

## RESEARCH ARTICLE

## EXPLANATION OF MORTALITY RATES WITH SOCIO-ECONOMIC INDICATORS

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**Abstract**

This study aims to examine the relationship between death rates and socioeconomic variables and to develop policy recommendations to reduce mortality rates. Therefore, the variables of maternal mortality rate, crude mortality rate, and infant mortality rate are explained with real health expenditures per capita, number of nurse midwives, total health expenditures, number of physicians, and number of hospitals. The most recent data available between 2002 and 2019 are used in the article. Data are taken from health statistics annually. While three different mortality rates are considered as dependent variables in the study, five different variables indicating socioeconomic status are used as independent variables. Since more than one dependent and independent variable is used, canonical correlation analysis is preferred as the method. In the results of the analysis, it has been revealed that there is a high relationship between maternal mortality rate, infant mortality rate, crude death rate, and the number of hospitals, the number of nurses-midwives, the number of physicians, total health expenditures and per capita health expenditures. According to this, it is important to increase health awareness, increase the quality of health services in society, and facilitate access to health services. In addition, it is recommended to increase the number of health workers, improve health literacy in society and increase investments in the field of health.

**Keywords:** Canonic correlation analysis, mortality rate, socio-economic indicators, statistical analysis.n

## 1. INTRODUCTION

According to the definition of the World Health Organization (WHO), health is not only the absence of infirmity and disease but also a state of complete physical, mental and social well-being (WHO, 2006:1). Health is the basic need of every individual. Without your health, other goods and services have no value. Due to the desire of individuals to live healthy lives, the demand for health services is increasing. With the increase in demand, discussions about health services have increased (Witter, 2002:4). The World Health Organization defines that the main purpose of health systems is to improve, renew and maintain health (WHO,2000).

Maternal mortality rate, infant mortality rate and total death rate show a country's development level. While the death rate is low in developed countries, this rate is high in developing and underdeveloped countries. Reducing the death rate will both improve the health status of the country and increase the level of development of the country. Mortality is an indicator of development. The decrease in this rate shows the success of health and development programs (F., Lorcu, B., Acar Bolat, 2009). Thanks to the policies aimed at reducing the death rate, the life span of society will be extended and the quality of life of the people will increase.

Therefore, the variables of maternal mortality rate, crude mortality rate and infant mortality rate are explained as the real health expenditures per capita, the number of nurse midwives, the total health expenditures, the doctors per 1,000 people and the number of hospitals. The most up-to-date data available for the years 2002-2019 are used. The data are taken from the statistical annuals of the Turkish Statistical Institute and the Ministry of Health.

In Turkey's 2002 data, while the maternal mortality rate was 39 per 100000 people, it decreased to 13.1 in 2019. Similarly, the infant mortality rate was 27.5 in 2002, it reduced to 8.5 in 2019. However, the paternal mortality rate increased from 16.8 in 2002 to 18.4 in 2020.

More than one dependent and independent variable is used in the study. For this reason, "canonical correlation analysis" is preferred to reveal the relationship. Canonical Correlation Analysis (CCA) is used to examine the relationship between two sets of variables.

As a result of the CCA; the maternal mortality rate provides the greatest contribution to the first dependent canonical variable from mortality rates. The second largest contributor to the canonical variable is infant mortality rates. The crude death rate provides the lowest contribution.

## 2. LITERATURE

Hertz et al. (1994) considered life expectancy at birth, infant mortality rate and maternal mortality rate as dependent variables in their study. Nutritional factors, percentage of households without clean water and total literacy level are important variables in determining infant mortality rate. According

to the results of the analysis, maternal mortality rate and total energy consumption and excess energy consumption variables are significantly related.

Zakir and Wunnava (1999) aimed to determine the factors affecting infant mortality rate by using data from 112 countries in their study. They emphasize that Gross Domestic Product (GDP) and female literacy rate have a large impact on the infant mortality rate. However, they revealed that healthcare expenditures did not affect the infant mortality rate.

Liu (2007) investigated the effect of per capita income and hospital birth rate on maternal mortality rate in counties of China. Two variables were found to be effective on maternal mortality rate. She concluded that the maternal mortality rate is 100.9 per 100000 live births in low-income districts, and 68.1 per 100000 live births in high-income districts.

Schell et al. (2007) explained the infant mortality rate with socioeconomic indicators (female literacy rate, per capita GDP, Gini index, public health expenditures, poverty rate). They analyzed data from 152 low-, middle- and high-income countries using regression analysis. In low-income countries, the female literacy variable was found to be more important than the GDP variable. The Gini index is significant in middle-income countries but insignificant in high-income countries.

Farahani et al. (2009) worked with a dataset of 99 countries at 5-year intervals between 1960 and 2000. They investigated the effect of changes in the number of doctors per capita on infant mortality in the short term and long term. In the study, it is concluded that if the number of available doctors is doubled, infant mortality rates are reduced by 15% in the short term and 50% in the long term.

Lorcu and Bolat, (2009) examined the relationship between death rates by age and socio-economic indicators with canonical correlation analysis. While death rates by age were used as a dependent variable, socio-economic indicators were used as independent variables. According to the results of the study, infant, under-five, 5-14 and over 60-year-old mortality rates are highly correlated with literacy, unemployment and GDP per capita.

Suriyakala (2016) aimed to determine the factors affecting the infant mortality rate by using the variables of fertility rate, national income, women in labour force, expenditure on health care. The data were analyzed with the regression model. It made recommendations to reduce mortality rates.

Azuh et al. (2017) aimed to determine the non-medical factors that may be effective in maternal death. A survey was conducted with 360 randomly selected individuals from rural and semi-rural communities in Nigeria. They said that strengthening maternal health services and the status of women can be effective in reducing maternal mortality rates.

Baraki (2020) worked with 2016 Ethiopian data. Infant mortality was explained by the variables of infant gender, mass birth and premature birth. Data were analyzed using a multivariate logistic regression model. He revealed that baby gender and mass births are effective on infant mortality.

Lamichhane et al. (2017) used the 2006 and 2011 datasets in the Nepal Demographic and Health Surveys. Two surveys were conducted to explain infant mortality. Multistage stratified cluster sampling techniques were used in the study. The ecological region, next birth interval, breastfeeding status and maternity assistance were determined as important determinants of infant mortality. Babies born with professional help have a lower risk of death. They found that infants who never received breast milk had a higher risk of death.

In the studies we examined in the literature, mortality rate variables are generally explained with socio-economic indicators, education, employment, population, and health services indicators. In our study, we explained mortality rates with socio-economic and health services indicators.

### 3. MATERIAL AND METHODS

In the study, variables of maternal mortality rate, crude mortality rate, and infant mortality rate are explained with real health expenditures per capita, number of nurse midwives, total health expenditures, number of physicians, and number of hospitals. In the article, canonical correlation analysis is preferred as the method. Because more than one dependent and independent variable is used.

#### 3.1. Data

In the study, the most recent data available between 2002 and 2019 years are used. The variables in table 1 are used in the article.

**Table 1.** Variables

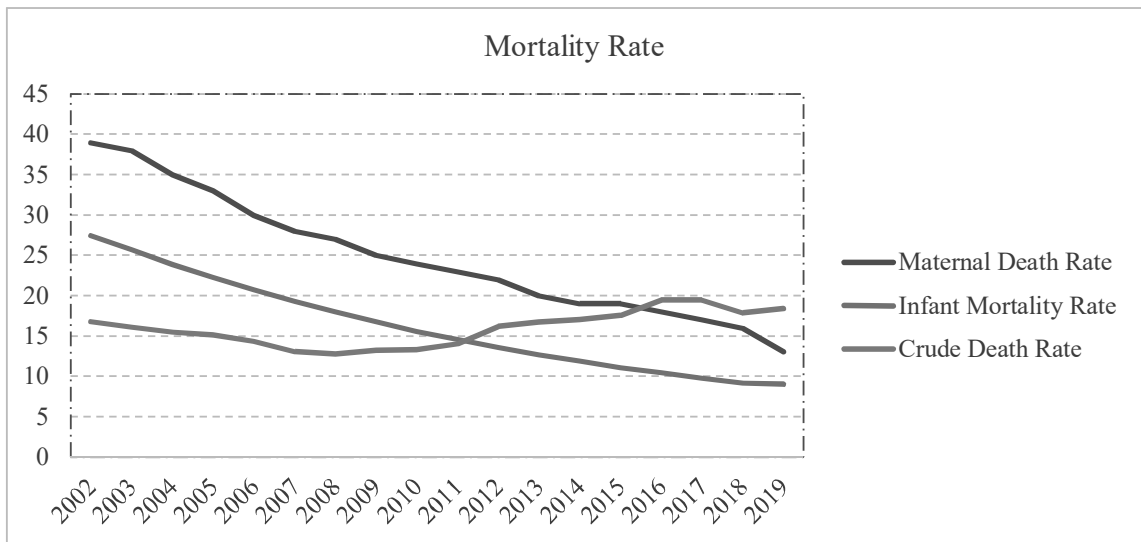
Dependent Variables	Independent Variables
Infant Mortality Rate	Total Health Expenditures
Maternal Death Rate	Per Capita Health Expenditures
Crude Death Rate	Number of Nurses-Midwives
	Number of Physicians
	Number of Hospitals

Infant mortality refers to infants who die under 1 year of age. The infant mortality rate gives the number of infants who die per 1000 live births in a year (Tüylüoğlu and Tekin, 2009). It is calculated by dividing the total number of babies born that year by the number of babies born that year and multiplying by 1000. This rate is one of the most important parameters that show the health, development, and

mother-child health status of a country. It is one of the most important success criteria of the health system (Aydın and Aba, 2018).

Maternal death is the death that occurs during pregnancy, during childbirth or 42 days (6 weeks) after birth from any cause within a year. The maternal mortality rate is calculated by dividing the number of female deaths during pregnancy, childbirth, and puerperium by the number of females aged 15-49 and multiplying by 100000 (Tezcan, 2017). The maternal mortality rate determines the level of women’s health in society. It is an important criterion that shows whether the services in this area are sufficient or not.

The crude death rate is calculated from the number of deaths from disease or general causes. The rate is obtained from the number of deaths per 1000 people, usually calculated annually. It is calculated by dividing the number of deaths in a year by the population. The low mortality rate indicates the quality of health services in a country and the development of the country. Death rates provide information about socioeconomic status.

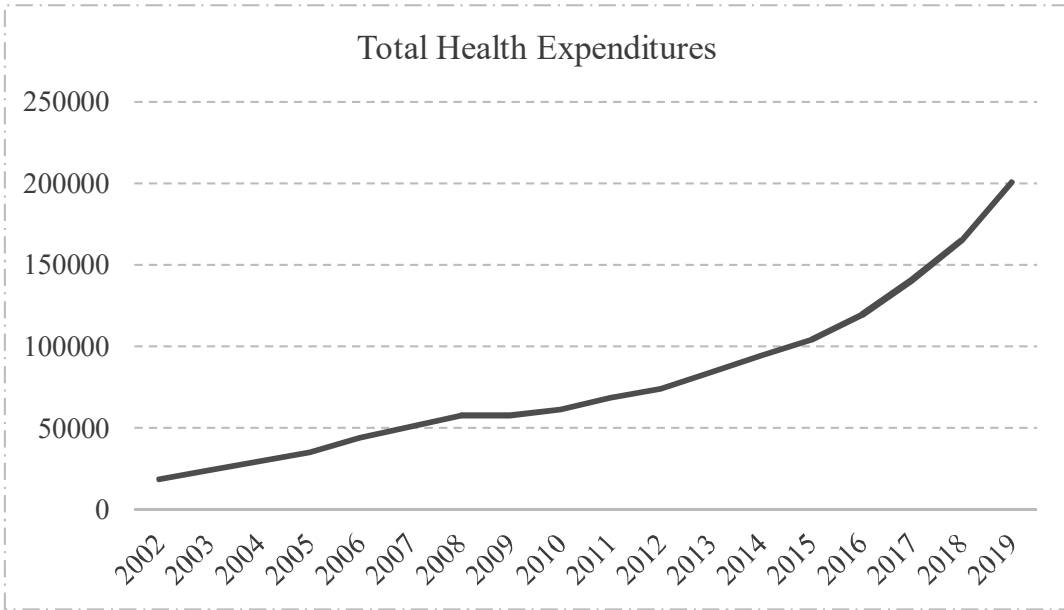


**Figure 1.** Mortality Rate

According to Figure 1, the maternal mortality rate decreased from 39 per 100,000 people in 2002 to 13.1 in 2019. While the infant mortality rate was 27.5 in 2002, it decreased to 8.5 in 2019. However, it is seen that the crude death rate increased from 16.8 in 2002 to 18.4 in 2019.

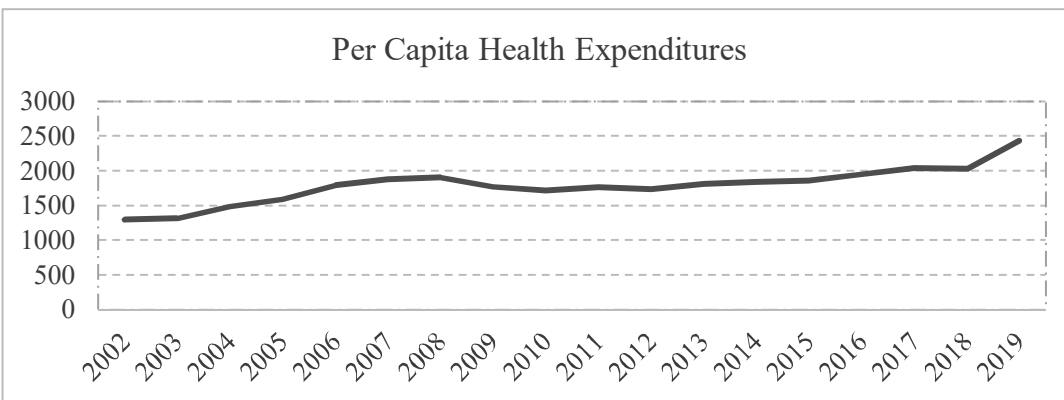
Health expenditures are expenditures made to provide the services necessary for a healthy society in a country. These expenditures include investments made not only for the healing of diseases but also

for the prevention of diseases that may occur (Loş, 2016). As the quality of life in individuals increases, the budget allocated to health expenditures also increases. Developed countries have high health expenditures (Atalan, 2018).



**Figure 2.** Total Health Expenditures

When Figure 2 is examined, total health expenditures increased from 18774 million in 2002 to 210131 million in 2019.

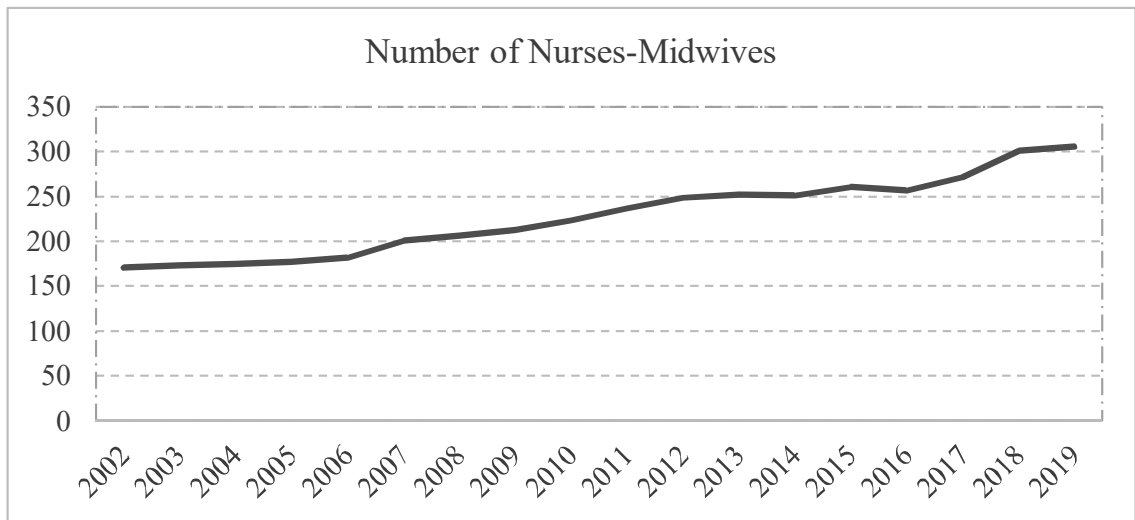


**Figure 3.** Per Capita Health Expenditures

While per capita health expenditures were 1294 million in 2002, it increased to 2434 million in 2019.

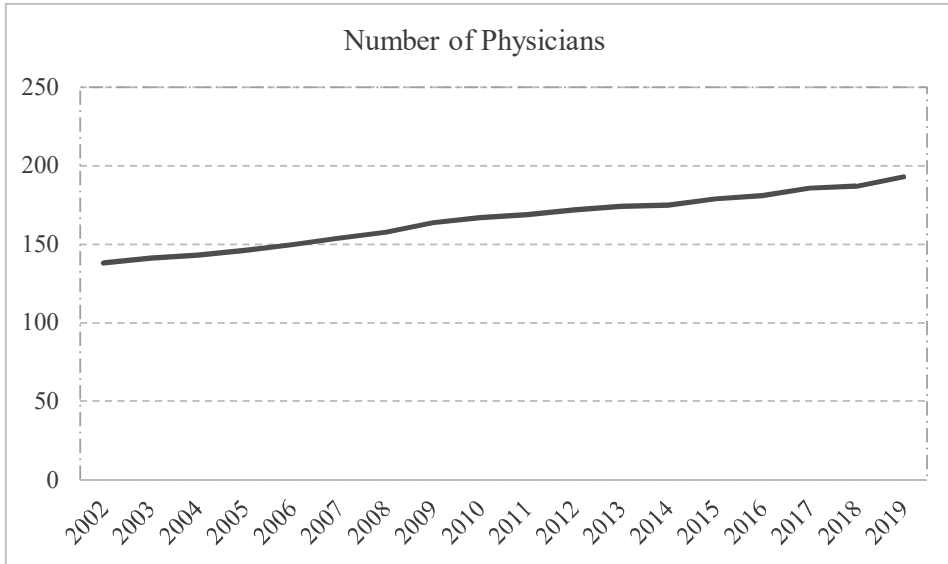
The first element of a society's health system is doctors, nurses and health technicians. For this reason, the education of doctors and other health workers is given importance in countries. The shortage in the number of doctors causes the effectiveness of the health system in the country to deteriorate. The increase in the number of doctors, nurses and midwives increases the level of health positively (Göztepe, 2017). One of the factors affecting the decrease in deaths is the quality of health services in the country. Health service is primarily based on trained manpower.

Social equality, which is one of the basic principles of health services, can be achieved by everyone receiving health services equally. To receive the service equally, there should be a sufficient number of doctors, nurses and midwives in health institutions.



**Figure 4.** Number of Nurses-Midwives

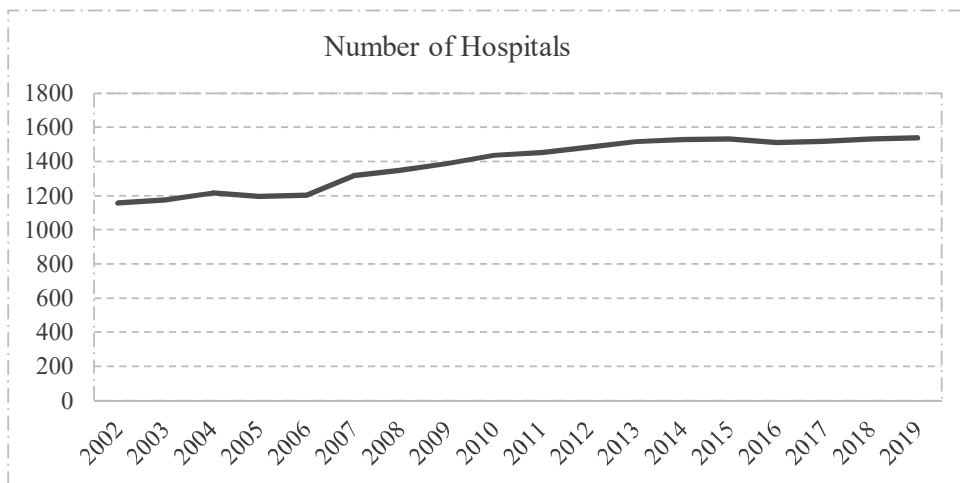
When the graph is examined, it is seen that while the number of nurses-midwives per 100000 people was 171 in 2002, this rate was 342 in 2019.



**Figure 5.** Number of Physicians (Per 1000 People)

It is seen that the number of physicians per 100000 people in 2002 was 138, and this number increased to 205 in 2019.

The number of hospitals should be sufficient to reach health services on time. More patients are reached through easier access to health services. Thus, the life span of individuals is extended and their quality-of-life increases.



**Figure 6.** Number of Hospitals

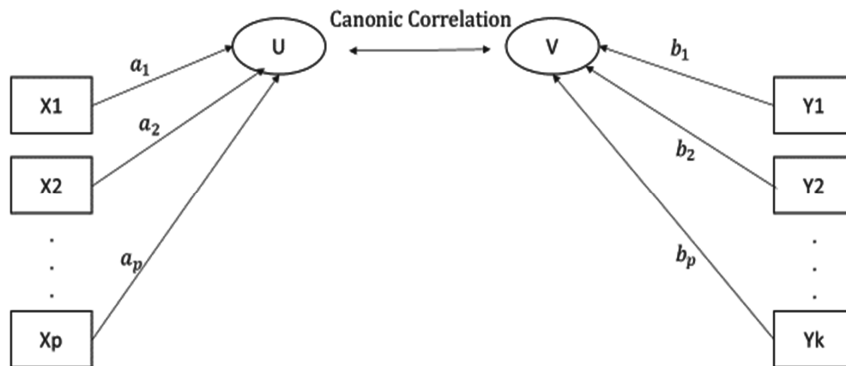


In Figure 6, it is seen that while the number of hospitals was 1156 in 2002, this number increased to 1534 in 2019.

### 3.2. Canonic Correlation Analysis

Canonical Correlation Analysis (CCA) is one of the multivariate analysis methods. CCA is an extension of multiple regression analysis. In multiple regression analysis, the relationship between one dependent and more than one independent variable is investigated. Canonical correlation analysis is used when it is necessary to investigate the relationship between more than one dependent and more than one independent variable. CCA is accepted as a generalized form of multiple regression analysis (Levine, 1977). This analysis is used to examine the relationship between two sets of variables with many variables. It divides many variables into two subsets, allowing us to obtain a small number of linear components of the variable. Interpretation of the relationship between variables becomes easier (Lorcu, Bolat, 2009).

CCA does not require a dependent or independent relationship between two variable groups. However, we can use one group of variables as dependent and the other variable group independently. In this analysis method, one of the variable sets is considered as dependent and the other as independent. New variables are produced from linear combinations of variables in each set (Hair et al., 2010). These new variables are called canonical variables. It is aimed to maximize the correlation between new variables (Tabachnick and Fidell, 2007).



**Figure 7.** General Structure of Canonical Correlation Analysis

$$X = \begin{bmatrix} X1 \\ \vdots \\ Xp \end{bmatrix} \tag{1}$$

$$Y = \begin{bmatrix} Y1 \\ \vdots \\ Yq \end{bmatrix} \tag{2}$$

Canonical correlation analysis is derived from the linear components of independent variables (X) and p dependent variables (Y) consisting of n observations. (Tacq, 1999).

CCA is known as a powerful method to reveal the relationships between two sets of variables. This analysis method aims to find the linear functions of two variable sets in the form that will show the highest correlation.

$$b_{i1}Y_{i1} + b_{i2}Y_{i2} + \dots + b_{ip}Y_{ip} \quad a_{i1} X_{i1} + a_{i2} X_{i2} + \dots + a_{iq} X_{iq} \quad (3)$$

The  $a_{ip}$  and  $b_{iq}$  coefficients represent the canonical weights.

Dependent and independent canonical variables are shown as follows (Levine, 1977).

$$U_1 = \alpha_{11}X_1 + \alpha_{12}X_2 + \dots + \alpha_{1q}X_q \quad (4) \quad V_1 = \beta_{11}Y_1 + \beta_{12}Y_2 + \dots + \beta_{1p}Y_p \quad (7)$$

$$U_2 = \alpha_{21}X_1 + \alpha_{22}X_2 + \dots + \alpha_{2q}X_q \quad (5) \quad V_2 = \beta_{21}Y_1 + \beta_{22}Y_2 + \dots + \beta_{2p}Y_p \quad (8)$$

$$\begin{matrix} \cdot \\ \cdot \\ \cdot \end{matrix}$$

$$U_s = \alpha_{s1}X_1 + \alpha_{s2}X_2 + \dots + \alpha_{sq}X_q \quad (6) \quad V_s = \beta_{s1}Y_1 + \beta_{s2}Y_2 + \dots + \beta_{sp}Y_p \quad (9)$$

q is the number of variables belonging to the argument set.

p represents the number of variables belonging to the dependent variable set.

s represents the number of variables of the set with the fewest variables.

$U_i$  is the independent canonical variable. It represents the linear combination of independent variables in the equation.

$V_i$  is the dependent canonical variable. It expresses the linear combination of dependent variables.

In CCA, the number of variables in the data sets does not have to be equal. In the analysis, new variables are produced with linear composites of the variables located between two variable sets. The correlation between these new variables is aimed to be maximum and unit variance.

The first canonical function indicates the relationship between the first independent canonical variable (U1) and the first dependent canonical variable (V1). The correlation between U1 and V1 gives the maximum canonical correlation coefficient. The canonical correlation coefficient is calculated as follows (Press and James 1972).

The canonical correlation coefficient is calculated as follows (Press, 1984).

$$\text{Cor}(U,V)=\frac{\text{Cov}(U,V)}{\sqrt{(\text{Var}(V)\text{Var}(U))}} \quad (10)$$

Canonical correlation takes values between 0 and +1. Canonical correlation value of 1 indicates a perfect linear relationship between the two sets. A canonical correlation value between 0.9 and 1 indicates a very high relationship between sets, while a value between 0 and 0.25 indicates a weak relationship.

The square of the canonical correlation is equal to the “eigenvalue” (Tabachnick and Fidell, 2007). The eigenvalue indicates the size of the common variance between the dependent canonical variable and the independent canonical variable (Hair et al., 2010). It includes the rate of variance explained by the independent variable in the dependent variable and the rate of variance explained by the dependent variable in the independent variable (Tacq, 1999). Analysis results are interpreted with the help of “canonical weight”, “canonical load”, “canonical cross load”, “explained variance ratio” and “redundancy index”.

The simple linear correlation between the original variable and the canonical variable is called “canonical load” (Lattin et al., 2003). High correlation indicates that the contribution of the related variable to its canonical variable is strong. Canonical cross load; It refers to the simple linear correlation between the original dependent variables and the independent canonical variables, or the correlation between the original independent variables and the dependent canonical variables (Hair et al., 2010). It shows the strength of the contribution of the highly correlated variable to the canonical variable in the cross-set.

### 3.3. Analysis Results

The analysis is carried out with IBM SPSS 23 package program.

According to correlation analysis, it is seen that the relationship between maternal mortality rate, infant mortality rate and crude death rate, number of hospitals, number of nurses-midwives, number of physicians, and total health expenditures are high.

In table 2, there is no statistically significant relationship between crude death rate and per capita health expenditures. But there is a significant relationship between other variables and per capita health expenditures. In addition, these relationships are strong.

Table 2. Correlations Between Original Variables

(Pearson Correlation=Cor.) Sig. (2-tailed)		Maternal Death Rate	Infant Mortality Rate	Crude Death Rate	Per Capita Health Expenditures	Number of Nurses- Midwives	Total Health Expenditures	Number of Physicians	Number of Hospitals
Maternal Death Rate	Cor.	1	0.995	-0.473	-0.879	-0.960	-0.898	-0.988	-0.965
	Sig.		0.000	0.047	0.000	0.000	0.000	0.000	0.000
Infant Mortality Rate	Cor.	0.995	1	-0.493	-0.841	-0.957	-0.880	-0.988	-0.974
	Sig.	0.000		0.038	0.000	0.000	0.000	0.000	0.000
Crude Death Rate	Cor.	-0.473	-0.493	1	0.320	0.599	0.658	0.559	0.454
	Sig.	0.047	0.038		0.196	0.009	0.003	0.016	0.058
Per Capita Health Expenditures	Cor.	-0.879	-0.841	0.320	1	0.822	0.881	0.848	0.746
	Sig.	0.000	0.000	0.196		0.000	0.000	0.000	0.000
Total Health Expenditures	Cor.	-0.960	-0.957	0.599	0.822	1	0.950	0.983	0.938
	Sig.	0.000	0.000	0.009	0.000		0.000	0.000	0.000
Number of Nurses- Midwives	Cor.	-0.898	-0.880	0.658	0.881	0.950	1	0.929	0.811
	Sig.	0.000	0.000	0.003	0.000	0.000		0.000	0.000
Number of Physicians	Cor.	-0.988	-0.988	0.559	0.848	0.983	0.929	1	0.961
	Sig.	0.000	0.000	0.016	0.000	0.000	0.000		0.000
Number of Hospitals	Cor.	-0.965	-0.974	0.454	0.746	0.938	0.811	0.961	1
	Sig.	0.000	0.000	0.058	0.000	0.000	0.000	0.000	

After testing the significance of the canonical correlation coefficients, “canonical load” and “canonical cross load” results can be interpreted for meaningful functions. In the analysis, canonical correlations can be calculated as much as the number of variables in the set with the least number of variables (Tacq, 1999). Since there are 5 independent and 3 dependent variables in the study, the number of canonical functions and canonical correlation coefficient that can be calculated is 3.

According to the Barlett test calculated for the significance of the canonical correlation coefficient, Wilk’s chi-square value shows  $\chi^2$  distribution in  $pxq$  degrees of freedom.

$H_0: \rho_1 = \rho_2 = \rho_3$  (Canonical correlations all equal zero)

$H_a$  At least one is nonzero

When the  $H_0$  hypothesis is rejected, the largest canonical correlation coefficient is subtracted from the hypothesis. The process is continued until the canonical correlation coefficients are not significant or until all the variables are exhausted (Tacq, 1999).  $H_0$  hypothesis is rejected when probability value  $< \alpha=0.05$ .

First, the results of the significance test of these three canonical correlations should be checked. When we look at the significant value according to the Wilks Lambda test result in the SPSS analysis output (Table 1), it is seen that the probability values of the three canonical variables are below 0.05. That is, all canonical correlations are statistically significant and can be interpreted. The first canonical correlation coefficient is (0.997). In the second canonical function, the relationship between the dependent and independent canonical variable (0.856) and the third canonical correlation coefficient (0.723) are calculated.

**Table 3.** Canonical Correlations

	Correlation	Wilks Statistic	F	Sig.
1	0.997	0.001	24.584	0.000
2	0.856	0.127	4.953	0.001
3	0.723	0.478	4.377	0.027

$$v_1 = -0.98y_1 - 0.032y_2 - 0.026y_3 \quad (11)$$

$$v_2 = 1.063y_1 - 0.559y_2 + 1.117y_3 \quad (12)$$

$$v_3 = 10.146y_1 - 10.363y_2 - 0.359y_3 \quad (13)$$

$$u_1 = 0.306x_1 + 0.082x_2 - 0.297x_3 + 0.74x_4 + 0.191x_5 \quad (14)$$

$$u_2 = -2.129x_1 - 2.665x_2 + 3.712x_3 + 0.76x_4 + 0.379x_5 \quad (15)$$

$$u_3 = -1.145x_1 - 0.295x_2 - 1.87x_3 + 3.633x_4 - 0.648x_5 \quad (16)$$

When the canonical loads belonging to the dependent set are examined, maternal mortality rate (-1.000) provides the greatest contribution to the first dependent canonical variable among the mortality rates. It provides the second largest contribution to the canonical variable (0.454) and the lowest contribution.

Crude death rate with 0.890 provides the biggest contribution to the second dependent canonical variable among mortality rates. Infant mortality rate makes a low contribution to the canonical variable at the rate of -0.052. Maternal mortality rate, on the other hand, provides the lowest contribution with -0.22.

When we examine the contributions made to the third dependent canonical variable, infant mortality rate made the highest contribution with -0.091. However, it has a very low contribution compared to the first and second canonical variables.

**Table 4.** Set 1 Canonical Loadings and Cross Loadings

Variable	Set 1 Canonical Loadings			Set 1 Cross Loadings		
	1	2	3	1	2	3
Maternal Death Rate	-1.000	-0.022	0.004	-0.997	-0.019	0.003
Infant Mortality Rate	-0.995	-0.052	-0.091	-0.992	-0.045	-0.066
Crude Death Rate	0.454	0.890	-0.049	0.453	0.762	-0.036

When the cross canonical loads of the dependent set are examined, similarly, maternal mortality rate (-0.997) made the highest contribution in the first canonical variable. Crude Death Rate (0.762) made the highest contribution to the second canonical variable. Infant Mortality Rate (-0.066) made the highest contribution to the third canonical variable.

According to the canonical loads of the independent set, the first independent canonical variable provides the largest number of physicians (0.988). Subsequently, the number of hospitals (0.967), the number of nurses-midwives (0.959), total health expenditures (0.893), per capita health expenditures (0.883) variables contribute to the canonical variable, respectively.

**Table 5.** Set 2 Canonical Loadings and Cross Loadings

Variable	Set 2 Canonical Loadings			Set 2 Cross Loadings		
	1	2	3	1	2	3
Per Capita Health Expenditures	0.883	-0.125	-0.436	0.880	-0.107	-0.315
Number of Nurses-Midwives	0.959	.214	-0.050	0.956	0.183	-0.036
Total Health Expenditures	0.893	0.318	-0.308	0.891	0.272	-0.223
Number of Physicians	0.988	0.147	0.011	0.986	0.126	0.008
Number of Hospitals	0.967	0.031	0.198	0.965	0.027	0.143

While total health expenditure (0.318) contributed the most to the second independent canonical variable, the second largest contribution is made by the number of nurses-midwives (0.214).

Health expenditure per capita (0.436) is made the highest contribution to the third independent canonical variable, total health expenditure (-0.308) is made the second largest contribution.

When the cross canonical loads of the independent set are examined, the highest contribution to the first canonical variable is Health Expenditures per Capita (0.880). Total Health Expenditures (0.273) made the highest contribution to the second canonical variable. Per Capita Health Expenditures (-0.315) made the highest contribution to the third canonical variable.

## 4. CONCLUSION

In the study, the causal relationship between death rates and socio-economic indicators is investigated. More than one dependent and more than one independent variable is used in the article. For this reason, "canonical correlation analysis" is preferred to reveal the relationship.

When correlation analysis are examined; It is seen that there is a strong relationship between death rates and socio-economic variables (0.997, 0.856, 0.723).

According to canonical correlation analysis, The number of hospitals, the number of nurses-midwives, the number of physicians, total health expenditures and per capita health expenditures are important variables in determining mortality rate.

The most important indicators of public health are maternal mortality rate, crude death rate and infant mortality rate. In order for countries to reach the level of high-income countries, public awareness should be raised. In addition, there is a need for systemic adjustments and developments. Various policy recommendations for this are recommended below.

- Awareness studies should be carried out to increase the health awareness of the society/ individuals.
- Prenatal and postnatal care and baby-child follow-ups determined by the Ministry of Health should be carried out in a timely and effective manner.
- The effectiveness of necessary trainings in health services should be increased.
- Studies should be carried out to increase the quality of health services in the community.
- Access to health services should be facilitated.
- The number of health workers should be increased.
- Improvement of health literacy in the society should be ensured.
- Investments in the field of health should be increased.

Thanks to all these recommendations, it is predicted that there will be a decrease in death rates. In addition, recording and sharing health data will contribute to the development of the field of health by paving the way for studies in this field.

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