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Socioeconomic Determinants of Infant Mortality in Turkey: The Role of Physician Density, Urbanization, Gender Equality, and Economic Growth

Türkiye'de Bebek Ölüm Oranlarının Sosyoekonomik Belirleyicileri: Hekim Yoğunluğu, Kentleşme, Toplumsal Cinsiyet Eşitliği ve Ekonomik Büyümenin Rolü

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ABSTRACT

Infant mortality rates can be said to be an important indicator of the health and welfare level of a society. The primary objective of this study is to reveal the effects of physician density, urbanization rate, gender equality and economic growth on infant mortality rates in Turkey using time series data for the period 1990-2020. In this study, the Autoregressive Distributed Lag (ARDL) method was applied to reveal the short- and long-term dynamics of the relationships between variables. The findings show that the increase in physician density significantly reduces infant mortality rates and that access to health services is a critical element. The positive and negative effects of urbanization were evaluated in this study. In addition, gender equality stands out as an important factor in reducing infant mortality rates. Contrary to expectations, no direct significant effect of economic growth on infant mortality rates was detected. The results emphasize the need for comprehensive policies to improve health infrastructure, support gender equality and ensure equal access to resources.

Keywords: *Infant Mortality, Physician Density, Urbanization, Gender Equality, Economic Growth, ARDL, Turkey.*

ÖZET

Bebek ölüm oranları, bir toplumun sağlık ve refah seviyesinin önemli bir göstergesi olduğu söylenebilir. Bu çalışmanın öncelikli amacı, Türkiye'de bebek ölüm oranları üzerindeki hekim yoğunluğu, kentleşme oranı, toplumsal cinsiyet eşitliği ve ekonomik büyümenin etkilerini 1990-2020 dönemine ait zaman serisi verilerini kullanarak ortaya çıkarmaktır. Bu çalışmada, değişkenlere ait ilişkilerin kısa ve uzun dönemli dinamiklerini ortaya çıkarmak amacıyla Otoregresif Dağıtılmış Gecikme (ARDL) yöntemi uygulanmıştır. Bulgular, hekim yoğunluğundaki artışın bebek ölüm oranlarını anlamlı şekilde azalttığını ve sağlık hizmetlerine erişimin kritik bir unsur olduğunu göstermektedir. Kentleşmenin hem olumlu hem de olumsuz etkilerinin değerlendirildiği bu çalışmada, toplumsal cinsiyet eşitliğinin bebek ölüm oranlarının düşürülmesinde önemli bir faktör olarak öne çıktığı anlaşılmaktadır. Beklentilerin aksine, ekonomik büyümenin bebek ölüm oranları üzerinde doğrudan anlamlı bir etkisi tespit edilememiştir. Sonuçlar, sağlık altyapısının iyileştirilmesi, toplumsal cinsiyet eşitliğinin desteklenmesi ve kaynaklara eşit erişimin sağlanmasına yönelik kapsamlı politikaların gerekliliğini vurgulamaktadır.

Anahtar Kelimeler: Bebek Ölüm Oranı, Hekim Yoğunluğu, Kentleşme, Toplumsal Cinsiyet Eşitliği, Ekonomik Büyüme, ARDL, Türkiye.

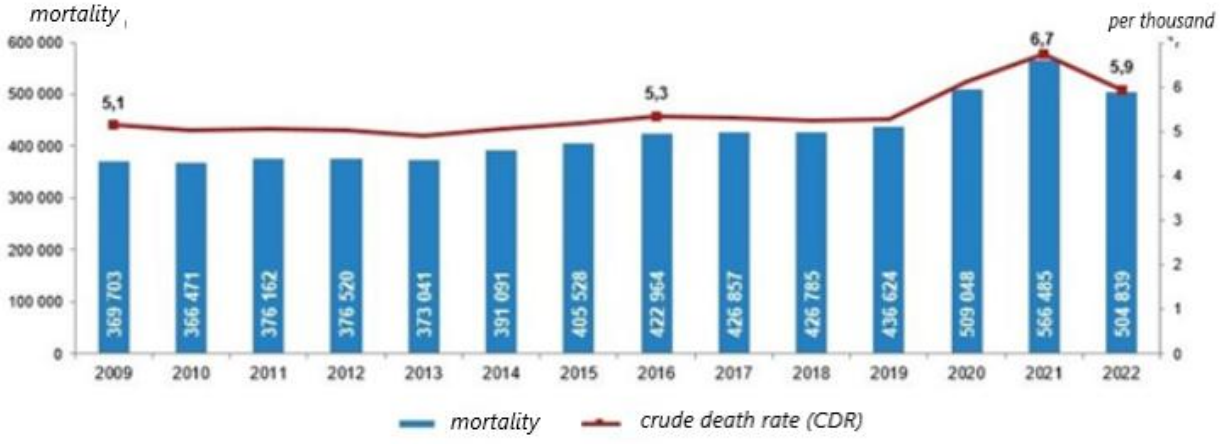
1. INTRODUCTION

Infant mortality rates are an important indicator of the health status and welfare level of a society. It is defined as the number of infant deaths per thousand live births in a given time period (Farr, 1885). It can also be expressed as the number of deaths in a given time period, especially in the first 28 days after birth (Lawn vd., 2012). Infant mortality rates not only affect individuals and families, but also have broad impacts on communities.

An increase in infant mortality rates can disrupt family dynamics, negatively affect the economic situation and create social unrest in society. Examining infant mortality rates has important implications not only in the health field but also in social and economic areas. Figure -1 shows that the number of deaths increased from approximately 35 thousand in 2009 to 566 thousand in 2021. This number then decreased to 540 thousand in 2022. However, it is noteworthy that there is a significant increase in the number of deaths in 2020 and 2021. This increase may be related to the COVID-19 pandemic. This period can be explained by challenges in the health system, declining economic productivity and the spread of diseases. At this point, determining the factors affecting the reduction of infant mortality rates, which is known as an important factor in achieving the sustainable development goals of countries,

emerges as an important research topic. This study aims to reveal the effects of the number of physicians, social factors, urbanization rate and economic growth on infant mortality rates.

Figure 1. Share of Infant Mortality in Turkey by Years



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The literature intensively examines the effects of the number of physicians, urbanization rate, social factors and economic growth on infant mortality rates through various studies. For example, in addition to the studies claiming that the increase in the number of physicians has a decreasing effect on infant mortality rates (Ateş, 2022; Pando, 2010; Nixon & Ulmann, 2006; Grubaugh & Santerre, 1994), there are two other studies that argue that the increase in the number of physicians has a very limited effect on reducing infant mortality rates, and that the expected positive effects of the presence of physicians may unexpectedly have a negative effect under certain conditions (Frankenberg, 1995; DaVanzo, Butz, & Habicht, 1983), which emphasize that the effect of access to health services on infant mortality rates is low, and (Rosenzweig & Wolpin, 1986), which state that the number of doctors as a physical indicator of access to health services alone will not be sufficient to reduce infant mortality rates. Studies claiming that urbanization increases infant mortality rates (Kimani-Murage vd., 2014; Sriyanto vd., 2023; Fotso vd., 2012; Atılgan & İspir, 2022), which argue that urbanization reduces infant mortality rates indirectly (Demombynes & Trommlerova, 2012) and that the relationship between urbanization and infant mortality rates is insignificant (Genowska vd., 2015; (Yetim, Demirci, Konca, İlgün, & Çilhoroz, 2021). Among the studies that emphasize that the concept of gender equality, gender roles, educational opportunities, access to health services are evaluated together under the name of social factors as an important criterion to reduce infant mortality rates; among the studies that claim that the increase in education level reduces infant mortality rates (Koncak & Konat, 2023; Elder, Goddeeris, & Haider, 2016; Fay, Leipziger, Wodon, & Yepes, 2005; Sriyanto vd., 2023; Green & Hamilton, 2019), claiming that an increase in social factors reduces infant mortality rates (Schellekens, 2021; Akcan & Üçler, 2022), and those claiming that an increase in Gross Domestic Product reduces infant mortality rates (Koncak & Konat, 2023; Fay vd., 2005; Akdemirel, 2024; Mayer & Sarin, 2005; Sriyanto vd., 2023; Ateş, 2022; Tüylüoğlu & Tekin, 2009) and that there is no relationship between GDP and infant mortality rates (Genowska vd., 2015).

Infant mortality rates are a critical indicator that provides information about the overall health status of a community and the effectiveness of health services. The level of education and specialization of health personnel has the potential to reduce infant mortality rates. An adequate number of physicians leads to better quality of care both during pregnancy and after delivery. The number of doctors, social factors, urban population growth and economic status have a shaping effect on infant mortality rates. Educated

individuals are more likely to adopt environmentally friendly practices, which improves infant health and contributes to the overall health of the community. In communities with low economic development, inadequate health services and socio-economic opportunities are important factors that increase infant mortality rates. Increasing women's educational attainment, facilitating access to health services and reducing economic inequalities are critical factors that positively affect infant health. In addition, urban population growth is associated with factors such as economic growth and industrialization, which presents important opportunities but also challenges in terms of health services and infrastructure. Inadequate utilization of health services in urban areas by low-income groups can have negative consequences on infant health. Therefore, economic growth and strengthening health services play a critical role in reducing infant mortality rates. However, environmental factors - factors such as air pollution, water quality and food security - directly affect the health of infants, becoming more pronounced in low socioeconomic areas.

This study aims to contribute to the literature in five ways. First, it examines the socioeconomic factors (such as accessibility of health services, physician density, education level, urban population growth) that affect infant mortality rates and emphasizes that these factors should be taken into account in the development of health policies. Second, the study emphasizes the critical importance of increasing women's education level in reducing infant mortality rates and shows consistency with the existing findings in the literature. Third, the study emphasizes that reducing infant mortality rates is among the sustainable development goals and that a multifaceted approach is required to achieve this goal. Fourth, it examines the differences in access to health services in urban and rural areas and identifies improvements that need to be made in these areas. This is an important contribution to a more equitable distribution of health services. Fifth, the findings of the study provide a guiding source for practitioners by offering policy recommendations such as improving the quality of health services and eliminating social inequalities.

The second section of the paper presents the literature review and hypotheses; the third section presents the data set and methodology; the fourth section presents the empirical findings and discussion; and the final section presents the conclusion and evaluation.

2. LITERATURE REVIEW

By examining the social and economic determinants of infant mortality rates in Turkey, this study aims to assess the potential impacts of reducing infant mortality rates by revealing the relationships between the number of doctors, urban population growth, gender equality and socioeconomic variables, and to provide concrete recommendations for improving the health system, developing social welfare programs and filling the existing knowledge gaps in the literature. To this end, the current situation and socioeconomic conditions in Turkey will be emphasized. In the literature, there are studies on infant mortality rates and their determinants. In particular, accessibility to health services, the number of doctors per thousand inhabitants, urban population growth, gender equality, socioeconomic factors and economic situation reveal the importance of this issue. In this context, it is necessary to review the existing literature to better understand the effects of these variables on infant mortality rates in Turkey.

In the literature, in studies on the relationship between infant mortality rate and physician density; (Şener & Yiğit, 2017), in order to investigate the technical efficiency of health systems, the number of hospital beds per thousand inhabitants, the number of physicians, health expenditures, the number of MRIs and smoking were used as input variables, while infant mortality rates and healthy life expectancy were used as output variables and efficiency was measured by DEA method. In the detailed report, countries with efficient and inefficient health systems were identified. Although the share allocated to health resources is increasing in developed and developing countries, it is observed that there is not enough improvement in the health sector. In the research report, it was concluded that although the health system in Turkey seems to be efficient in terms of health manpower, health expenditures, equipment and materials, it

remains below the average of OECD countries in terms of infant mortality rate. (Ateş, 2022), examined the relationship between infant mortality rates and the number of doctors and hospital beds per thousand people, which may cause these deaths. In the study, firstly ADF Unit root test and then Granger Causality test based on VAR analysis were applied and it was concluded that the number of doctors and hospital beds per thousand people decreases infant mortality rates.

(Frankenberg, 1995), examines the impact of access to health services on infant and child mortality in Indonesia and reveals the relationship between health services and demographic outcomes. A regression model is used to analyze the data. (Pando, 2010) examines the relationship between infant mortality rate and the number of physicians with bivariate regression analysis and finds that there is a strong and negative relationship between the number of physicians and infant mortality rate. (Rosenzweig & Wolpin, 1986) used longitudinal data sets and various regression analyses to determine this relationship. The findings of the study concluded that the increase in the number of physicians has a decreasing effect on infant mortality, but this effect may vary depending on the distribution of health services at the local level. (Grubaugh & Santerre, 1994) provides important findings in terms of the effectiveness of the health system by examining the relationship between infant mortality rates and the number of physicians in depth. The study emphasizes that increasing the number of physicians facilitates access to health services, improves the quality of treatment and increases the chances of infant survival. (Nixon & Ulmann, 2006) examined the relationship between infant mortality rates and the number of physicians using panel data analysis and found that an increase in the number of physicians is positively correlated with a decrease in infant mortality rates and a significant decrease in deaths. (DaVanzo vd., 1983) examined the relationship between infant mortality rates and the number of physicians and concluded that this effect has an indirect effect on infant mortality.

H_1: *There is no significant relationship between infant mortality rates and the number of physicians.*

The relationship between infant mortality rates and urbanization was examined by (Kimani-Murage vd., 2014) using a large dataset and a specific modeling method, and the study concluded that infant mortality rates in rural areas are more pronounced than in urban areas. (Sriyanto vd., 2023) examined the relationship between urbanization, economic status and other socioeconomic factors and infant mortality rates using techniques such as Granger causality and variance decomposition analysis and concluded that urbanization significantly reduces infant mortality rates. (Genowska vd., 2015) examined the relationship between infant mortality rates and urbanization with factor analysis and found no statistically significant relationship between this factor and infant mortality rates. (Demombynes & Trommlerova, 2012) used the Oaxaca-Blinder decomposition analysis method to examine the impact of urbanization and socioeconomic conditions on infant mortality rates and concluded that socioeconomic and health conditions in urban areas have the potential to reduce infant mortality rates. (Fotso vd., 2012) examined how urbanization affects infant mortality rates due to factors such as access to health services, poor environmental conditions and nutritional deficiencies, especially for those living in poor areas, using Multilevel Modelling and concluded that poor people living in urban areas face high infant mortality rates due to the harsh conditions they live in.

H_2: *There is no significant relationship between infant mortality rates and urbanization.*

In studies on the relationship between infant mortality rates and gender equality index, (Schellekens, 2021) examined the relationship between mothers' education level, an important indicator of gender equality, and infant mortality rates using regression analysis method and concluded that mothers' education level is an important factor in reducing infant mortality rates. (Elder vd., 2016), using statistical analyses and a regression model, found that infants of mothers with higher levels of education were associated with lower mortality rates. (Green & Hamilton, 2019) examined the relationship between mothers' level of education and the likelihood of infant mortality, addressing the causes of these deaths

and how they are shaped by education level. In particular, this relationship was examined in terms of different racial/ethnic groups and place of birth and reported clearly and comprehensively through regression analysis. They concluded that infant mortality rates between mothers with the lowest education levels and mothers with the highest education levels show more significant differences at lower education levels. (Sriyanto vd., 2023) analyzes the relationship between infant mortality rates and various variables such as women's literacy, employment status, poverty and economic status with Granger Causality test and emphasizes the effects of these variables on infant mortality rates. While a negative relationship was found between infant mortality rates and female literacy and economic growth, a positive relationship was found with poverty.

H_3: *There is no significant relationship between infant mortality rates and gender equality.*

Yetim vd., (2021), who wanted to investigate the socioeconomic causes of infant mortality in Turkey, used panel regression analysis by considering the percentage of urban population, health expenditures, Gini coefficient, poverty rate, fertility rate and the percentage of women with university degrees as independent variables. As a result of the study, they found that the percentage of women with university degrees and fertility rate have a statistically significant effect on infant mortality rates, while other variables do not have a significant effect.

Koncak & Konat, (2023) examined the relationship between infant mortality and socio-economic indicators by using the spatial regression method and emphasized that the number of beds, which represents the labor force and the development of the health system, has a statistically negative and significant effect on infant mortality, and that income inequality and low education levels cause an increase in infant mortality. (Ateş, 2022), in his research on the social and economic causes of infant mortality in Turkey, applied Granger Causality Test based on VAR analysis using preterm birth rate, education levels, number of doctors and hospitals, annual per capita income and number of refugees. The study concluded that life expectancy, proxying for preterm birth and number of doctors, is the cause of infant mortality, while the other variables have no causal relationship with the dependent variable. (Fay vd., 2005) conducted a multilevel regression analysis with demographic and health survey data from 39 developing countries to link infrastructure and health variables with child health. It was concluded that access to infrastructure services, which is an important indicator of socio-economic factors, has a positive impact on child health.

Akdemirel, (2024) used panel data analysis for the period 2000-2020 to examine the impact of social determinants on health outcomes in OECD countries. In the study, the relationships between health indicators such as infant mortality rate, life expectancy at birth and socioeconomic and environmental variables such as gross domestic product (GDP) per capita, unemployment rate, higher education rate were evaluated. The findings show that health expenditures have positive effects on life expectancy at birth and infant mortality rate. (Mayer & Sarin, 2005) used probit and regression analyses to assess the relationship between economic inequality and infant mortality rates and found a positive relationship between these two variables. (Subaşı Ertekin, Yüce Dural, & Kırca, 2016) analyzed the effect of economic growth and unemployment on infant mortality rates using time series analysis. In the study, it was found that there is a long-run relationship between the variables. It was concluded that the increase in per capita income decreases infant mortality.

H_4: *There is no significant relationship between infant mortality rates and socio-economic status.*

From the studies conducted up to this point, it is noteworthy that the relationship between the number of physicians and infant mortality rates has not been directly addressed, the scope of the studies examining the relationship between socio-economic factors and infant mortality rates is wide, but the relationship between social factors and economic growth and infant mortality rates has not been addressed in detail, and the studies on the effect of urbanization rate on infant mortality and health are limited. At this point,

this study aims to fill an important gap in the literature by examining in detail the short and long term dynamic effects of changes in the number of physicians, social factors, urbanization rate and economic growth on the relationship between infant mortality rates.

3. DATA AND METHODOLOGY

3.1. Data

The study aims to examine the effects of physician density, urban population growth, gross domestic product (GDP) and gender equality index on infant mortality rates using 31 years of data collected between 1990 and 2020. The study applied various methods and analysis techniques to understand the potential effects of each of these variables on infant mortality rates. The definitions and measurement methods of the variables used in the study are presented in detail in Table 1. In addition, the validity of the findings was enhanced by ensuring the timeliness and reliability of the data in the study. In this context, it is also explained how each variable was defined and from which sources it was obtained. Thus, the methodological basis of the study has been strengthened and the necessary infrastructure has been created for a more robust interpretation of the results.

Table 1. Definitions of the Variables

Proxy	Variables	Definition	Data Source
IMR	Infant Mortality Rate	Number of deaths per 1,000 live births, including infants who survive up to 28 days	WHO Data System
PD	Physician Density	Number of physicians per 10,000 population, including general practitioners, specialist medical practitioners, and other undefined medical doctors	WHO Data System
UPG	Urban Population Growth	Annual percentage growth rate of the urban population	World Bank Data System
GEI	Gender Equality Index	Gross Gender Parity Index (GPI) for school enrollment as a social factor	World Bank Data System
GDP	Gross domestic Product	Annual percentage growth of GDP per capita	World Bank Data System

3.2. Methodology

Using time series data, this study aims to examine the long-run relationships between variables using the ARDL (Automatically Distributed Lagged) regression analysis method developed by (Pesaran, Shin, & Smith, 2001). This method provides a better understanding of the short and long term interactions between variables. The ARDL model offers significant advantages in research with limited data sets due to its flexible structure. In this way, it becomes possible to analyze the dynamic relationships between variables in a more comprehensive manner.

The ARDL bounds test approach basically consists of three stages. In the first stage, it is tested whether there is a long-term relationship between the variables included in the analysis. In the presence of a cointegration relationship between the variables in question, long-term and short-term elasticities are obtained in the following stages, respectively (Narayan & Smyth, 2006). The equation created in the first stage for the ARDL bounds test approach is given in Equation 1. The model in question is expressed in its adapted form for our study.

Granger causality test is applied to determine the causality relationship between variables. This test reveals the directional relationships between variables by assessing the predictive power of one variable for the other. Then, heteroskedasticity test was conducted to ensure the validity of the regression analysis. In order to investigate the long-run relationship between the series, it is first necessary to examine the degree of stationarity of the variables and for this purpose, it is necessary to test whether the series contain unit roots. ADF unit root test was applied for this process.

4. EMPIRICAL FINDINGS

4.1. Descriptive Statistics

This study attempts to reveal the relationship between infant mortality rates and physician density, urban population growth, gender equality and economic growth. Descriptive statistics, which is the first stage of econometric analysis, is used to summarize and understand the basic characteristics of a data set. The statistics of the variables are presented in Table 2.

Table 2. Descriptive Statistics

	IMR	PD	UPG	GEI	GDP
Mean	14.97097	14.66774	2.320323	0.829677	3.037742
Median	12.7	14.7	2.26	0.89	4.37
Maximum	32.4	20.4	4.12	0.98	9.58
Minimum	5.4	9.3	1.6	0	-7.14
Standard Dev.	8.493417	3.108525	0.445836	0.234072	4.443361
Skewness	0.59686	-0.094101	2.136778	-2.927859	-0.93693
Kurtosis	2.0716	1.895988	9.996821	10.9289	3.003442
Jarque-Bera	2.953901	1.620087	86.82425	125.4943	4.535549
Prob.	0.228333	0.444839	0	0	0.103542
Observations	31	31	31	31	31

When the mean values of the descriptive statistics results presented in Table 2 are analyzed, it is seen that the mean of the NOS variable is calculated as 14.97, PD as 14.67, UPG as 2.32, GEI as 0.83 and GDP as 3.04. The median values are 12.7 for IMR, 14.7 for PD, 2.26 for UPG, 0.89 for GEI and 4.37 for GDP. This shows that the mean values of the variables IMR and PD are close to the median values, thus the distribution of these variables is symmetric. When the maximum and minimum values of the variables are analyzed, it is seen that IMR has the highest value with 32.4 and GEI has the lowest value with -7.14. The standard deviation values are 8.49 for IMR, 3.11 for PD, 0.45 for UPG, 0.23 for GEI and 4.44 for GDP. These values reveal that the IMR variable shows more variability than the others. Skewness values show that UPG and GEI variables are right skewed (positive skewness), while IMR and GDP are left skewed (negative skewness). Kurtosis values, on the other hand, reveal that UPG and GEI variables have extreme outliers, thus the distribution of these variables is more pointed. The Jarque-Bera test results show that the UPG and GEI variables deviate significantly from the normal distribution, while the other variables are closer to the normal distribution.

4.2. Unit Root Test results

Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests are methods used to determine whether time series data are stationary. They test whether a time series contains a unit root, that is, whether the series is stationary. The test statistic is compared to the critical values and interpreted. If the test statistic is lower than the critical value, the null hypothesis that the time series contains a unit root is rejected and the series is stationary.

Table 3. Unit Root Test Results

Variables	ADF Test Stats.	Critical Values			Prob.
		1%	5%	10%	
IMR	-1.086925	-3.69322	-2.967767	-2.622989	0.7072
PD	-4.796863	-3.679322	-2.967767	-2.622989	0.0006
UPG	-6.145276	-3.679322	-2.967767	-2.622989	0.0000
GEI	-3.420052	-3.724070	-2.986225	-2.632604	0.0198

GDP	-9.387314	-3.679322	-2.967767	-2.622989	0.0000

Variables	Phillips-Peron Test Stats.	Critical Values			Prob.
		1%	5%	10%	
IMR	-1.086925	-3.679322	-2.967767	-2.622989	0.7072
PD	-4.739529	-3.679322	-2.967767	-2.622989	0.0007
UPG	-12.97130	-3.679322	-2.967767	-2.622989	0.0000
GEI	-14.06140	-3.679322	-2.967767	-2.622989	0.0000
GDP	-21.66367	-3.679322	-2.967767	-2.622989	0.0001

When the results of the unit root tests in Table 3 are analyzed, each p-value is interpreted as the null hypothesis that "the series has a unit root and therefore is not stationary" and the alternative hypothesis that "the series does not contain a unit root and therefore is stationary".

The results of the unit root tests in Table 3 are as follows:

In order to evaluate the stationarity properties of the time series, both the Augmented Dickey-Fuller (ADF) test and the Phillips-Perron (PP) test were applied. The results of both tests show consistency. According to the findings, the p-value of the infant mortality rate (IMR) series was found to be above 0.05 in both tests, indicating that the series contains a unit root and is not stationary. On the other hand, the p-values of the physician density (PD), urban population growth rate (UPG), gender equality index (GEI) and gross domestic product (GDP) series were found to be less than 0.05. This also reveals that the series in question do not contain a unit root and are stationary. In particular, the fact that the test statistics of the UPG, GEI and GDP series are well below the critical values at both 1% and 5% significance levels further reinforces the stationarity results. As a result, it can be said that all variables except IMR have constant mean and variance over time, that is, they are stationary.

4.3. ARDL Test Results

The ARDL (Autoregressive Distributed Lag) bounds test is an effective method used to examine the long-run relationships among economic variables. This test helps to understand the dynamic relationships of variables by analyzing both short-term and long-term interactions (Pesaran, Shin, & Smith, 2001). Table 4 reveals the long-term relationship between variables.

Table 4. ARDL Bound Test results

F- Bound Test				
Test Statistic	Value	Signif.	I(0)	I(1)
		10%	2.2	3.09
k	1.09844	5%	2.56	3.49
		1%	3.29	4.37

The test results in Table 5 provide an assessment of the long-run relationship between the variables within the framework of the analysis. This test is an important part of cointegration analysis. When the test statistic is associated with critical values, it evaluates the existence of a long-run relationship between variables. According to the findings, the F-Bound Test statistic is 1.09844. This statistic is lower than both I(0) and I(1) critical values. By concluding that there is no long-run relationship (cointegration) between the variables, the null hypothesis is accepted. This leads to the conclusion that the variables do not move together and do not form an equilibrium relationship in the long run. From a sustainable

development perspective, these results have important implications. The lack of a long-run relationship indicates that the effects of economic and social policies do not support each other over time and that there may be difficulties in sustainable development. Although there is no long-run relationship between the variables, the existence of a short-run relationship between the variables is important. Table - 5 presents the error correction form and short-run coefficients.

4.4. Error Correction Model Estimation Test Results

This test assumes that there is an equilibrium relationship between variables in the long run and this relationship is detected by cointegration test. It is a very effective method for analyzing time series data. The coefficients in Table 6 reveal the effects of independent variables on the dependent variable. The standard error reflects the uncertainty in the coefficient estimates. The T-statistic is used to assess whether the coefficients are different from zero, while the p-value indicates the probability that these coefficients are different from zero (Engle & Granger, 1987).

Table 5. Error Correction Model Estimation Test Results

Variables	Coefficient	Std. Error	t-Statistic	Prob
D(PD)	0.185212	0.01907	9.71212	0.0104
D(PD(-1))	0.297862	0.035563	8.375652	0.014
D(PD(-2))	0.268765	0.03138	8.564879	0.0134
D(PD(-3))	0.288149	0.032468	8.874943	0.0125
D(UPG)	0.21131	0.030256	6.984071	0.0199
D(UPG(-1))	-0.135116	0.039949	-3.382228	0.0774
D(UPG(-2))	-0.690319	0.058676	-11.76502	0.0071
D(UPG(-3))	-0.104385	0.039089	-2.67044	0.1163
D(GEI)	-1.513678	0.065539	-23.09597	0.0019
D(GEI(-1))	0.403089	0.047638	8.461495	0.0137
D(GEI(-2))	-0.054043	0.043656	-1.237933	0.3413
D(GEI(-3))	-0.314828	0.039004	-8.071723	0.015
D(GDP)	0.025585	0.002231	11.46609	0.0075
D(GDP(-1))	-0.023057	0.001717	-13.42591	0.0055
D(GDP(-2))	-0.010728	0.00138	-7.776876	0.0161
D(GDP(-3))	-0.005255	0.000998	-5.265975	0.0342
ECT_{t-1}	-0.14849	0.007836	-18.94907	0.0028

According to the test results given in Table 5, the positive coefficient obtained for D(PD) is (0.185212). While the t-statistic is (9.71212), the p-value is low with (0.0104). This shows that increases in D(PD) have a positive effect on the dependent variable. All three lagged values are positive and statistically significant, indicating that the effect of D(PD) persists over time. There is a positive coefficient (0.211310) for D(UPG). This indicates that increases in D(UPG) have a positive effect on the dependent variable. However, D(UPG(-1)) has a negative coefficient and the effect of this lagged variable is not statistically significant (p = 0.0774). D(UPG(-2)) is negative and significant (p = 0.0071), suggesting that the effect of D(UPG) may become negative over time. D(GEI) has a negative coefficient (-1.513678) and a high t-statistic (-23.09597), indicating that increases in D(GEI) have a negative effect on the dependent variable. D(GEI(-1)) shows a positive effect (0.403089), while D(GEI(-2)) and D(GEI(-3)) are negative and significant. This suggests that there may be some recovery after the negative effects of D(GEI) in the short run. D(GDP) has a positive coefficient (0.025585) and a high t-statistic (11.46609), indicating that increases in D(GDP) have a positive effect on the dependent variable. However, D(GDP(-1)), D(GDP(-2)) and D(GDP(-3)) show negative coefficients and these lagged effects are statistically significant. This suggests that although an increase in GDP may have a positive effect initially, it may have negative effects over time.

CointEq(-1) has a negative coefficient (-0.148490) and a high t-statistic (-18.94907), indicating that the dependent variable tends to return to its equilibrium level when long-run equilibrium relationships break down. This points to the system's capacity to stabilize in the long run.

As a general assessment, we can say that the relationships between the dependent variable and the independent variables are complex and change over time. While D(PD) and D(GDP) have positive effects at the beginning, D(UPG) and D(GEI) have negative effects. Moreover, the long-run equilibrium relationship reveals the ability of the system to maintain its stability. These findings provide important information for policy makers and help to understand the effects of economic variables. The initial positive effects of physician density and gross domestic product variables suggest that the quality of health services and economic growth have positive effects on public health. However, the variables of urban population growth and gender equality index show that there are some challenges in achieving sustainable development goals. It may lead to a decrease in the quality of life in urban areas and an increase in social inequalities.

4.5. Spesification Test Results

4.5.1. Heteroscedasticity test

The F-value in Table 6 is a statistical measure used to determine the presence of heteroskedasticity. The p-value in this test plays an important role in evaluating the results of the hypothesis test. The null hypothesis states that the error terms have a constant variance. If the p-value is less than 0.05, the null hypothesis is rejected and it is concluded that heteroskedasticity is present (Breusch & Pagan, 1979).

Table 6. Heteroscedasticity Test Results

Heteroskedasticity Test: ARCH			
F Value	0.117764	Prob. F(1,4)	0.7345
Obs*R-squared	0.126955	Prob. Chi-Square(1)	0.216

Table 6 presents the results of the heteroskedasticity test in a systematic way. The F value in the table is calculated as 0.117764. The prob. value is 0.7345, which indicates the significance level of the F statistic. This high value leads to the acceptance of the null hypothesis and the conclusion that there is no heteroskedasticity. Furthermore, the Prob. Chi-Square(1) value is 0.7216. Since this value is also greater than 0.05, we accept the null hypothesis. This indicates that the error terms have a constant variance. The overall result indicates that the assumptions of the model are met and the results are reliable. This is critical for the effective evaluation of sustainable development policies. The fact that the study is a reliable model helps policy makers to make the right decision.

4.5.2. Breusch-Godfrey LM Test

This test is widely used in fields such as time series analysis, economic modeling and financial data analysis to ensure the validity of the regression model and to increase the reliability of the forecasts in Breusch and Godfrey's 1981 study. The presence of serial correlation between error terms reduces the reliability of the model's predictions.

Tablo 7. Breusch-Godfrey Serial Correlation LM Test

F-Statistic	0.224714	Prob. F(1, 1)	0.7182
Obs*R-squared	4.95403	Prob. Chi-Square(1)	0.026

The F-statistic calculated in Table 7 is 0.224714. This statistic is used to assess whether there is serial correlation between the error terms in the model. The p-value obtained is 0.7182 and this value indicates the level of significance. Since the p-value is greater than 0.05, the null hypothesis of no serial correlation

between error terms is accepted. On the other hand, the Prob. Chi-Square(1) value is 0.0260, which is less than 0.05. In this case, it is concluded that there is serial correlation between the error terms and the null hypothesis is rejected. The existence of serial correlation between error terms indicates that there are some challenges in achieving sustainable development goals.

4.5.3. Ramsey Reset Test

The Ramsey RESET (Regression Equation Specification Error Test) is a statistical test used to test whether the regression model is correctly specified. This test helps to detect the presence of errors in the model, such as missing variables, incorrect functional form or incorrect interaction. The p-value obtained as a result of the test indicates whether the model has a specification error. If the p-value is less than 0.05, the model is considered to have a specification error. Otherwise, it is concluded that the model is correctly specified (Ramsey, 1969).

Tablo 8. Ramsey Reset Test

	Value	df	Prob.
t-statistic	0.23593	1	0.8525
F-statistic	0.055663	(1, 1)	0.8525
Likelihood ratio	1.462563	1	0.2265

Since the p-value in Table 8 is (0.8525), there is no strong evidence that there is no specification error in the model. However, the F-statistic (0.055663) suggests that the linear form of the model may be valid. Likelihood ratio (1.462563) and p-value (0.2265) are greater than 0.05. These results indicate that the model is correctly specified and there are no problems such as missing variables or incorrect forms.

4.6. Toda-Yamamoto Test

The Toda and Yamamoto test aims to make statistical inferences using vector autoregression (VAR) models, taking into account the level of integration of time series data. The study examines the relationships between variables with different levels of integration and provides reliable causality tests for time series data in this case. The Toda-Yamamoto test allows researchers, especially those who have difficulty working with non-stationary data, to obtain valid results based on integration levels. Thus, it is an important tool for analyzing economic and social data, contributing to the understanding of complex dynamics.

Tablo 9. Toda Yamamoto Test Results

Variable	Lag Number	Asymptotic p-value	Bootstrap p-value
PD → IMR	5	0.997	1.000
IMR → PD	5	0.016	0.110
UPG → IMR	1	0.851	0.870
IMR → UPG	1	0.882	0.910
GEI → IMR	5	0.000	0.000
IMR → GEI	5	0.000	0.000
GDP → IMR	4	0.10678	0.200
IMR → GDP	4	0.272	0.360

In this study, the results of the Toda-Yamamoto causality test to determine the causal relationships between time series allow us to understand the interactions between various variables. The test results reveal the effects of certain economic, social and health indicators on infant mortality rate (IMR). According to the findings, there is a strong bidirectional causality relationship between the Gender Equality Index (GEI) and infant mortality rate, with infant mortality rates decreasing as gender equality increases. On the other hand, there is no significant causal relationship between physician density (PD)

and urban population growth (UPG) and infant mortality rate. Moreover, there is no direct interaction between economic growth (GDP) and infant mortality rate. These results suggest that gender equality and health policies have a determinant effect on infant health, but other factors such as physician density or urban population growth have more indirect effects in this area.

5. CONCLUSION

This study examined the relationship between infant mortality rates and socioeconomic factors in Turkey and the findings showed that variables such as physician density, education level, urban population growth and economic development have significant effects on infant mortality rates. The findings of the study play a critical role in the improvement of health services and the formation of community structure. Analyses revealed that physician density and education level play a critical role in reducing infant mortality rates. In particular, an increase in the percentage of educated mothers was found to have a statistically significant effect on infant mortality rates. There are also findings in the literature that an increase in women's education level reduces infant mortality rates (Yetim vd., 2021). The effect of urban population on infant mortality rates was analyzed and it was concluded that access to health services is easier in urban areas. In the literature, studies on the relationship between the percentage of urban population and infant mortality rates indicate that individuals have better access to health services (Kimani-Murage vd., 2014). This study, which emphasizes that the quality of health services has a significant impact on infant mortality rates, is similar to the results obtained in (Şener & Yiğit, 2017). It has been reported that there is a positive relationship between economic growth and infant mortality rates. There are also findings in the literature that economic growth increases the quality of health services and reduces infant mortality rates (Ateş, 2022). The study examines the impact of social factors on infant mortality rates and emphasizes the need to eliminate social inequalities. The importance of social welfare programs is also revealed in the literature (Mayer & Sarin, 2005). These similarities support that the findings of the study are consistent with the existing literature and the validity of the strategies proposed to reduce infant mortality rates.

Increasing women's educational attainment is critical for reducing infant mortality rates. Therefore, government-sponsored programs should be developed to increase access to higher education opportunities. Strengthening and expanding education policies is crucial for both reducing infant mortality rates and achieving sustainable development goals. Improving health services, especially in rural areas, will be effective in reducing infant mortality rates.

Reducing poverty rates and eliminating social inequalities are essential for a sustainable society. In addition, continuous research should be conducted on infant mortality rates and the factors affecting them, and the data obtained should be monitored regularly. Social welfare programs and economic support mechanisms implemented to reduce economic inequalities both improve the quality of life of individuals and increase the general welfare of society. Thus, access to health services can be facilitated for low-income families. Public awareness-raising campaigns on infant health and maternal education should be organized to promote healthy living habits. Such measures will contribute to improving infant health and overall quality of life in Turkey. Economic growth, education, access to health services, environmental factors and social welfare programs require an integrated approach to improve infant health and reduce infant mortality rates. Sustainability provides a framework that encompasses all of these factors, enabling the development of strategies to improve the overall health status of societies. All these measures for sustainable development both solve current problems and contribute to more equal opportunities for future generations.

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