been identified, the countries were grouped according to the research variables using the k-means method. The k-means method was employed, with the model run 10 times and 300 iterations selected.

The WARD method was chosen as the best hierarchical clustering method for this research because it is well-known for its effectiveness in the literature (Tekin, 2018; Ferreira and Hitchcock, 2009; Hands and Everitt, 1987). The Ward method provides more detailed evidence because it is based on the average distance of the observation falling in the middle of a cluster from the observations in the same cluster (Tekin and Gümüş, 2017).

The data were standardised using SPSS 26 (Statistical Package for the Social Sciences). The hierarchical clustering analysis and k-means method were applied to the dataset using open-source Orange software. Orange is a data mining application that enables the utilisation of machine learning and data visualisation through the creation of visual workflows (Dobesova, 2024). Orange is an open-source software program provided by the University of Ljubljana in Slovenia. Furthermore, the software is capable of supporting files in a variety of formats, including *.csv, *.tsv, *.arff, *.txt, *.tab, *.xml, and *.svm. (Orange, 2024).

III. FINDINGS

Table 2 shows that the largest share of GDP allocated to health expenditures is in the USA (18.76), while the smallest share is in Turkey (4.62). The country with the highest share of public health expenditure in total health expenditure is the Czech Republic (87.4) and the country with the lowest is Switzerland (35.9). Colombia has the highest maternal mortality rate (per hundred thousand births) at 75, while Norway and Poland have the lowest at 2. The countries with the highest infant mortality is Mexico (1.14); the country with the lowest rate is Estonia (0.14). Mexico has the highest under-five child mortality rate (1.4%), while Estonia, Finland, Japan, Norway, Slovenia have the lowest (0.2%). The country with the highest HDI is Norway (0.963), and the country with the lowest is Colombia (0.756).

Table 2. Country Scores Based on Research Variables

No	Countries	THE	PHE	MMR	IMR	CMR	HDI
1	Australia	10.68	73.7	3	0.31	0.4	0.948
2	Austria	11.39	76.7	5	0.32	0.3	0.916
3	Belgium	11.2	77.9	5	0.32	0.4	0.93
4	Canada	13.04	73.7	11	0.44	0.5	0.928
5	Chile	9.73	56.3	15	0.5	0.7	0.849
6	Colombia	8.71	71.3	75	1.09	1.3	0.756
7	Costa Rica	7.83	71.8	22	0.69	0.8	0.811
8	Czechia	9.21	87.4	3	0.23	0.3	0.891
9	Denmark	10.56	84.8	5	0.31	0.4	0.946
10	Estonia	7.58	77	5	0.14	0.2	0.891
11	Finland	9.63	81.3	8	0.19	0.2	0.939
12	France	12.13	76.8	8	0.35	0.4	0.9
13	Germany	12.69	78.5	4	0.31	0.4	0.948
14	Greece	9.5	54	8	0.32	0.4	0.887
15	Hungary	7.29	70.5	15	0.34	0.4	0.849
16	Iceland	9.61	83.3	3	0.29	0.3	0.955
17	Ireland	7.11	78	5	0.28	0.3	0.945
18	Israel	7.71	68.2	3	0.22	0.4	0.906
19	Italy	9.63	75.9	5	0.25	0.3	0.892
20	Japan	11	84.9	4	0.18	0.2	0.917
21	Korea	8.35	59.8	8	0.23	0.3	0.922
22	Latvia	7.25	63.4	18	0.34	0.4	0.873
23	Lithuania	7.48	68.7	9	0.27	0.4	0.88
24	Luxembourg	5.74	87.4	6	0.45	0.3	0.921
25	Mexico	6.22	52.9	59	1.14	1.4	0.757
26	Netherlands	11.21	68.9	4	0.38	0.4	0.938
27	New Zealand	10.07	77.9	7	0.38	0.5	0.935
28	Norway	11.25	86	2	0.17	0.2	0.963
29	Poland	6.5	71.9	2	0.35	0.4	0.874
30	Portugal	10.55	64.2	12	0.24	0.3	0.861
31	Slovak Republic	7.13	80.3	5	0.5	0.6	0.86
32	Slovenia	9.43	72.6	5	0.21	0.2	0.91
33	Spain	10.75	73.1	3	0.25	0.3	0.894
34	Sweden	11.33	86.2	5	0.23	0.3	0.944
35	Switzerland	11.73	35.9	7	0.37	0.4	0.957
36	Türkiye	4.62	78.8	17	0.9	1.1	0.835
37	United Kingdom	12.16	83.7	10	0.37	0.4	0.92
38	United States	18.76	57	21	0.53	0.6	0.923

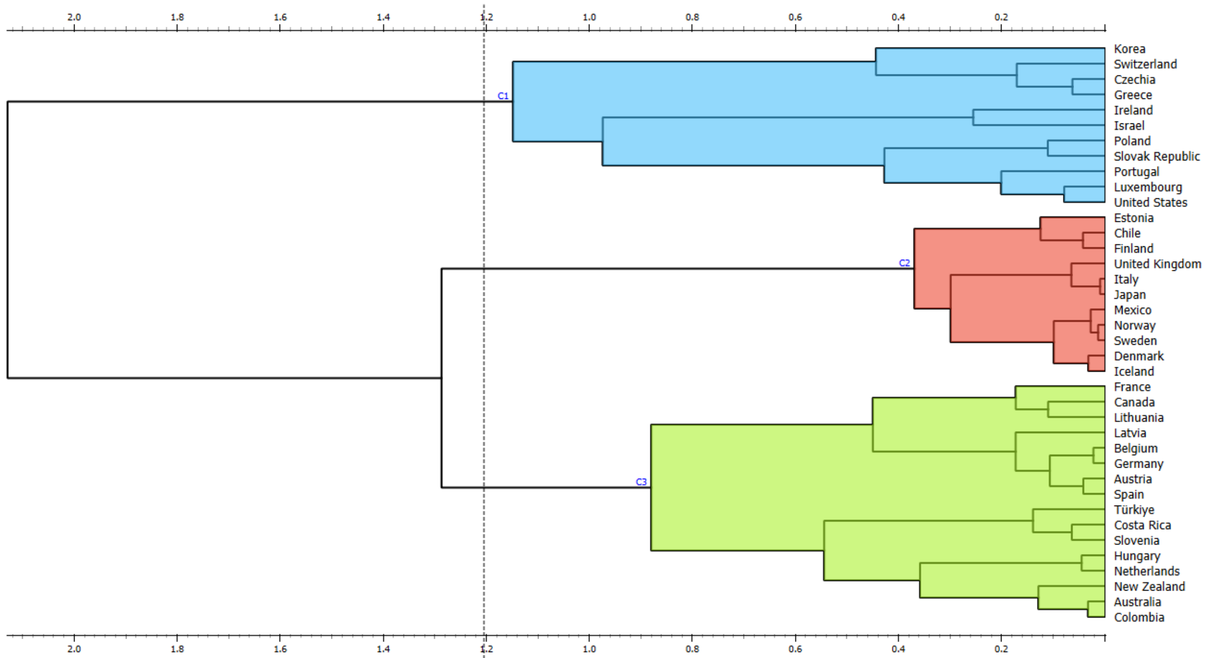
Table 3 shows the correlation analysis results for the variables. To evaluate correlations among the study variables, Alpar's specified intervals were used (Alpar, 2013). Table 3 illustrates a significant and positive correlation between HDI and total health expenditure and the share of health services. Additionally, there is a negative and statistically significant correlation between HDI and maternal, infant and child mortality rates.

Table 3. Correlation Analysis among Variables

	THE	PHE	MMR	IMR	CMR	HDI
THE	1	+0.279	-0.157	-0.246	-0.251	+0.485
PHE	-0.079	1	-0.320	-0.268	-0.309	+0.279
MMR	-0.157	-0.320	1	+0.859	+0.857	-0.782
IMR	-0.246	-0.268	+0.859	1	+0.978	-0.753
CMR	-0.251	-0.309	+0.857	+0.978	1	-0.781
HDI	+0.485	+0.279	-0.782	-0.753	-0.781	1

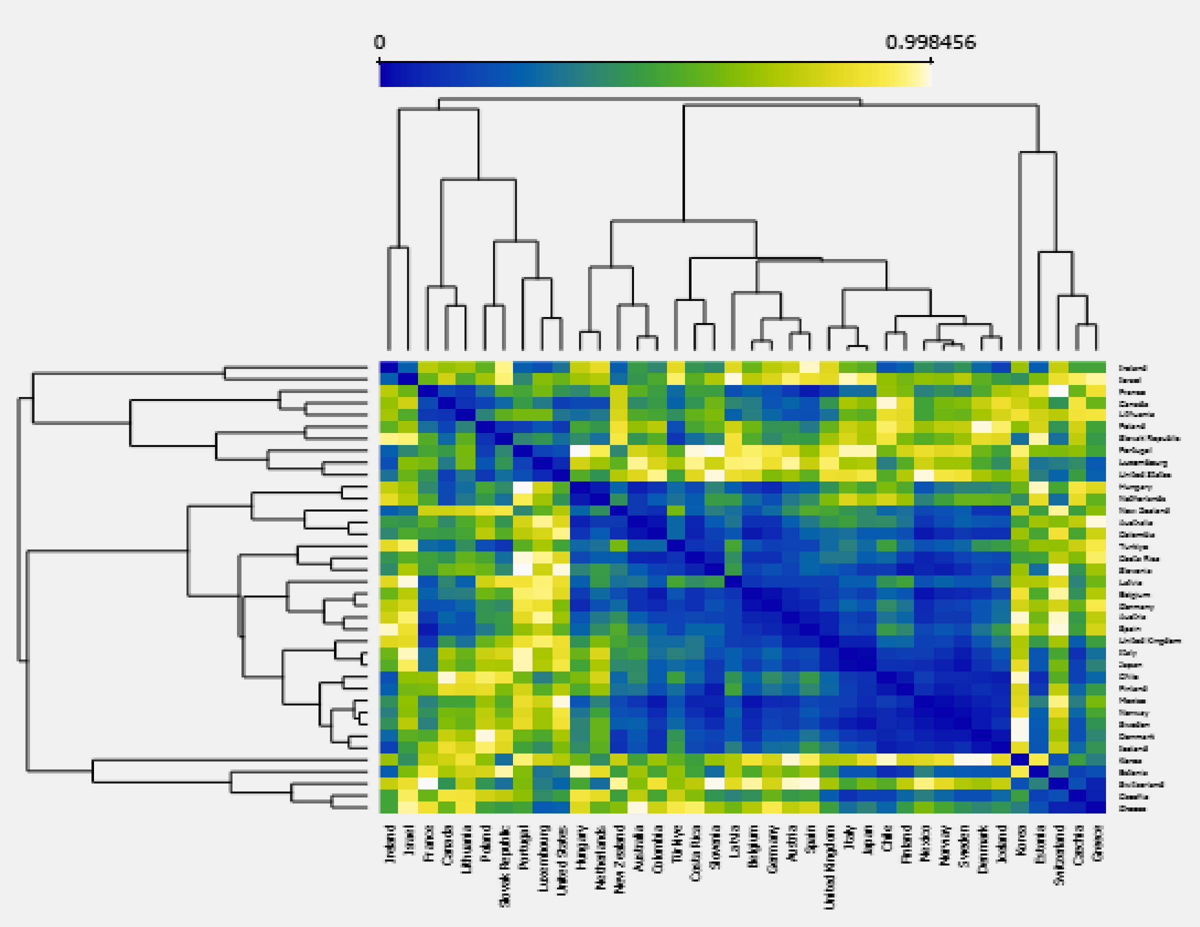
Ward's method, one of the hierarchical clustering methods, was initially employed to ascertain the number of clusters within the scope of the analysis. The resulting dendrogram diagram, produced by the hierarchical clustering analysis, is presented in Figure 1. When the dendrogram diagram was examined, the number of clusters that should be used when applying the k-means method was determined as 3.

Figure 1. Dendogram Graph Created using Ward's Method



One of the key instruments utilized to elucidate the distinctions between the constituent data points within the data set of the Orange data mining tool is the distance matrix unit. The distance matrix offers a valuable means of comparing observations in pairs. According to distance matrix, the countries of Australia and Colombia are the most closely related, with the lowest value of 0.008. This can be clearly seen in the dendogram diagram in Figure 1 or the distance map in Figure 2.

Figure 2. Distance Map



The K-means clustering method was executed for 38 countries utilising the Orange application. The results indicated that there were 22 countries in Cluster 3, three in Cluster 2, and 13 in Cluster 1. The Silhouette index, which is one of the various metrics for evaluating the reliability of the k-means method, ranges between -1 and +1. Values approaching 1 indicate optimal clustering (Tebala and Marino, 2023). Upon examination of Table 4, it becomes evident that Sweden exhibits the highest Silhouette value (0.671093), while Israel displays the lowest (0.45814).

Table 4. Cluster Groups

Countries	Cluster	Silhouette
Australia	C3	0.650127
Austria	C3	0.660166
Belgium	C3	0.666706
Canada	C3	0.60692
Chile	C1	0.582661
Colombia	C2	0.645937
Costa Rica	C1	0.540969
Czechia	C3	0.637483
Denmark	C3	0.669812
Estonia	C3	0.582933
Finland	C3	0.660381
France	C3	0.634051
Germany	C3	0.655608
Greece	C1	0.564787
Hungary	C1	0.548443
Iceland	C3	0.666164
Ireland	C3	0.612198
Israel	C1	0.45814
Italy	C3	0.62165
Japan	C3	0.66305
Korea	C1	0.496159
Latvia	C1	0.57114
Lithuania	C1	0.519559
Luxembourg	C3	0.5812
Mexico	C2	0.649484
Netherlands	C3	0.614107
New Zealand	C3	0.641805
Norway	C3	0.659905
Poland	C1	0.503708
Portugal	C1	0.501937
Slovak Republic	C1	0.48335
Slovenia	C3	0.617545
Spain	C3	0.621386
Sweden	C3	0.671093
Switzerland	C1	0.531656
Türkiye	C2	0.485741
United Kingdom	C3	0.653867
United States	C1	0.48123

The results of the k-means cluster analysis and the cluster locations of the countries are also shown in Figure 3. The visualisation of the multidimensional scaling according to the k-means method is shown in Figure 4. Looking at Figure 4, we can see that Turkey, which is in cluster 2, deviates from cluster 1.

Figure 3. Scatter Plot with K-Means

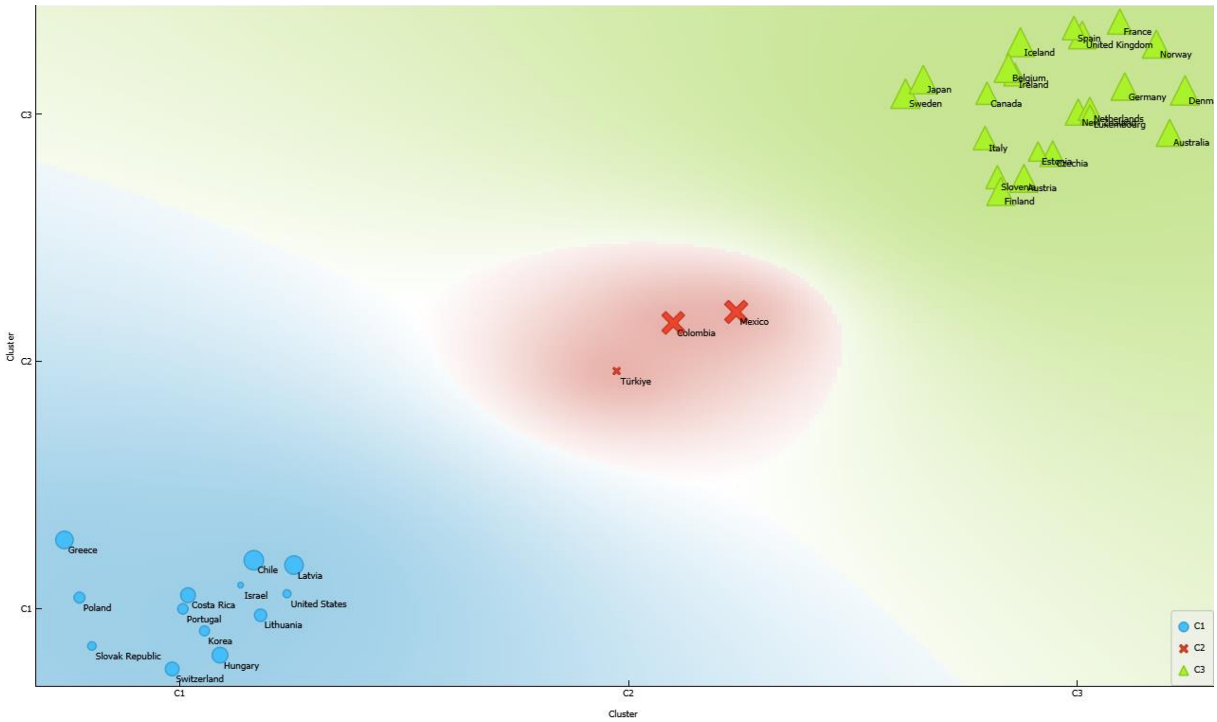


Figure 4. MDS K-Means

IV. DISCUSSION AND CONCLUSION

This paper presents a classification of OECD member countries according to the HDI, mortality rates and health expenditures, which is arguably the most prevalent measure of welfare. The study employed cluster analysis to examine the relationships between health expenditure, mortality rates and the human development index across 38 OECD countries. In the study, the data were initially standardised. Thereafter, the most appropriate number of clusters was determined by means of the hierarchical cluster analysis technique. Finally, the clustering was conducted using the k-means method.

The results of the correlation analysis indicate a significant and positive relationship between the HDI and total health expenditure as well as the share of health expenditure. A negative and strong relationship was found between HDI and maternal, infant and child mortality rates. The measurement of health indicators constitutes an essential element of the HDI. Cluster analysis revealed that Colombia, Mexico and Turkey belong to the same cluster group. These countries were also found to have the lowest HDI and the lowest proportion of health expenditure and the highest mortality rates. Additionally, an examination of the development level reveals that Colombia and Mexico exhibit a medium development level (HDI<0.80), while Turkey, despite its high development status, continues to require advancement in comparison to other OECD members. It is also noteworthy that these countries possess fragile economies. Particularly noteworthy is Turkey's underperformance in comparison to other EU countries, despite its candidacy for EU membership. To address these challenges, Turkey must prioritize investment in development and augment its health expenditures over the long term.

While some of the observed inequalities in health outcomes, such as mortality rates, are associated with access to and the quality of health care (Peters et al., 2008), there are notable connections between these inequalities and seemingly unrelated factors, including education and income levels. A notable finding is that populations from lower socioeconomic backgrounds experience a disproportionate impact on these outcomes (United Nations Children's Fund, 2025). This phenomenon has been consistently documented by various sources, including the (World Health Organization, 2021; World Health Organization, 2020; Chu et al., 2007). The correlation between maternal and infant mortality in certain countries, such as Western Europe and Canada, and the quality of healthcare is not as significant as previously thought. Instead, this phenomenon can be better explained by socioeconomic development (Nuhu et al. 2018).While these countries allocate a higher share to health expenditures, it is observed that the rate of health expenditures and the share of public health expenditures are lower in some Central European countries, which are in the lower group among European Union countries. A similar observation can be made when examining the data on health expenditure variables. It is evident that the lower share allocated to public health expenditures in the USA and Switzerland contributes to their shared grouping with Central and Eastern European countries and countries with lower levels of development, such as Chile and Costa Rica.

The HDI is an appropriate method for evaluating the development of a country and is the most crucial index for estimating the infant mortality (Morse, 2014). Infant mortality is highly responsive to policy interventions that directly or indirectly impact the health of infants. These include policies pertaining to the availability and accessibility of child and maternal health services, as well as those concerning the education of girls (Reidpath and Allotey, 2003). Infant and under-five mortality rates were included as a key indicator in the 60,000-year socio-economic development plan, which was implemented in 2015 to assess progress in socio-economic development and health (United Nations, 2007). The infant mortality rate is therefore considered one of the most effective mortality indicators to reflect general socio-economic development (Doorslaer and Koolman, 2004).

One study determined that health expenditure mediates the relationship between HDI and maternal and infant mortality (Nuhu et. al, 2018). The available evidence indicates that health expenditure at the central and local government levels has a positive effect on the HDI and its constituent elements (Miranda-Lescano et al., 2023). This was achieved through their panel data analysis, which encompassed the period between 2000 and 2018 and included 57 developed and developing countries. In a study covering 191 countries, it was stated that the current health expenditure per capita variable, among the health expenditure variables, has a significant effect on the HDI (Akın and Koç, 2021). Another study concluded that the increase in health expenditures in 25 Southwest Asian countries between 2000 and 2008 led to an increase in the HDI (Mirahsani, 2016). In a study covering 81 countries and classifying countries according to variables affecting HDI levels, stated that the statistical effect of health expenditures and infant mortality rate variables was significant (Yakut et al., 2015). As a result of the research conducted to determine the impact of some health indicators on the HDI in OECD countries and covering the years 2011-2016, it was found that the most effective variable on the HDI was the infant mortality rate (Coşar, 2020).

The present study demonstrates that there is a positive correlation between a country's HDI and health expenditure, and a negative correlation between mortality rates. The findings of the study indicate that health expenditure is a crucial determinant of human development. It is thought that countries with low HDI can improve health outcomes by reducing maternal, infant and under-five child mortality rates by increasing health expenditures. It is therefore clear that increasing the share of health expenditure allocated by policy makers can be a useful strategy for achieving higher levels of human development. It is thought that future studies would be useful to reclassify countries by adding more health indicators to the human development index. It is evident that the United Nations (UN) community has directed its attention toward the advancement of maternal and infant health, along with the reduction of mortality rates, within the framework of the Millennium Development Goals (MDGs) established by the year 2015. Moreover, the UN has identified the promotion of economic growth, the alleviation of poverty and hunger, the facilitation of basic education, and the promotion of gender equality as pivotal to human development. Among the 17 fundamental Sustainable Development Goals (SDGs) that the UN aspires to achieve by the year 2030, significant emphasis has been placed on the advancement of health and the amelioration of issues such as hunger, poverty, education, gender equality, hygiene, and inequality, all of which are instrumental in fostering human development. In this regard, it is imperative for nations to prioritize the formulation of studies that address these areas within their respective agendas, with the objective of effecting tangible improvements.

The principal limitation encountered in studies employing secondary data is the absence of suitable variable and country data for the targeted year. In addressing this challenge, this study employed a diverse set of year-specific data for the variables under consideration. In such instances, data from adjacent years is favored. While this is not an optimal solution, it aligns with the findings of analogous studies in the extant literature. These studies suggest that when direct access to data for the desired year is not possible, data from the closest year can be utilized. In studies that span multiple countries, the presence of incomplete and non-standard statistics poses significant challenges to effective comparison and analysis.

Cluster analysis is a simple and interpretable method for classifying complex data sets according to specific variables and providing decision-makers with guidance. In future studies, the application of various clustering methods to the same data set will facilitate a comparative analysis of the outcomes produced by these methods and the distribution of data groups. Furthermore, the relationship between human development, mortality rates, and health expenditures can be examined using panel regression analysis based on a time period belonging to different years. Furthermore, studies that utilize health indicators derived from disparate databases are poised to further enrich the existing body of knowledge.

Ethics Committee Approval: This study does not require ethics committee approval.

REFERENCES

Akın, P., & Koc, T. (2021). Prediction of human development index with health indicators using tree-based regression models. *Adıyaman University Journal of Science, 11*(2), 410-420.

Alijanzadeh, M., Asefzadeh, S., & Moosaniaye, Z. S. A. (2016). Correlation between human development index and infant mortality rateworldwide. *Biotech Health Sciences, 3*(1), e35330.

Alpar, R. (2013). *Çok değişkenli istatistiksel yöntemler (4. Bs.).* Detay Yayıncılık, Ankara.

Altaş, D., & Arikan, G. (2017). The analysis of human development index with cluster analysis techniques. *Social Sciences Research Journal, 6*(3), 126-138.

Anand, S., & Sen, A. (2000). The income component of the human development index. *Journal of Human Development, 1*(1), 83-106.

Arntzen, A., Samuelsen, S. O., Bakketeig, L. S., & Stoltenberg, C. (2004). Socioeconomic status and risk of infant death. A population-based study of trends in Norway, 1967–1998. *International Journal of Epidemiology, 33*(2), 279-288.

Babiarz, P., Grabiński, T., Migała-Warchoł, A., & Szczygieł, E. (2018). The application of customized human development index to the analysis of socio-economic development of the European Union member states. *Economics & Sociology, 11*(4), 332.

Chu, K. C., Miller, B. A., & Springfield, S. A. (2007). Measures of racial/ethnic health disparities in cancer mortality rates and the influence of socioeconomic status. *Journal of the National Medical Association, 99*(10), 1092.

Coşar, K. (2020). *OECD sağlık verilerinin veri madenciliği yöntemleri ile analizi.* Yüksek Lisans Tezi, Marmara Üniversitesi, İstanbul.

Crémieux, P. Y., Ouellette, P., & Pilon, C. (1999). Health care spending as determinants of health outcomes. *Health Economics, 8*(7), 627-639.

Dobesova, Z. (2024). Evaluation of Orange data mining software and examples for lecturing machine learning tasks in geoinformatics. *Computer Applications in Engineering Education,* e22735.

Doorslaer, E. V., & Koolman, X. (2004). Explaining the differences in income- related health inequalities across European countries. *Health Economics, 13*(7), 609-628.

Fahmiyah, I., & Ningrum, R. A. (2023). Human development clustering in Indonesia: Using K-means method and based on Human Development Index categories. *Journal of Advanced Technology and Multidiscipline, 2*(1), 27-33.

Ferreira, L., & Hitchcock, D. B. (2009). A comparison of hierarchical methods for clustering functional data. *Communications in Statistics-Simulation and Computation, 38*(9), 1925-1949.

Güloğlu, H., Güloğlu, B., & Güven, M. (2018). K means clustering analysis of the determinants of Human Development Index for the member states of the Organization for Islamic Cooperation. Eurasian Academy of Sciences Eurasian Econometrics, *Statistics & Emprical Economics Journal, 11*, 67- 77.

Hakobyan, M., Mkrtchyan, A., & Yepiskoposyan, L. (2006). Infant mortality in Armenia, 1992–2003. *Economics & Human Biology, 4*(3), 351-358.

Hands, S., & Everitt, B. (1987). A Monte Carlo study of the recovery of cluster structure in binary data by hierarchical clustering techniques. *Multivariate Behavioral Research, 22*(2), 235-243.

Khosravi, A., & Rahbar, M. R. (2009). *Health profile indicators in the Islamic Republic of Iran.* Ministry of Health & Medical Education Deputy for Health, Iran.

Krylovas, A., Kosareva, N., & Dadelo, S. (2020). European countries ranking and clustering solution by children's physical activity and human development index using entropy-based methods. *Mathematics, 8*(10), 1705.

Mirahsani, Z. (2016). The relationship between health expenditures and human development index. *Journal of Research & Health, 6*(3), 373- 377.

Miranda- Lescano, R., Muinelo- Gallo, L., & Roca- Sagalés, O. (2023). Human development and decentralization: The importance of public health expenditure. *Annals of Public and Cooperative Economics, 94*(1), 191-219.

Morse, S. (2014). Stirring the pot. Influence of changes in methodology of the Human Development Index on reporting by the press. *Ecological Indicators, 45,* 245-254.

Mylevaganam, S. (2017). The analysis of Human Development Index (HDI) for categorizing the member states of the United Nations (UN). *Open Journal of Applied Sciences, 7*(12), 661-690.

Nixon, J., & Ulmann, P. (2006). The relationship between health care expenditure and health outcomes: Evidence and caveats for a causal link. *The European Journal of Health Economics, 7,* 7-18.

Nuhu, K. M., McDaniel, J. T., Alorbi, G. A., & Ruiz, J. I. (2018). Effect of healthcare spending on the relationship between the Human Development Index and maternal and neonatal mortality. *International Health*, 10(1), 33-39.

OECD (2024). Retrieved from https://www.oecd.org/ (Accessed 06.10.2024).

Orange, 2024. Retrieved from http://orange.biolab.si/. (Accessed 01.10.2024).

Peters, D. H., Garg, A., Bloom, G., Walker, D. G., Brieger, W. R., & Hafizur Rahman, M. (2008). Poverty and access to health care in developing countries. *Annals of the New York Academy of Sciences, 1136*(1), 161-171.

Polat, E. (2021). The classification of countries' Human Development Index level under economic inequality by using data mining classification algorithms. *Romanian Statistical Review, 4,* 27-44.

Prados De La Escosura, L. (2015). World human development: 1870–2007. *Review of Income and Wealth, 61*(2), 220-247.

Reidpath, D. D., & Allotey, P. (2003). Infant mortality rate as an indicator of population health. *Journal of Epidemiology & Community Health, 57*(5), 344-346.

Repiská, R., Grisáková, N., & Štetka, P. (2022). Hierarchical clustering based on international sustainability indices of EU countries. *Ekonomické rozhľady–Economic Review, 51*(2), 149-170.

Reyes, G. E., & Useche, A. J. (2019). Competitiveness, economic growth and human development in Latin American and Caribbean countries 2006-2015: A performance and correlation analysis. *Competitiveness Review: An International Business Journal, 29*(2), 139-159.

Rohani, H. S., Ahmadvand, A., & Garmaroudi, G. (2018). The relationship between important reproductive health indices and human development index in Iran. *Medical Journal of the Islamic Republic of Iran, 32,* 54.

Stanton, E. A. (2007). *The Human Development Index: A history, Working Papers wp127,* Political Economy Research Institute, University of Massachusetts at Amherst.

Sulkowski, A., & White, D. S. (2016). A happiness Kuznets curve? Using model-based cluster analysis to group countries based on happiness, development, income, and carbon emissions. *Environment, Development and Sustainability, 18*, 1095-1111.

Tebala, D., & Marino, D. (2023). Companies and artificial intelligence: an example of clustering with orange. In *Innovations and Economic and Social Changes due to Artificial Intelligence: The State of the Art* (pp. 1-12). Cham: Springer Nature Switzerland.

Tekin, B. (2018). Ward, k-ortalamalar ve iki adimli kümeleme analizi yöntemleri ile finansal göstergeler temelinde hisse senedi tercihi. *Balıkesir Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 21*(40), 401-436.

Tekin, B., & Gümüş, F. B. (2017). The classification of stocks with basic financial indicators: An application of cluster analysis on the BIST 100 index. *International Journal of Academic Research in Business and Social Sciences, 7*(5), 1-32.

United Nations, (2007). *The millennium development goals report.* NewYork

United Nations Children's Fund, (2017). Monitoring the situation of children and women. Retrieved from https://data.unicef.org/topic/education/literacy/ (Accessed 14.02.2025).

United Nations Development Program (2001). *Human Development Report 2001. Making New Technologies Work for Human Development.* Oxford University Press. New York.

United Nations Development Program, (2014). UNDP, Human Development Report. New York.

World Health Organization, (2020). *Children: Reducing mortality fact sheet.* Retrieved from http://www.who.int/mediacentre/factsheets/fs178/en/ (Accessed 14.02.2025).

World Health Organization, (2021). *Maternal mortality fact sheet.* Retrieved from https://www.who.int/europe/news-room/fact-sheets/item/maternal-mortality (Accessed 14.02.2025).

World Health Organization-Global Health Observatory, (2024). – processed by Our World in Data. Retrieved from https://ourworldindata.org/financing-healthcare (Accessed 01.10.2024).

Yakut, E., Gunduz, M., & Demirci, A. (2015). Comparison of classification success of human development index by using ordered logistic regression analysis and artificial neural network methods. *Journal of Applied Quantitative Methods, 10*(3), 15-34.

Yalçın, A. Z., & Çakmak, F. (2016). Türkiye'de kamu sağlık harcamalarının insani gelişim üzerindeki etkisi. *Atatürk Üniversitesi İktisadi ve İdari Bilimler Dergisi, 30*(4), 705-724.