Sosyoekonomi

2025, Vol. 33(64), 77-102

RESEARCH ARTICLE

ISSN: 1305-5577
DOI: 10.17233/sosyoekonomi.2025.02.04
Date Submitted: 08.07.2024
Date Revised: 25.01.2025
Date Accepted: 01.03.2025

Economic Development, Maternal Education and Infant Mortality in Türkiye 1960-2010

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Türkiye'de Ekonomik Kalkınma, Anne Eğitimi ve Bebek Ölüm Hızları 1960-2010

Abstract

This study revisits the unusual relationship between infant mortality and economic growth in Türkiye between 1960 and 2010, considering the effects of female education. The independent influences of economic development and women's education on infant mortality are assessed using fractional polynomial regressions applied to World Bank data on 108 middle-income countries, as well as indirect mortality estimations and logistic regressions with Turkish census data from 1985 to 2000 and Demographic and Health Surveys from 1993 to 2008. Results show that Türkiye consistently displayed higher levels of infant mortality in comparison to other countries at similar levels of economic development, but eliminating significant within-country disparities in women's primary and secondary school education could have removed both subpopulation-level heterogeneity in death rates and population-level excess deaths.

Keywords : Infant Mortality Rates, Economic Development, Maternal Education, Socioeconomic Factors.

JEL Classification Codes : I15, I14, N30.

Öz

Bu çalışma bebek ölümleri ile ekonomik büyüme arasındaki Türkiye'ye özgü ilişkiyi yeniden değerlendirerek, ülkenin kadın nüfus eğitim düzeyinin bu ilişkiyi nasıl etkilemiş olabileceğini sorgulamaktadır. 1960 ve 2010 yılları arasında ekonomik büyüme ve anne eğitiminin birbirlerinden bağımsız olarak ölüm hızları üzerindeki etkileri Dünya Bankası'nın 108 orta-gelirli ülkeye ilişkin verileri ile kullanılan kesirli polinom regresyonları, 1985-2000 nüfus sayımı ve 1993-2008 Demografik ve Sağlık Araştırması verilerine uygulanan Brass dolaylı ölüm tahmin metodu, ve lojistik regresyonlar ile incelenmektedir. Sonuçlar, diğer orta-gelirli ülkelerle karşılaştırıldığında Türkiye'nin sürekli olarak beklenenden yüksek seviyelerde bebek ölüm hızı sergilediğini, ancak annelerin eğitimindeki eşitsizliklere yatırım yapılmış olması halinde hem ülke genelindeki fazladan ölümlerin hem de alt nüfus düzeyinde ölüm hızlarındaki heterojenliğin ortadan kaldırabileceğini göstermektedir.

Anahtar Sözcükler : Bebek Ölüm Hızları, Ekonomik Kalkınma, Anne Eğitimi, Sosyoekonomik Faktörler.

1. Introduction

Infant mortality rates (IMRs) in developing countries are considered to be the most responsive to economic progress among various measures of mortality, as repeatedly indicated by higher-order correlation coefficients recorded between countries’ IMRs and GDP per capita levels (Preston, 1975; Hanmer et al., 2003; Preston, 2007; Schady & Friedman, 2007; Baird et al., 2011). Comprising the value of all goods and services produced within a specified period, GDP is considered the most reliable indicator of a country's living standards. Its growth as an aggregate income level implies a more significant real consumption of items by families, such as food, housing, and access to medical services, which positively affect health. While the association of GDP levels with mortality is significant due to the multiplicity of factors represented by GDP as an indicator, its relation with infant mortality is even stronger because mortality from infectious diseases to which infants and children are most vulnerable is primarily reactive to rising income and nutritional status levels (Preston, 1980; Cutler et al., 2006; Preston, 2007).

Türkiye’s infant mortality trends in the second half of the twentieth century have been described as a ‘demographic puzzle’ by social scientists and demographers due to persistently higher than expected or “excess” death rates given the levels of economic progress (Gursoy, 1992; Gursoy, 1994; Aksit & Aksit, 1989; Behar et al., 1999; Koc & Eryurt, 2017). For instance, Aksit and Aksit, who examined the determinants of infant and child mortality in the 1980s, noted, “It is known that the historical relationship between income and mortality can be highly variable during economic development, yet it is puzzling that Sri Lanka with one-third of the Turkish GNP has half the Turkish infant mortality” (1989: 571). Gursoy-Tezcan stated, “In Türkiye, as in most Middle Eastern countries, neither the GNP per capita nor other development criteria seem to explain the high incidence of infant deaths” (1992: 131). In addition, population studies from earlier years revealed that national infant mortality rates were influenced by significant regional and provincial disparities (Fisek, 1969; Shorter & Macura, 1982), with notable differences among metropolitan, urban, and rural residential types (Shorter, 1969; Goldberg & Adlakha, 1969). Although these studies acknowledged the role of uneven levels of modernisation and industrialisation across Türkiye in contributing to such variations, most rather stressed the role of sociocultural factors in delaying the infant mortality transition, particularly problematising low levels of maternal education even in large urban centres (Fisek, 1989; Goldberg & Adlakha, 1969; Aksit & Aksit, 1989).

Although it is known that Türkiye’s experience with IMRs was ‘exceptional’ in the sense of being markedly at variance with what would have been expected based on economic growth alone, the relationship between GDP and IMRs needs to be revalidated after considering Türkiye's closing decades of transition. The same holds for the relationship between female education and IMRs. More recent studies either use individual-level data with a broad set of socio-economic variables without comparing the effects of mothers’ education and economic resources on mortality as separate determinants (Yanikkaya & Selim, 2010; Yetim et al., 2021) or use aggregate- and individual-level data to specifically target its regional and/or ethnic variations (Eryurt & Koc, 2015; Koc et al., 2008). This article presents the results of the most extensive study of its kind on Türkiye, encompassing various levels of analysis, a comprehensive period, diverse data sources, and effective empirical strategies, as well as the number of reports from reproductive-age women. It has four main goals. First, it attempts to empirically update the analysis on the association between IMR and national income levels until the very end of Türkiye's infant mortality transition, using a large cross-national dataset on lower- and upper-middle-income countries between 1960 and 2010. This way, we can get a comprehensive picture of the extent of population-level deviation (in excess deaths) from the shared experience in other developing countries. Second, the paper tries to account for the influence of female schooling levels on infant mortality in the same pool of countries using gender ratios in primary and secondary education. Third, the study aims to produce mortality estimates to measure the extent of within-country heterogeneities since the 1970s, obtained by applying the Brass method to reports from over two million women regarding the survivorship of their children. In addition, the role of maternal education in mitigating the main inequalities between the East and the rest of the country, as well as between the Kurdish and Turkish populations, is examined using counterfactual analysis with indirectly estimated IMRs and population distributions. Fourth and last, the study tries to assess the independent effects of material resources and maternal education on the risk of infant mortality in families, using survival histories of children born between 1988 and 2008.

The following section introduces the economic and cultural theories of infectious disease mortality decline, previously proposed by demographers who reported strong associations and causal relationships of IMR with national income levels and maternal education in developing countries. The method section describes the demographic procedures and data used in Türkiye's aggregate and individual-level analyses. After presenting the main findings in the results section, the paper addresses possible implications of the conclusions of the discussion section and concludes.

2. Economic and Cultural Theories of Mortality Decline from Infectious Diseases

Much of the significant and sustained reductions in mortality in the history of both developed and developing countries have been due to decreased mortality from infectious and parasitic diseases to which infants and children are the most vulnerable. These diseases are commonly known as pneumonia, diarrhoea, whooping cough, measles, smallpox and malaria. Previous theories that have been advanced to explain mortality declines from these causes are divided between a) "Economic" explanations with an emphasis on improvements in a population's standards of living and b) "cultural" explanations that invoke ideational shifts with which individuals conceive the medical causes of diseases, and methods of prevention and treatment.

The economic argument with an emphasis on improving standards of living favoured *nutritional improvements* as the leading cause of mortality decline in high-mortality populations due to two main reasons (McKeown, 1976; Fogel, 1986; Fogel, 2004): First, economic improvements increase the per capita supply of food that alleviates the prevalence of chronic or severe malnutrition. Second, economic development improves food quality and dietary composition. It reduces nutritional deficiencies, such as iron and protein-energy malnutrition, which are closely related to negative growth and health outcomes in infants and young children. In addition, a reciprocal and synergistic relationship exists between nutritional status and infection (Scrimshaw, 1968; Scrimshaw, 1997; Lunn, 1991). Malnutrition is associated with a decrease in immunocompetence and increased susceptibility to infectious diseases, whereas infection results in a more malnourished subject, completing the vicious circle. Given that malnutrition is a significant factor in the occurrence of infections and infections are a common precipitating factor of malnutrition, the economic argument suggests that deaths from infectious diseases in a high-mortality population cannot be eliminated in the absence of population-level improvements in standards of living and nutritional status.

Cultural explanations of mortality decline have emphasised the role of socio-cultural and behavioural factors as determinants of health and mortality improvements in developing countries (Caldwell & McDonald, 1982; Caldwell, 1986, 1990, 1994). This emphasis was based on a perception of mortality decline as a 'social' transition in addition to an 'economic' one, which required changes in attitudes toward life and death, as well as in the cultural and normative contexts and systems of values, beliefs, ideologies, and normative pressures. Maternal education, the most significant driver of social change, was associated with the emergence of a new, calculating rationality that transformed the grounds of the processes of decision-making about health, consequently moving these decisions from the realm of custom and tradition (i.e. fatalism) to a legitimate object of rational choice (i.e. a sense of control of destiny). Another key element produced by maternal education was the ability to rattle the cage of cultural and traditional constraints: It was the most significant driver of mortality decline, not primarily because of enhancing women's involvement as mothers to use and efficiently allocate the material resources available, but because of the greater autonomy it brings with important health benefits for children, mainly through educated mothers' rejection of traditional age and sex differentiations in power, decision-making and benefits in families.

Thus, earlier economic and cultural studies of mortality decline in developing countries empirically investigated mortality reductions as a product of one of the two fundamental sources of change at the population level: primarily as a function of profound economic changes or somewhat independent of economic changes and dependent on ideational shifts. Both groups of arguments were supported by evidence. The pioneering work by Preston (1975, 1980, 1985), who decomposed mortality reductions into economic and other structural factors, showed that mortality trends cannot be dissociated from countries' national income levels at any point in time, even though the cross-sectional relationship might change due to other factors related to the availability and accessibility of the new medical technologies. Other studies that followed Caldwell's seminal work on cultural effects demonstrated that maternal education had a strong, independent and positive impact on infant survival in developing countries, even after statistically controlling for other important variables such as family income or urban/rural type of residence (Hobcraft et al., 1984; Mensch et al., 1985; Cleland & van Ginneken, 1988; Cleland, 1990). These studies identified numerous mechanisms between education and mortality and stated that educated mothers attached a higher value to the welfare and health of their children, had greater decision-making power on health-related matters, were less fatalistic about diseases and death, more knowledgeable about disease and cure, more innovative in the use of remedies, and more likely to adopt new codes of behaviour that have indirect but positive consequences for the health of infants.

In more recent years, some studies presented updated empirical analyses on the effects of economic growth and female education on infant and child mortality in developing countries (Kuhn, 2010; Fuchs et al., 2010; Pamuk et al., 2011; Baker et al., 2011, Lutz and Kebede, 2018). All of these studies were in agreement that children of better-educated mothers are at a lower risk of mortality on all continents and across all levels of socio-economic development. In addition, they empirically found that per capita GDP is such a powerful determinant of mortality that any other powerful determinant (such as female education) is better understood by first stripping out income effects. The findings on the *relative* strength of economic growth and female education were consistent in that the impact of education dominated that of income and wealth in both aggregate- and individual-level analyses. For instance, Fuchs et al. (2010) used data from the Demographic and Health Surveys (DHS) from Africa, Asia and Latin America to test the existence of independent effects of education and wealth and to establish which effect is more important, found that the educated poor was doing better than the uneducated with more incredible wealth in these countries. Pamuk et al. (2011), who similarly used DHS from 43 low- and lower-income nations, showed that the decline in the average odds of infant death with increasing education level was more significant than the decline associated with household wealth at the national level, but the impact of education was even more important in families and communities.

3. Methodology

Given the availability of information on past economic growth and mortality trends for many countries today, it is possible to investigate this relationship for Türkiye and determine to what extent its experience diverged from that of other developing countries. The effect of national income on mortality levels in a group of countries can be estimated by fractional polynomial modelling, as proposed by Royston and Altman (1994) and Royston and Sauerbrei (2008). Fractional polynomials generalise the polynomial function, allowing for a nonlinear relationship between a dependent variable (national income levels) and an independent variable (IMRs), but require that all power terms are positive integers. Fractional polynomial models are more flexible and permit fractional and negative exponents, which is more appropriate if IMR drops rapidly with increasing GDP values until it hits a floor. For a single predictor x, polynomial fractions are of the form:

$$Y = \beta_0 + \beta_1 x + \beta_2 x^2 + \cdots + \beta_h x^h + \varepsilon \quad (1)$$

where h (the degree of the polynomial) is selected from the set [-2, -1, -0.5, 0, 0.5, 1, 2, 3] alone and in pairs, the Stata software attempts 44 different models involving these polynomials. It selects a model with the best-fitting combination of powers. In models involving repeated powers, the second term is multiplied by ln (x). For instance, the model FP (2,2) is of the form:

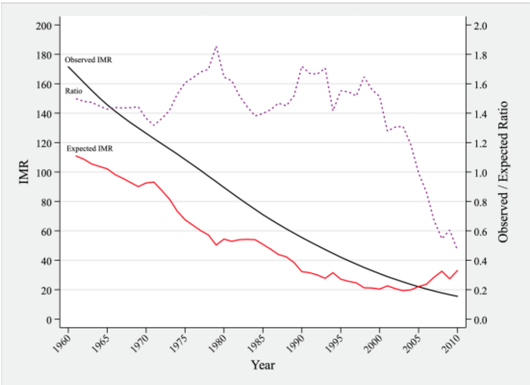
$$Y = \beta_0 + \beta_1 x^2 + \beta_2 x^2 \ln(x) \qquad (2)$$

The most straightforward means of determining whether certain countries differ significantly from others in their response to economic growth is to recompute the relationship between national income per capita and infant mortality in a group of countries and, on each occasion, employ a dummy variable representing a different country from the group. This is equivalent to adding the country from which an observation derives as an independent, explanatory variable to the equation. Since the dummy variable takes the value of 1 if an observation is in a country and 0 otherwise, the coefficient of the dummy would thus indicate by how much, on average, death rates in a particular country lie above or below the regression line. The average excess infant mortality Türkiye (D=1) experienced between 1960 and 2010, compared to other middle-income countries, was obtained by applying this procedure to cross-sectional data from 108 countries classified as either lower- or upper-middle-income countries (World Bank, 2023). Repeating the same procedure for each country enabled comparisons based on the sign and size of d_i. The magnitude of excess deaths was also viewed from a different angle, namely, by comparing observed mortality levels in Türkiye with those expected if Türkiye had experienced the same relation between GDP and IMR as in other middle-income countries. To achieve this, the relationship between detrended GDP and IMR in the pooled sample of countries (excluding Türkiye) was first estimated and subsequently used, along with Türkiye's GDP levels, to compute counterfactual values. Ratios of observed to expected values were used to determine whether Türkiye would have experienced lower IMRs if the Turkish GDP time trend had remained unchanged, but the relation between GDP and IMR in the pooled sample of developing countries had prevailed. If this is the case, these ratios become measures of the extent of Turkish “underachievement,” which can be explained by unmeasured factors unrelated to GDP that have kept Türkiye’s IMR at levels exceeding those expected given its national income levels. Finally, maternal education, the most significant indicator of unmeasured (cultural) factors not related to GDP, was integrated into estimations in two steps by adding the Gender Parity Index (GPI) in primary school education (i.e. ratio of female to male students enrolled at the primary level of education) and GPI in secondary school education (i.e. the ratio of female to male students enrolled at the secondary level of education) to the relationship between GDP and IMRs in middle-income countries.

The next group of analyses were conducted at the subpopulation level. The study of heterogeneity and subgroup analysis of infant mortality within Türkiye by geographical location, ethnicity, and maternal education relied on a robust indirect estimation method in demography that specifically targets infant mortality. The Brass method, which revolutionised the estimation of infant and child mortality in developing countries, uses the actual proportions of children born who have died to indicate infant mortality (Manual X UN, 1983; Preston et al., 2001: 224-233). Because the sample size of mothers who report about the survivorship of their children is the largest in a census, the Brass method was primarily applied to the Turkish census data from 1985, 1990 and 2000, using proportions of children ever born and proportions of children surviving by mother's five-year age group. However, four cross-sections of the DHS from 1993, 1998, 2003, and 2008 were also analysed to verify the accuracy of the results by ethnicity. The UN software package for mortality measurement, MORTPAK, and its CEBCS procedure were used to estimate IMRs. Turkish censuses could generate estimates for twenty-five years between 1971 and 1996, and DHS data produced estimations between 1979 and 2004.

By default, the Brass method generates four sets of IMRs, each corresponding to one of the four model life tables produced by the Coale-Demeny system (Coale & Demeny, 1966; Coale et al., 1983). Each model life table has a different pattern of age-specific mortality and a characteristic pattern in early life mortality: The 'north' model is distinguished by relatively low mortality in infancy and after age 50, 'east' model is characterised by relatively high mortality in infancy and after age 50, 'south' model is characterised by high mortality under age 5, low mortality at ages 40-60 and high mortality over age 65, and 'west' model is identified as an 'average' mortality pattern. The reported IMRs in this study were generated for the 'south' model (with Trussell's set of adjustment factors), as it historically aligns most closely with the Turkish experience (Shorter & Macura, 1982). Appendix Figure 1 shows that country-level IMR estimates produced using these specifications, based on reports from over 2 million women in the Turkish Censuses, were highly similar to the IMRs reported by the World Bank (2023).

Figure: 1
Ratios of Observed to Expected IMR in Türkiye using the Relation between GDP and IMR that Prevails in Middle-Income Countries



Data Source: The World Bank, World Development Indicators, 2023

Regional and ethnic variations in infant mortality were investigated by using regions, regional and urban-rural combinations of locations, and the Kurdish ethnicity. Regional analysis was limited to the Marmara, East Anatolia, and Southeast Anatolia regions to avoid clutter. Geographical combinations were constructed as replicates of some of the categories used by Shorter and Macura (1982) earlier, spanning the period from 1945 to 1970. They included a) Istanbul and Izmir, b) Urban West, c) Rural Central and d) Rural East. As no direct question of ethnicity was available through census data, the estimation of Kurdish infant mortality levels using census data was performed by selecting ten provinces in eastern Türkiye where the percentage of Kurds in the total population was at least 60% in 1990 (Mutlu, 1996). This group of estimations was supported by DHS data that included answers to a question about respondents’ native language and, therefore, provided a more accurate measure of Kurdish ethnicity. Variations in maternal education with the Brass method were estimated across mothers with less than primary education, primary education, secondary education, and a university degree. Estimated IMRs were later used to calculate the expected reduction in infant mortality based on counterfactual scenarios, which assumed hypothetical educational distributions of women at the country and subpopulation levels. These counterfactual scenarios are helpful as they demonstrate the contribution of women’s educational distribution to high death rates. They answer how much reduction in IMR would be expected if every mother in the country or a given subpopulation had at least a primary school education. Appendix Table 1 presents the sample size of women in each Brass estimation with further explanations.

Lastly, an individual-level analysis of the main determinants of infant mortality was conducted using the DHS data from 1993 to 2008. Although DHS data can capture only the final years of Türkiye’s mortality transition, it is still rich in detailed survival histories for children born in the last 5 years preceding the survey, as well as sociodemographic indicators. Here, the main goal was to assess the independent effects of economic resources and mothers’ education on utilising maternal and child health services and the risk of infant mortality, controlling for other potentially confounding socio-demographic and socio-economic characteristics of families, mothers and children. To achieve this, the pooled individual recode file of ever-married women aged 15-49 was reshaped into a long format, with children born to these women serving as the unit of observation. The outcome variables, prenatal care and infant mortality were constructed as binary variables, taking a positive value if the mother received prenatal care or the child died before their first birthday. The formula of the logistic regressions that modelled prenatal care utilisation and risk of infant mortality is:

$$\ln \frac{P\ (outcome)}{1-P\ (outcome)} = \alpha_{+} \beta_1 x_{1+} \beta_2 x_{2+} \ldots + \beta_k x_k \quad (3)$$

where P = Probability of prenatal care utilization or infant death

X = vector of independent variables (1-k)

Household wealth, one of the two most important independent variables, was categorised into five levels of economic status, ranging from the poorest to the wealthiest households. The other crucial independent variable, the mother’s education, was constructed as a categorical variable that differentiated between women with no education, women with primary education, and women with secondary or higher education. Other socio-economic variables included ethnicity, type of residence (urban or rural), five DHS regions, and the father’s education. The mother’s age, sex, birth order of the child, and the survey year were used as controls.

Table: 1
Significant Coefficients of Country Dummy Variables (di) in Fractional Polynomial Regressions Relating National Income to Infant Mortality Rates in Middle-Income Countries 1960-2010

Countries	Coef.	Std. Err.	Countries	Coef.	Std. Err.
Angola	67,86	4,40	Vanuatu	-13,76	4,46
Nigeria	57,17	3,58	Russian Federation	-14,16	5,28
Cote d'Ivoire	55,32	3,43	Georgia	-14,22	5,50
Equatorial Guinea	52,19	4,62	Kenya	-14,63	3,56
Benin	32,15	3,53	Jordan	-14,88	3,73
Cameroon	31,33	3,51	Montenegro	-14,99	7,60
Djibouti	30,40	5,03	Serbia	-15,72	6,30
Haiti	30,27	3,54	Mauritius	-15,90	4,28
Gabon	30,18	3,95	Colombia	-16,13	3,54
Pakistan	30,10	3,53	Paraguay	-16,97	3,72
Comoros	27,59	4,52	Grenada	-17,11	4,35
Bolivia	26,44	3,52	Dominica	-19,97	4,34
Algeria	24,24	3,53	Albania	-20,26	4,84
Turkiye	23,42	3,58	Kyrgyz Republic	-20,86	5,52
South Africa	22,09	4,17	Bulgaria	-21,12	4,53
Bangladesh	22,05	3,57	Armenia	-21,87	5,50
Nepal	20,02	3,63	Guyana	-22,13	3,52
Egypt, Arab Rep.	19,55	3,71	Thailand	-22,54	3,52
Senegal	18,01	3,53	Samoa	-23,02	4,67
Lao PDR	16,80	4,88	Jamaica	-23,27	3,55
Eswatini	16,64	3,53	Belarus	-23,50	5,49
Bhutan	15,85	4,53	Vincent and the Grenadines	-23,73	3,52
Namibia	15,48	4,54	Fiji	-25,07	3,53
Morocco	15,44	3,53	Ukraine	-26,23	5,13
India	15,34	3,56	Moldova	-26,39	6,30
Guatemala	14,75	3,54	Costa Rica	-26,40	3,53
Iran, Islamic Rep.	14,31	4,11	Philippines	-27,42	3,52
Brazil	11,27	3,56	Bosnia and Herzegovina	-27,44	6,10
Mauritania	11,07	3,57	Solomon Islands	-27,46	3,83
Mongolia	10,91	4,60	Cuba	-28,03	3,94
Peru	10,36	3,55	Malaysia	-30,61	3,53
Argentina	-7,80	3,98	Tonga	-31,13	4,18
Belize	-8,87	3,82	China	-32,83	3,88
Zimbabwe	-9,78	3,54	Vietnam	-41,00	4,94
Lebanon	-10,82	5,27	Sri Lanka	-48,28	3,47
North Macedonia	-11,95	5,50	Myanmar	-51,80	3,89
St. Lucia	-12,75	4,60			

Notes: i. Only those middle-income countries with significant coefficients at the .95 confidence interval are shown here. ii. All models control for t (Year 1959) using linear, quadratic and cubic terms. Data Source: The World Bank, World Development Indicators, 2023.

4. Results

Table 1 presents the ranked regression coefficients for country dummy variables, which display significant effects on infant mortality levels, either positive or negative, independent of the impact of economic growth jointly estimated for all countries between

1960 and 2010. Those countries with coefficients (di) at either end of the list are ‘exceptions’ in the sense that their observed mortality levels significantly deviate from what would be expected by the relationship between economic progress and infant mortality gains in the pool of developing countries. Those countries that appear at the top are the underachievers, displaying higher-than-expected rates of infant mortality, while those at the bottom are the ones that outperform and reduce mortality beyond what would be expected given their economic performance. The coefficient for Türkiye is both significant and positive, and it appears to be the first coefficient from an upper-middle-income country in this list. It is also more critical than the coefficients of countries such as Argentina, Brazil, Colombia, Bulgaria and Ukraine, which have had similar economic performances to Türkiye. The value of the coefficient indicates an average excess of 23.4 infant deaths per 1,000 births between 1960 and 2010, which cannot be explained solely by national income levels.

Another way to assess the magnitude of excess deaths is by comparing the observed mortality levels with those expected if Türkiye had experienced the relationship between GDP and IMR observed in other middle-income countries. To do this, the relation between detrended GDP and IMR in the pooled sample of countries (excluding Türkiye) is first estimated (see Appendix Table 2). Next, Türkiye's GDP levels and the model's parameter estimates are used to compute counterfactual values. Figure 1 displays ratios of observed to expected values of IMR. Here, the ratios above unity indicate that if the Turkish GDP time trend had remained unchanged, but the relation between GDP and IMR in the pooled sample had prevailed (if Türkiye had the same average relationship as other middle-income countries), Türkiye would have experienced a significantly lower IMR. Until 2005, the ratios hovered in the range of 1.19-1.86, suggesting that IMRs should have been up to 54% lower than the observed, conditional on economic performance.

These ratios reflect the extent of unmeasured factors unrelated to GDP that contributed to Türkiye’s IMR remaining at levels exceeding those expected, given its economic achievements.

A plausible argument is that lagging improvements in female education, the most significant driver of social change, delayed Türkiye’s decline in infant mortality despite improvements in national income. The results of two additional regressions, which include GPI in primary school education and GPI in secondary education, are presented in Table 2. Türkiye’s country variable is still significant but notably reduced after controlling for female-to-male ratios in primary education and only loses its significance after controlling for female-to-male ratios in secondary education: The initial country coefficient corresponding to 23.4 excess deaths (per 1,000 births on average) in the first model, is reduced almost by half to 12.3 in the second model, and later to 3.4 excess deaths (per 1,000 births on average) in the third model. Therefore, the gap in infant mortality between Türkiye and other middle-income countries shrinks notably when we control for primary education and disappears entirely when we control for secondary education, demonstrating the powerful role of female education, independent of the effect of economic growth, on mortality. Between Models 1 and 3, the coefficients associated with GDP are altered, indicating a weakened effect on IMR after including gender ratios in primary and secondary education. For example, a $1,000 increase in GDP from $1,000 to $2,000 decreases the IMR by 14.4%, 12.3%, and 10.2% in the first, second, and third models, respectively. Between Model 2 and Model 3, the coefficient associated with gender ratios in primary education is significantly reduced but remains statistically significant, and its magnitude is more extensive than that associated with gender ratios in secondary education. While a one percentage point increase in the male ratio in primary education decreases the IMR by 0.96 in the second model, a one percentage point increase in the to-male ratio in primary and secondary education decreases the IMR by 0.40 and 0.38, respectively, in the third model.

Table: 2
Fractional Polynomial Regressions Relating National Income Levels and Female-To-Male Ratios in Education to Infant and Child Mortality Rates Between 1960 and 2010 in Middle-Income Countries

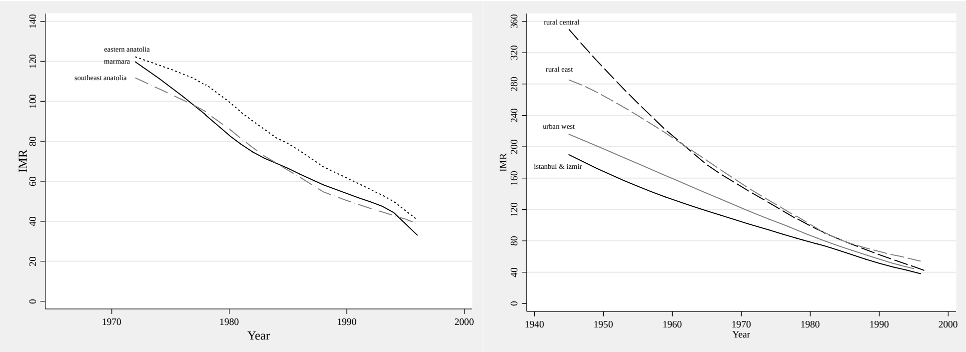
	Model I				**Model II**				**Model III**			
Number of obs	4.001				2.766				2.024			
F	(6, 3994)	=	1074,85		(7, 2758)	=	789,18		(8, 2015)	=	621,26	
Prob > F	0,0000				0,0000				0,0000			
R-squared	0,62				0,67				0,7115			
	Coef.		Std. Err.	t	Coef.		Std. Err.	t	Coef.		Std. Err.	t
Constant	183,64	★★★	2,90	63,39	208,41	★★★	8,31	25,09	214,91	★★★	8,92	24,11
gdp_1	-9,13	★★★	0,35	-26,01	-1,94	★★★	0,08	-24,12	-5,38	★★★	0,38	-14,21
gdp_2	0,87	★★★	0,04	23,59	0,01	★★★	0,00	16,12	0,50	★★★	0,04	12,56
GPI in primary school education					-0,97	★★★	0,03	-31,70	-0,41	★★★	0,05	-8,10
GPI in secondary school education									-0,38	★★★	0,03	-13,02
Country dummy variable for Türkiye	23,42	★★★	3,58	6,55	12,32	★★★	3,33	3,70	3,14		3,28	0,96
t	-0,25		0,34	-0,73	0,80		0,88	0,91	-0,53		0,92	-0,57
t^2	-0,05	★★★	0,01	-3,58	-0,07	★★	0,03	-2,50	-0,03		0,03	-1,07
t^3	0,00	★★★	0,00	-20,31	0,00	★★★	0,00	3,15	0,00	★	0,00	1,85

*Notes: i. *** = p<0.01, ** = p<0.05, * = p<0.10. ii. After trying 44 different models involving polynomials, the selected model for Models 1, 2, and 3 uses the powers (0.5-0.5), (0.5-1), and (0.5-0.5) as the best-fitting combination of polynomials. iii. In Model 1 and Model 3, gdp_1 and gdp_2 reflect the terms associated with (GDP per capita ^ 0.5) and (GDP per capita ^ 0.5) * ln (GDP per capita), respectively. In Model 2, they reflect (GDP per capita ^ 0.5) and (GDP per capita). Data Source: The World Bank, World Development Indicators, 2023.*

Having established at the population level that higher levels of female education would have exerted significant negative effects on infant mortality, independent of the impact of economic growth, one can assess to what extent different distributions of maternal education at the subpopulation level contributed to disparities in IMR across Türkiye. Infant mortality trends across three regions and four regional and urban-rural combinations of locations are displayed in Figure 2, demonstrating the principal axes of inequality in death rates. The upper panel compares the most economically advanced Marmara region with the least economically advanced regions of East and Southeast Anatolia. In the early 1970s, when Türkiye’s country-level IMR was 116 and regional IMRs ranged between 106 and 132, Southeast Anatolia was one of the regions with relatively lower mortality levels (IMR = 112). Marmara and East Anatolia are high mortality regions with IMRs of 120 and 122, respectively. Marmara experienced significant mortality gains from the 1970s onward, but the decline curve in both the East Anatolia and Southeast Anatolia regions is less steep. Although IMRs in the mid-1990s converged around 33 in most other regions, East Anatolia and Southeast Anatolia had IMRs of 39 and 41, respectively. This corresponds to 18% and 24% more infant deaths in these regions at this time.

Figure: 2
Estimated IMRs by Selected Regions and Geographical Divisions in Türkiye

Panel A **Panel B**

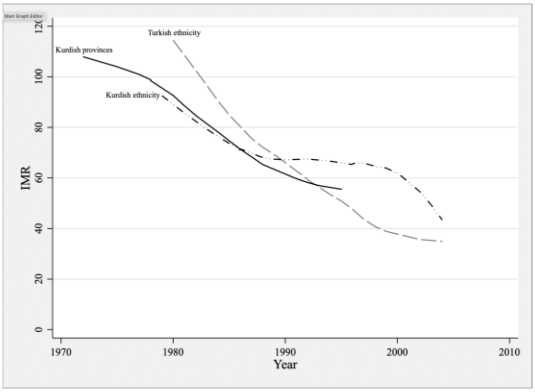


Notes: i. Except for Istanbul and Izmir, all geographical divisions are measured by representative locations. The cities of Aydın and Usak represent the urban West. Rural Kırşehir and Sivas represent rural Central Anatolia. Rural Mardin, Hakkari, Siirt, Sırnak, Kars, Igdir and Ardahan represent rural East. These arbitrary choices may differ from those in urban and rural units in Shorter and Macura's (1982) estimations.

The lower panel examines geographical variations in infant mortality in two ways: first, by presenting earlier IMR estimates from Shorter and Macura (1982) for the period 1945-1970, and second, by distinguishing between metropolitan, urban, and rural areas. This graph compares the country's most advanced regions: two metropolitan centres in the west, less-industrialized urban centres in the West, and the least developed rural areas in central and eastern Türkiye. At first glance, the results indicate a significant fluctuation in initial mortality rates across the country, with an IMR of 260 at the national level reflecting very different mortality experiences. In the mid-1940s, for instance, a significant gap existed in the initial mortality levels experienced in Istanbul and Izmir, on the one hand, and the rural central and eastern regions, on the other, which had IMRs of 182, 350, and 285, respectively. Therefore, the starting infant mortality rates in rural central and rural eastern areas are 92% and 57% higher than in metropolitan cities. Another feature is the relatively slow mortality decline rate in the rural east throughout the analysis period despite higher starting mortality levels in the 1940s. By contrast, the mortality decline in rural central areas is faster. It reduced the IMR by 87% between 1945 and 1995, eliminating most of the initial disadvantages compared to Western metropolitan and urban areas. The gap in IMR between Istanbul and Izmir, as well as the rural east, remains significant by the end of the 1990s: the infant mortality level in the rural east is 42% higher than in the most advanced regions in the west.

Locations that experienced a stalling of mortality, specifically the East and Southeast Anatolia regions in the upper panel and eastern rural areas in the lower panel, are considered traditional areas of the Kurdish population, despite massive movements that geographically redistributed the Kurds to the western and southern parts of the country during the 1990s. Thus, Figure 3 shifts focus to infant mortality levels in the Kurdish population between the early 1970s and mid-2000s, based on census and DHS data estimations. The figure reveals several important features. The first is that the IMR in predominantly Kurdish provinces (estimated from census data) decreased by 48% between the early 1970s and the late 1990s, dropping from 108 to 56. This is a minor reduction compared to the rates estimated for other high-mortality locations during the same period. Second, IMR estimates from the DHS data, representing the Kurdish population not only in predominantly Kurdish provinces in the east but across all regions in Türkiye, are very close to the rates in Kurdish provinces, at least until the mid-1980s. There is a divergence after this period, and the IMRs estimated for traditional Kurdish provinces are lower than those calculated for the entire Kurdish population using DHS data. This finding is compatible with the higher participation of the younger Kurdish population in internal migration at that time, as a result of which we may be underestimating Kurdish infant mortality or introducing more bias using Kurdish provinces rather than more accurate measures of ethnicity. In other words, if Kurdish infant deaths are occurring outside these provinces, we are not counting them. Third and most importantly, a comparison of levels between Kurdish and Turkish infant mortality reveals that IMR was lower among the Kurdish population until the end of the 1980s, but there was a 'cross-over' in rates at the beginning of the 1990s when the Kurdish mortality decline slows down and eventually comes to a halt. Ten years before the cross-over, the Turkish IMR was in the range of 114 and 66, and the Kurdish IMR was in the range of 92 and 66. After the cross-over, the rates increasingly diverge, leading to a large disadvantage gap for the Kurdish population by the mid-2000s. The Turkish IMR is 35, and the Kurdish IMR is 43, or 23% higher. Kurdish provinces also experienced a crossover in IMRs, even though census data show a gap only for a short time, until the mid-1990s.

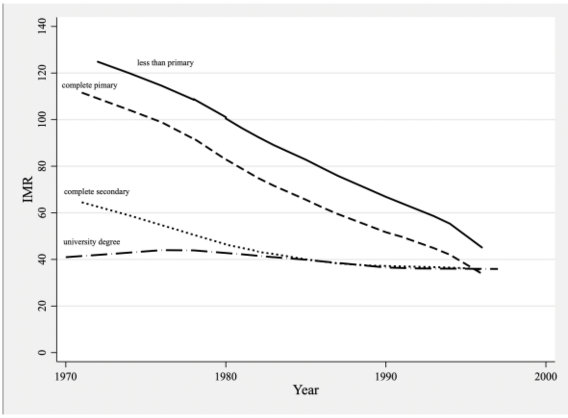
Figure: 3
Estimated IMRs by Ethnicity in Türkiye



Notes: i. Agri, Bitlis, Bingol, Diyarbakir, Hakkari, Mardin, Siirt, Batman, Sirnak and Kars are the names of the ten Kurdish-majority provinces.

Suppose maternal education is strongly associated with infant mortality. In that case, it is plausible that lack of satisfactory levels of education, particularly in some subpopulations of women of reproductive age (for instance, among Kurdish women residing in eastern Türkiye), is a contributing factor to high levels of death rates observed in these groups. Consequently, it is also a contributing factor to the excess IMR observed at the country level, especially in comparison to other countries at similar levels of economic achievement but with less unequal distributions of education or lower rate schedules at the lower end of the *educational distribution*. To determine the extent to which the distribution of maternal education by geographical location or ethnicity explains the disparities described in Figures 2 and 3, the IMRs by mothers' educational attainment need to be estimated first. The results of this estimation are presented in Figure 4, which demonstrates the most striking variation in death rates in Türkiye, based on the initial levels in the early 1970s, the rates achieved by the mid-1990s, and the pace of decline in between.

Figure: 4
Estimated IMRs by Maternal Education in Türkiye



The starting IMRs of mothers with less than primary education, primary education, secondary education, and university degrees are 125, 112, 65 and 41, respectively. To put it another way, the infant mortality level experienced by mothers without any educational attainment is more than two times higher than that of mothers with a university degree and almost twice as high as that of mothers with secondary education. The gap is large enough to suggest two mortality regimes until the end of the 1980s, one shared by those with complete primary school education or less and another shared by secondary education graduates and university degree holders. During the period from the early 1970s to the late 1990s, the intensity of change was most significant for mothers with primary education, followed by those without a complete primary education. The IMR of mothers with less than primary education decreased by 64%, whereas the IMR of mothers with primary education declined by 70%. The IMR of mothers with a university degree declined by only 12%. The pace of decline in infant deaths to mothers with complete secondary education is slower than declines in lower educational categories, with nearly two-thirds of their intensity. The gap in mortality rates between mothers with no education and those with some level of education shrinks but does not disappear by the mid-1990s. Currently, the IMR of mothers with less than primary education is 45, whereas the IMRs of mothers with primary education, secondary education and university degrees are 34-36.

Table: 3
Counterfactual Infant Mortality Rates by Maternal Education

	Türkiye		
	C(x) in 1985	**Observed IMR in 1985**	**Counter**
Less than Primary Education	36,25	83	66
Primary Education	55,39	66	
Secondary Education	6,45	40	
University Degree	1,91	40	
Total	100,00	69,70	63,62
	Kurdish Provinces		
	C(x) in 1985	**Observed IMR in 1985**	**Counter**
Less than Primary Education	79,82	83	66
Primary Education	17,66	66	
Secondary Education	1,89	40	
University Degree	0,63	40	
Total	100,00	78,68	65,28
	Istanbul and Izmir		
	C(x) in 1985	**Observed IMR in 1985**	**Counter**
Less than Primary Education	23,55	83	66
Primary Education	61,43	66	
Secondary Education	11,47	40	
University Degree	3,55	40	
Total	100,00	65,81	61,86
	East Anatolia		
	C(x) in 1985	**Observed IMR in 1985**	**Counter**
Less than Primary Education	64,51	83	66
Primary Education	32,06	66	
Secondary Education	2,73	40	
University Degree	0,71	40	
Total	100,00	75,82	64,99
	Southeast Anatolia		
	C(x) in 1985	**Observed IMR in 1985**	**Counter**
Less than Primary Education	77,21	83	66
Primary Education	19,40	66	
Secondary Education	2,56	40	
University Degree	0,83	40	
Total	100,00	78,28	65,04
	Rural East		
	C(x) in 1985	**Observed IMR in 1985**	**Counter**
Less than Primary Education	74,53	83	66
Primary Education	23,4	66	
Secondary Education	1,61	40	
University Degree	0,47	40	
Total	100,00	77,89	65,38

Notes: i. Only those women of reproductive age with a non-missing value on the number of everborn children are included in the analysis. ii. C(x) refers to the proportion of women in each education category in the 1985 census year. iii. The author's estimations of the IMRs were observed in 1985 by educational category (Figure 4). Data Source: Turkish census data for 1985, 1990, and 2000.

Values of IMR that would have been observed if every mother completed at least primary school education are displayed in Table 3. If every mother had at least a primary school education in 1985, Türkiye’s population-level IMR would decline by 9%, dropping from 70 to 64. This change may seem trivial, but it is expected, given that the main dissimilarity was identified above to be between mothers with less than a secondary school education and those with at least a secondary school education. If every mother graduated from secondary school, Türkiye’s IMR would drop to 40 in 1985, a substantial reduction of 43%. However, even though the condition requiring mothers to have at least a primary school education may seem inconsequential compared to the impact of secondary education, its significance increases when we focus on high-mortality subpopulations. For instance, in East and Southeast Anatolia, where the percentage of women without any education was 65% and 77% in 1985, the counterfactual scenario in which every woman who has ever given birth has at least primary school education decreases the IMR by 14% and 17%, respectively. This also eliminates the gap between metropolitan cities, Istanbul and Izmir, and these locations. In the same counterfactual scenario, the IMR in Kurdish-populated provinces would decline by 17%, and rural eastern regions would experience a 16% reduction.

Table: 4
The Proportion of DHS Children Who Died During Infancy by DHS Year and Selected SES Indicators

		1993	1998	2003	2008
By Household Wealth Index	Poorest households	0,081	0,060	0,049	0,025
	Poorer households	0,047	0,050	0,036	0,020
	Middle-wealth households	0,058	0,036	0,027	0,014
	Richer households	0,030	0,033	0,025	0,015
	Richest households	0,023	0,018	0,009	0,014
By Mother's Education	No education	0,062	0,065	0,057	0,026
	Primary education	0,055	0,039	0,026	0,019
	Secondary education and Higher	0,015	0,024	0,016	0,013
Geographical Region	West	0,044	0,030	0,023	0,009
	South	0,052	0,033	0,025	0,022
	Central	0,057	0,043	0,025	0,018
	North	0,039	0,035	0,027	0,011
	East	0,058	0,059	0,041	0,024
Urban or Rural Place of Residence	Rural	0,060	0,054	0,039	0,020
	Urban	0,044	0,036	0,028	0,018
Ethnicity	Turkish	0,046	0,039	0,022	0,015
	Kurdish	0,068	0,047	0,050	0,024
Total		0,050	0,042	0,032	0,019

Data Source: Türkiye DHS 1993, 1998, 2003 and 2008.

Given the powerful role of education in reducing infant mortality at the population and subpopulation levels, we next assess whether two indicators of socioeconomic status (SES) at the individual level -education and material resources -act independently on the risk of infant mortality in families. The proportion of DHS children born between 1988 and 2008 who died during infancy is presented in Table 4 by survey year and the most critical SES indicators. At first glance, the proportions of children who died during infancy by region, ethnicity and maternal education are consistent with prior Brass estimates: Children born to families in the eastern region with Kurdish ethnicity and low maternal education have higher infant mortality rates throughout all DHS years. The results of logistic estimations on the use of prenatal care and the risk of mortality applied to the same DHS data, along with these and other critical socio-economic variables, are presented in Table 5. It is important to note that, according to the model results predicting the risk of infant mortality, region and ethnicity are statistically insignificant determinants once household wealth and maternal education are controlled for.

Table: 5
Results of Logistic Regressions Predicting Prenatal Care During Pregnancy and Infant Mortality in Türkiye (1993-2008)

Dependent Variable	**Prenatal Care During Pregnancy**				**Infant Mortality**			
Number of Observations	14.719				15.620			
LR chi2	4951,68				196,33			
Prob>chi2	0,0000				0,0000			
	Odds Ratio	**Standard Error**	**z**	**P>z**	**Odds Ratio**	**Standard Error**	**z**	**P>z**
Household Wealth								
Poorest Households (Omitted)	-	-	-	-	-	-	-	-
Poorer Households	1,74	0,10	9,44	0,000	0,83	0,10	-1,51	0,132
Middle-Wealth Households	2,72	0,19	14,38	0,000	0,81	0,11	-1,51	0,132
Richer Households	3,91	0,34	15,78	0,000	0,70	0,12	-2,13	0,034
Richest Households	6,48	0,87	13,84	0,000	0,51	0,12	-2,86	0,004
Mother's Education								
No Education (Omitted)	-	-	-	-	-	-	-	-
Primary Education	1,62	0,09	8,43	0,000	0,88	0,10	-1,11	0,267
Secondary Education And Higher	3,39	0,36	11,45	0,000	0,68	0,13	-2,00	0,046
Father's Education								
No Education (Omitted)	-	-	-	-	-	-	-	-
Primary Education	1,08	0,09	0,97	0,332	1,24	0,20	1,35	0,177
Secondary Education And Higher	1,77	0,17	6,08	0,000	0,94	0,18	-0,35	0,727
Geographical Region								
West (Omitted)	-	-	-	-	-	-	-	-
South	0,74	0,06	-3,44	0,001	0,99	0,16	-0,06	0,956
Central	0,46	0,04	-9,21	0,000	1,17	0,18	1,04	0,298
North	0,60	0,06	-5,40	0,000	0,89	0,16	-0,65	0,518
East	0,32	0,03	-13,69	0,000	1,10	0,17	0,63	0,528
Urban or Rural Place of Residence								
Urban	1,35	0,07	5,95	0,000	1,03	0,10	0,25	0,805
Ethnicity								
Turkish (Omitted)	-	-	-	-	-	-	-	-
Kurdish	0,76	0,05	-4,08	0,000	1,00	0,14	-0,03	0,976
Other	1,07	0,12	0,58	0,563	1,04	0,22	0,21	0,836
Mother's Age								
15-19	0,94	0,12	-0,52	0,604	1,96	0,45	2,95	0,003
20-24	0,78	0,06	-3,44	0,001	1,42	0,21	2,44	0,015
25-29	0,83	0,06	-2,73	0,006	1,15	0,15	1,03	0,303
30-34 (Omitted)	-	-	-	-	-	-	-	-
35-39	1,18	0,10	1,89	0,059	1,11	0,18	0,64	0,524
40-44	1,18	0,15	1,31	0,189	1,12	0,25	0,51	0,609
45-49	1,25	0,32	0,85	0,394	1,33	0,52	0,72	0,470
Child Sex								
Female	0,96	0,04	-0,85	0,395	0,89	0,08	-1,33	0,183
Birth Order	0,87	0,01	-9,47	0,000	1,10	0,03	3,63	0,000
DHS Year								
1993 (Omitted)	-	-	-	-	-	-	-	-
1998	1,17	0,07	2,65	0,008	0,85	0,10	-1,47	0,143
2003	2,21	0,14	12,89	0,000	0,62	0,07	-3,99	0,000
2008	8,21	0,70	24,79	0,000	0,36	0,05	-6,76	0,000
Constant	1,24	0,19	1,39	0,165	0,05	0,01	-10,38	0,000

Data Source: Türkiye DHS 1993, 1998, 2003 and 2008.

According to the results of logistic estimation predicting prenatal care utilisation, mothers in higher wealth categories are significantly more likely to receive prenatal care during pregnancy than mothers in the lowest wealth category. Compared with the poorest households, the odds of prenatal care utilisation increase gradually in the range of 1.74-6.48 in wealthier households. Additionally, in comparison to children born to women with no education, children born to women with primary education are 62% more likely to receive prenatal care, and children born to women with secondary education are 2.4 times more likely to receive prenatal care. Thus, the difference in the probability of utilising prenatal care between the most and least educated mothers is almost equivalent to the difference between the richest and poorest households. The effect of mothers' secondary education on prenatal care use is also more significant than the effect of fathers' secondary education. The results of logistic estimation on the risk of infant mortality reveal that children born to families in the poorest households have 30% and 49% more likelihood of death in comparison to children born to families in richer and the richest households, respectively. However, children born to women with secondary or higher education are 34% less likely to die during infancy than children born to women with no education, indicating that the difference in the risk of infant mortality between children born to mothers with secondary or higher education, and no education, is more significant than the difference in the risk of mortality between children in richer and the poorest households. Mother's primary school education is not statistically related to infant mortality, a finding that is consistent with the increasing weight of secondary education on infant mortality decline in the later phases of mortality transition. In contrast to a mother's education, a father's education is not significantly associated with the risk of infant mortality. Together, both groups of findings demonstrate that families' economic resources and mothers' education have exerted independent and strong influences on infant mortality.

5. Discussion

For decades, Türkiye was considered a singular case among countries undergoing mortality decline due to its exceptionally high infant mortality rates. Reductions were achieved. However, a significant gap in death rates persisted compared to other countries in Europe and elsewhere with similar levels of economic development. This study has examined two fundamental forces of change that could have been experienced commonly across Türkiye's population and impacted its mortality trends on a large scale: economic growth and improvements in female education. The powerful association between economic improvements and infant mortality reductions is due to the critical importance of nutrition for survival gains, but the positive effect of the cultural and attitudinal change brought by education on infant survivorship is caused by multiple mechanisms that include better health-specific knowledge, rejection of fatalism and other traditional beliefs, greater female empowerment and autonomy.

This study presents an updated assessment of the relationship between infant mortality, on the one hand, and national income and female education levels, on the other, using a large dataset on middle-income countries. The cross-national analysis of the relationship between national income and infant mortality confirmed an anomaly: Türkiye consistently displayed excess levels of infant mortality between 1960 and 2010. If Türkiye had experienced the same GDP-IMR relationship estimated for middle-income countries, substantial reductions (up to 54%) in death rates could have been observed until 2005. While this was interpreted as evidence for unmeasured factors unrelated to GDP that kept Türkiye's IMRs at levels exceeding those expected, given its economic performance, the results of regression models incorporating female-to-male ratios in education, as well as cross-national analysis, highlighted Türkiye's historically significant gender gap in education. Two findings based on the interpretation of Türkiye's country variable (which measures the extent of its excess rates) stood out: The coefficient remained significant but was significantly reduced once the model controlled for female primary education, and it lost its statistical significance entirely once the model controlled for female secondary education. Both findings supported the argument that low maternal education levels might have delayed Türkiye's mortality transition at the expense of economic growth. Second, the subpopulation-level analysis presented in this study aimed at geographic and ethnic variations in infant mortality that characterised Türkiye's mortality transition. Indirectly estimated mortality rates with census and DHS data described the extent of inequalities in deaths, while the hypothetical educational distributions of reproductive-age women, with education-specific mortality rate schedules, showed that a large portion of these inequalities could have been eliminated with primary school education. Third, an individual-level analysis of the main determinants of infant mortality risk revealed that families' material resources and mothers' education were the only significant socioeconomic status (SES) factors associated with the risk of infant mortality. Having a mother with secondary or higher education (rather than no education) had a more substantial effect on the risk of infant mortality than living in a rich household (rather than a poor household). Because this part of the analysis corresponded to the very end of Türkiye's mortality transition, mothers' primary school education was not found to be significantly related to the risk of infant mortality.

Some points are worth mentioning. A third explanation of infectious disease mortality transition intentionally left out from the theoretical boundaries of this paper emphasises the social interventions in public health (theoretically not an automatic outcome of economic development) as one of the main drivers of infant mortality decline in high mortality settings (Szreter, 1988; Morel, 1991; Easterlin, 2004). First, correcting environmental conditions that expose populations to disease is possible only through public health initiatives, as most risk factors are beyond individual control. Services that promote health, such as providing pure water supply, proper sewage disposal and spraying insecticides, are beyond individual means. Second, individuals often lack access to modern health facilities and adequate health infrastructure. These methods of public health to control the spread of infectious diseases require, by principle, the development of new institutions centring on the public health system, with functions including sanitation, health education, regulation, and the financing and direct provision of health services (such as immunisation campaigns or oral rehydration therapies). Third, social interventions in public health are crucial not only for the implementation of new techniques of disease control but also for providing the public with knowledge of the mechanisms of infectious disease causation, transmission, and treatment. In this sense, they have the potential to reduce health inequalities through maternal education, as well as other SES indicators.

One limitation of the current study is its inability to isolate the role of public health interventions in reducing infant mortality. While health expenditure per capita is an effective indicator of public health investments in a given country, this data is only available from the 2000s onwards in the group of middle-income countries. Similarly, measures such as 'percentage of mothers who received antenatal care during pregnancy', 'percentage of births attended by skilled health staff', or 'percentage of children who have received medical treatment after fever and/or cough’ are inconsistently available after the 1990s. The only measures that can be used for middle-income countries and are suitable to the period of analysis in this paper are ‘hospital beds per 1,000 people’ and ‘physicians per 1,000 people’, which can be seen as somewhat unpolished indicators for measuring the capacity of health care systems and its relation to infant mortality rates in countries. When these variables are added to the last regression model predicting infant mortality, the estimation sample size shrinks considerably, but both appear to be significant predictors, and their inclusion increases the R-squared value (see Appendix Table 4).

Despite the limited ability to test the role of public health factors, the analytic approach adopted in this study was based on the primary opposition between the economic and cultural theories of infectious disease mortality decline in developing countries. There is a nuance in the main findings: The empirical inconsistency between IMR-GDP in Türkiye’s case does not necessarily attest to the weakness of economic explanation and its emphasis on nutritional improvements as the key driver of mortality decline but to the impediment factors; the cultural and ideational constraints, existing in the absence of satisfactory levels of education in the female population. These constraints limited the response of infant death rates to improving economic conditions at the population level, while stark inequalities in primary and secondary education at the subpopulation level were the maintainers of high mortality. Since infant deaths remain common in the developing world today, the implication of these findings for future research in high-mortality settings is that maternal education is critically important as a driver of social change and should accompany economic change to avoid mortality lags and achieve equal reductions. Türkiye’s experience over five decades between 1960 and 2010 suggests that there is some degree of independence between the effects of economic and social development and that whereas the former can contribute to infant mortality decline in the absence of the latter, its effects are ultimately conditioned by mothers’ education having a powerful role in children’s survival outcomes.

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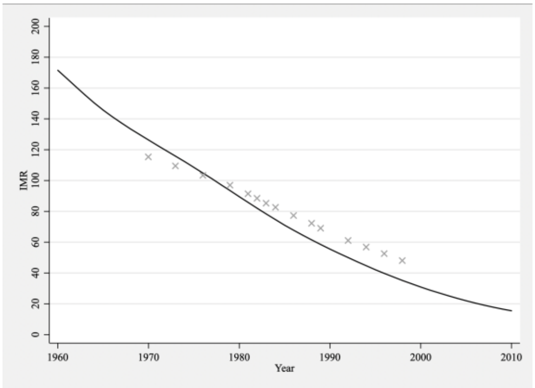
Appendix Figure: 1
Estimated IMRs for Türkiye with the Brass Method 1971-1996



Notes: i. The solid line represents IMRs reported by the World Bank, as per the World Development Indicators 2023. Indirectly estimated IMRs using the Brass technique, as estimated by the author, are marked with an X.

Appendix Table: 1
Mothers' Samples Used in Brass Estimations

Total Sample - Census		**1985**	**1990**	**2000**
		500.059	705.564	912.889
By Geographical Regions - Census		**1985**	**1990**	**2000**
Black Sea		32.935	73.069	78.718
Marmara		93.979	127.343	176.911
Aeagan		59.908	72.397	90.032
Mediterranean		57.004	68.674	93.212
Central Anatolia		68.847	89.594	110.161
East Anatolia		38.422	50.872	59.610
Southeast Anatolia		10.148	19.298	25.115
By Geographical Divisions - Census		**1985**	**1990**	**2000**
Istanbul and Izmir		62.015	81.626	113.187
Urban West		1.941	3.062	4.077
Rural Central		1.318	5.358	4.934
Rural East		10.491	11.660	7.951
Kurdish-Majority Provinces - Census		**1985**	**1990**	**2000**
		22.641	34.676	42.282
By Ethnicity - DHS	**1993**	**1998**	**2003**	**2008**
Turkish	5.671	6.879	6.249	5.700
Kurdish	665	1.390	1.529	1.465
By Education - Census		**1985**	**1990**	**2000**
Less than Primary Education		130.921	151.152	127.796
Primary Education		200.056	298.938	399.628
Secondary Education		23.303	36.759	73.150
University Degree		6.886	14.200	32.962

Notes: i. Mothers' samples consist of all women of reproductive age (15-49) with a non-missing value on the number of ever-born children. ii. Except for Istanbul and Izmir, all geographical divisions are measured by representative locations. The cities of Aydın and Usak represent the urban West. Rural Kırşehir and Sivas represent rural Central Anatolia. Rural Mardin, Hakkari, Siirt, Sırnak, Kars, Igdir and Ardahan represent rural East.

Appendix Table: 2
Results of Fractional Polynomial Regression Relating National Income Levels to Infant Mortality Rates between 1960 and 2010 in Middle-Income Countries

Number of Observations	3951			
F(5,3945)	1249,92			
Prob>F	0,00			
R-squared	0,61			
	Coefficient	Standard Error	t	P<t
Constant	184,26	2,93	62,94	0,000
gdp_1	-9,36	0,36	-26,25	0,000
gdp_2	0,89	0,04	23,87	0,000
t	-0,20	0,34	-0,57	0,565
t^2	-0,05	0,01	-3,58	0,000
t^3	0,00	0,00	4,54	0,000

*Notes: i. Türkiye is excluded from this analysis. ii. After trying 44 different models involving polynomials, the selected model uses the powers 0.5 and 0.5 as the best-fitting combination of polynomials. iii. gdp_1 and gdp_2 reflect the terms associated with (GDP per capita ^ 0.5) and (GDP per capita ^ 0.5) * ln (GDP per capita), respectively. iv. The model controls for t (Year 1959) using linear, quadratic and cubic terms.*

Appendix Table: 3
Descriptive Statistics for the Analysis of Infant Mortality with DHS Data (1993-2008)

	1993		1998		2003		2008	
	%	n	%	n	%	n	%	n
Infant Death	5,05	188	4,24	151	3,20	145	1,89	73
Total Number of Children		3.724		3.565		4.533		3.857
Prenatal Care During Pregnancy	64,04	2.383	66,38	2.357	73,00	3.301	89,42	2.662
Total Number of Children		3.721		3.551		4.522		2.977
Household Wealth Index								
Poorest Households	22,48	837	24,12	860	27,73	1.257	32,30	1.246
Poorer Households	22,15	825	23,34	832	21,38	969	23,80	918
Middle-Wealth Households	22,15	825	22,75	811	17,43	790	18,87	728
Richer Households	19,01	708	17,07	609	19,17	869	14,26	550
Richest Households	14,21	529	12,71	453	14,30	648	10,76	415
Total Number of Children		3.724		3.565		4.533		3.857
Mother's Education								
No Education	29,00	1.080	24,49	873	26,94	1.221	21,70	837
Primary Education	55,08	2.051	55,54	1.908	50,23	2.277	50,92	1.964
Secondary Education and Higher	15,92	593	19,97	712	22,83	1.035	27,38	1.056
Total Number of Children		3.724		3.565		4.533		3.857
Father's Education								
No Education	7,92	295	7,35	261	7,73	349	4,33	166
Primary Education	56,67	2.110	51,82	1.839	48,60	2.194	48,17	1.847
Secondary Education and Higher	35,40	1.318	40,83	1.449	43,66	1.971	47,50	1.821
Total Number of Children		3.723		3.549		4.514		3.834
Geographical Region								
West	21,56	803	19,47	694	21,22	962	16,88	651
South	20,60	767	18,65	665	13,10	594	12,89	497
Central	21,70	808	19,47	694	13,94	632	17,27	666
North	15,82	589	12,90	460	8,12	368	9,13	352
East	20,33	757	29,51	1.052	43,61	1.977	43,84	1.691
Total Number of Children		3.724		3.565		4.533		3.857
Urban or Rural Place of Residence								
Rural	40,17	1.496	35,65	1.271	32,45	1.471	32,88	1.268
Urban	59,83	2.228	64,35	2.294	67,55	3.061	67,12	2.589
Total Number of Children		3.724		3.565		4.533		3.857
Ethnicity								
Turkish	79,19	2.949	69,82	2.489	61,57	2.791	62,90	2.426
Kurdish	17,83	664	25,02	892	33,80	1.532	32,36	1.248
Other	2,98	111	5,16	184	4,63	210	4,74	183
Total Number of Children		3.724		3.565		4.533		3.857

Mother's Age									
	15-19	4,73	176	4,54	162	3,18	144	2,70	104
	20-24	29,59	1.102	27,69	987	25,04	1.135	22,97	886
	25-29	31,74	1.182	33,02	1.177	33,40	1.514	34,25	1.321
	30-34	20,81	775	20,39	727	22,44	1.017	23,31	899
	35-39	9,13	340	10,49	374	11,01	499	11,67	450
	40-44	3,41	127	3,23	115	4,24	192	4,23	163
	45-49	0,59	22	0,65	23	0,71	32	0,88	34
Total Number of Children			3.724		3.565		4.533		3.857
Child Sex									
	Male	51,45	1.916	52,45	1.870	51,25	2.323	50,51	1.948
	Female	48,55	1.808	47,55	1.695	48,75	2.210	49,49	1.909
Total Number of Children			3.724		3.565		4.533		3.857
Birth Order	Mean		2,84		2,75		2,93		2,69
	SD		2,23		2,13		2,34		2,01
	Min		1		1		1		1
	Max		15		16		17		15
Total Number of Children			3.724		3.565		4.533		3.857

Data Source: Türkiye DHS 1993, 1998, 2003 and 2008.

Appendix Table: 4
Results of Fractional Polynomial Regressions Relating National Income, Female-To-Male Ratios in Education, and Two Public-Health Measures to Infant Mortality Rates Between 1960 and 2010 in Middle-Income Countries and Türkiye

	Model IV				**Model V**				**Model VI**			
Number of Observations	814				766				515			
F	(9, 804)	=	233,06		(9, 756)	=	248,49		(10, 504)	=	182,35	
Prob>F	0,0000				0,0000				0,0000			
R-squared	0,72				0,75				0,78			
	Coef.		Std. Err.	t	Coef.		Std. Err.	t				
Constant	216,43	★★★	14,10	15,35	230,52	★★★	13,33	17,29	237,94	★★★	15,23	15,62
gdp_1	-1,34	★★★	0,12	-11,22	-1,54	★★★	0,11	-13,69	-5,09	★★★	0,55	-9,19
gdp_2	0,01	★★★	0,00	7,36	0,01	★★★	0,00	9,85	0,48	★★★	0,06	8,36
GPI in primary school education	-0,42	★★★	0,09	-4,90	-0,59	★★★	0,09	-6,94	-0,39	★★★	0,11	-3,61
GPI in secondary school education	-0,37	★★★	0,05	-7,48	-0,22	★★★	0,05	-4,40	-0,37	★★★	0,07	-5,25
Physicians per 1,000 people	-4,07	★★★	0,44	-9,17					-2,39	★★★	0,758	-3,16
Hospital beds per 1,000 people					-1,38	★★★	0,21	-6,69	-0,29		0,35	-0,83
Country dummy variable for Türkiye	-2,51		3,94	-0,64	3,48		3,34	1,04	-0,15		3,89	-0,04
t	-3,26	★★	1,32	-2,47	-4,13	★★★	1,26	-3,29	-4,00	★★★	1,47	-2,72
t^2	0,05		0,04	1,20	0,08	★	0,04	1,86	0,08		0,05	1,57
t^3	0,00		0,00	-0,48	0,00		0,00	-1,09	0,00		0,00	-0,97

*Note: *** = p<0.01, ** = p<0.05, * = p<0.10. Data Source: The World Bank, World Development Indicators, 2023.*