DETERMINANTS OF INFANT MORTALITY DECLINE IN INDIA, 2000–2020

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ABSTRACT

Infant mortality explains not only the health of a country, but also its overall development. The infant mortality rate (IMR) in India declined from 67 per 1,000 live births in 2000 to 28 in 2020, but the state wise variation is evident. This study focuses on the determinants of decline with the help of World Bank data and regression analysis. The findings indicate that antenatal care and immunization were the drivers of IMR decline. This decline in IMR can be attributed to the improvement in maternal and preventive health services in India. To achieve IMR at the level of top ten countries of the world, we need to focus on better health care system, sustained immunization and improvement in antenatal care.

KEYWORDS: Infant mortality, India, Antenatal care, Immunisation, Health expenditure, Sanitation, Female literacy, SDG

INTRODUCTION

Infant mortality explains not only the health of a country, but also its overall development. There has been a significant decline in Infant Mortality Rate (IMR) worldwide. The World Bank data 2023 shows that top three countries have achieved IMR below 2 (San Marino 1.4, Estonia 1.6, and Singapore 1.7). India's IMR was 24.5 deaths per 1,000 live births in 2023, positioning the country 140th worldwide. India has also made significant progress in reducing IMR from 2000 when it was around 66. A significant number of research has highlighted India's IMR decline. Trend shows there has been a steady fall in IMR since the 1980's, but reginal disparities persist. (Chaurasia, 2020; Drèze et al., 2020). This decline can be attributed to improvement in access to institutional delivery, antenatal care, and immunization, (Prinja et al., 2021). Considerable number of research based on determinants shows a number of variables such as maternal health services (Sharma, 2008; Srivastava et al., 2021), immunisation (Lahariya & Paul, 2010), sanitation (Geruso & Spears, 2018), female education (Jain et al., 2025), and public health expenditure (Bhalotra, 2007; Barenberg et al., 2016) have played an important role in it. There are studies which highlight the issue of persistent inequalities based on low Income, Scheduled Castes and Tribes in spite of overall decline in IMR. (Ram et al., 2019; Singh et al,2011).

LITERATURE REVIEW

The review of literature covers multiple perspectives related to declining IMR. It can be divided into seven categories, which are as follows:

Trends in Infant Mortality in India: Chaurasia 2020 in his study shows that there are joint-point shifts in mortality reduction. The Global Burden of Disease study confirms a substantial fall in IMR but with slow progress in central and eastern states (India State-Level Disease Burden Initiative, 2020).

Policy Interventions and the National Health Mission: The launch of the National Health Mission in 2005 led to the expansion of institutional delivery, skilled birth attendance and immunisation coverage, resulting in a sharp decline in IMR (Prinja et al., 2021; MoHFW, 2019)Public Health Expenditure: Bhalotra (2007) and Barenberg et al. (2016) found a significant effect of state spending on mortality reduction, but this is conditional on governance and efficiency (Kaushal et al., 2013)

Maternal, Antenatal, and Preventive Care: Sharma and Srivastava et al. (2021) indicates that improvement in antenatal care reduces neonatal and infant deaths. Preventive health care, such as immunisation, plays a significant role in reducing pneumonia and iarrhoea-related deaths, which remain the leading causes of infant deaths. Socioeconomic, Caste, and Gender Inequalities: The inequalities related to socio-economic, caste and gender persist in India. According to Jain et al. (2025), poorer households have high IMR, which reflects widening socioeconomic inequalities. The existence of caste-based disparity has been highlighted by Ram et al. (2019) and Singh et al. (2011). The gender-based inequality with high female post-neonatal mortality is prominent, despite the higher biological survival advantage of girls (Bhatia et al., 2019).

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Sanitation and Environmental Health: Sanitation and a clean environment also determine low IMR. According to Geroso and Spears(2018), open defecation and environmental health are critical determinants of IMR. Access to clean water and improved sanitation reduces diarrhoeal and infection-related mortality. Forecasting, SDG Targets, and Future Challenges: A Study based on forecasting highlights that neonatal stagnation needs to be addressed to meet the Sustainable Development Goal (SDG) (Chaurasia, 2020; Bora & Saikia, 2018). It is time to improve quality care and reduce inequalities to sustain this progress, Subramanian et al. (2024) and Jain et al. (2025). The above literature confirms that there are multiple factors leading to IMR decline, but significant challenges remain.

RESEARCH GAP AND MOTIVATION

Although a significant amount of work has focused on Infant mortality in India. Studies have examined various determinants, including antenatal care, immunisation, and public expenditure, but most of the literature has focused on shorter time periods. It provides valuable insights but limits understanding of how different factors interact over the long run. There are a few studies which systematically integrate maternal health services, preventive care, sanitation, education, and fiscal inputs within a single framework, leaving their relative impacts unclear.

This study examines the combined influence of antenatal care, immunisation, public health expenditure, sanitation, and female literacy on the decline of infant mortality in India from 2000 to 2020. It identifies the key policy-relevant determinants that can guide progress toward India's 2030 Sustainable Development Goal targets for infant and neonatal mortality.

DATA AND METHODS

The study uses annual data from the *World Bank's World Development Indicators* for the period 2000–2020, supplemented with cause-of-death data from the *Sample Registration System (SRS) Report 2020–22*. These sources provide consistent national-level information on health and socioeconomic indicators relevant to infant mortality in India.The dependent variable is the *Infant Mortality Rate (IMR)*, defined as the number of deaths of infants under one year per 1,000 live births. The key explanatory variables include *antenatal care coverage (ANC)*, *immunisation coverage (DPT3)*, *public health expenditure as a share of GDP*, *access to improved sanitation*, and *female literacy rate*. Together, these indicators represent the major programmatic and structural factors influencing child survival. Descriptive statistics showing general improvements in these indicators over time are presented in *Table 1*.

The analysis employs multiple regression models estimated using Ordinary Least Squares (OLS). To address

heteroskedasticity and autocorrelation, Newey–West robust standard errors were applied. Potential multicollinearity among predictors was assessed through Variance Inflation Factors (VIF). Model adequacy was examined using R-squared, adjusted R-squared, the Durbin–Watson statistic, and the Breusch–Pagan test.

To test the robustness of the results, models were re-estimated with lagged health expenditure and alternative specifications excluding highly collinear variables. Additional checks using *Principal Component Analysis (PCA)* and time-trend adjustments confirmed the consistency of results.

Table 1. Summary Statistics of Key Variables (2000–2020)

Variable	Mean	SD	Minimum	Maximum
Infant Mortality Rate (IMR)	47.09	12.78	28.2	66.3
Immunization (% of children)	75.9	13.85	56	95
Clean Water Access (%)	53.65	18.33	27.82	79.37
Health Expenditure (% of GDP)	1.2	0.25	0.89	1.65
Female Literacy (%)	61.06	7.77	47.8	74.4
Sanitation Access (%)	41.42	22.36	6.1	70.3
Antenatal Care (%)	54.63	8.56	37	67.9
Rural Sanitation (%)	28.48	19.49	0.45	59.1
Urban Sanitation (%)	54.87	17.31	20.87	77.5

Source: Author's calculations based on World Bank data.

RESULTS

The analysis clearly shows that improvements in maternal and preventive health services were central to India's decline in infant mortality between 2000 and 2020. As shown in Table 1, the Infant Mortality Rate (IMR) fell sharply from 67 deaths per 1,000 live births in 2000 to 28 in 2020. During the same period, antenatal care coverage rose from around 42% to over 80%, immunisation increased from 61% to above 90%, access to sanitation improved from about 24% to nearly 74%, and female literacy advanced from under 50% to around 70%. Together, these changes indicate steady progress in maternal care, preventive health services, sanitation, and education in India.

Table 2 shows that prematurity and low birth weight caused about one-third (31.6%) of infant deaths in 2020–22, followed by pneumonia (16.2%) and diarrhoeal diseases (3.6%). These causes align with the key variables of the study - antenatal care, immunisation, sanitation, and female literacy - which directly influence maternal health, infection control, and care practices.
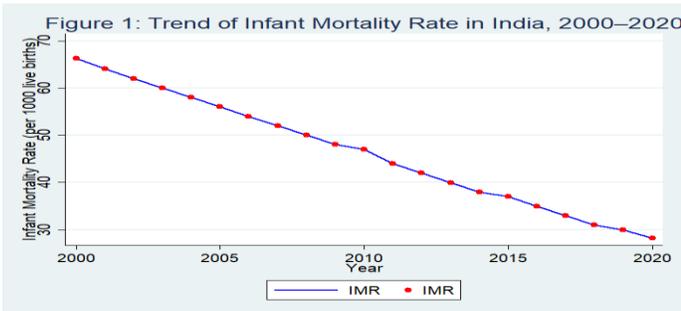
REGRESSION ESTIMATES

Results in **Table 3** show that antenatal care and immunisation were the strongest determinants of IMR decline. Antenatal care had a significant negative effect ($\beta = -1.52$, $p < 0.001$), and immunisation also showed a strong association ($\beta =$
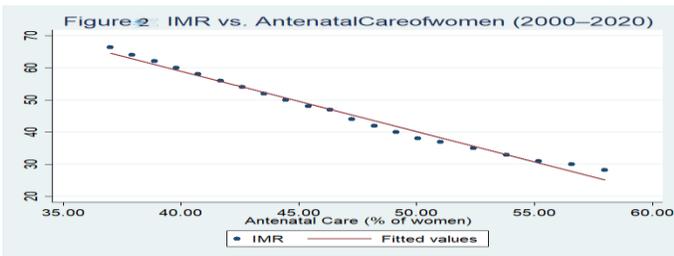
–0.22, p < 0.01). Sanitation access was significantly linked to lower IMR (β = –5.19, p < 0.001). Female literacy and public health expenditure had negative but insignificant coefficients, indicating indirect influences through health awareness and service utilisation.
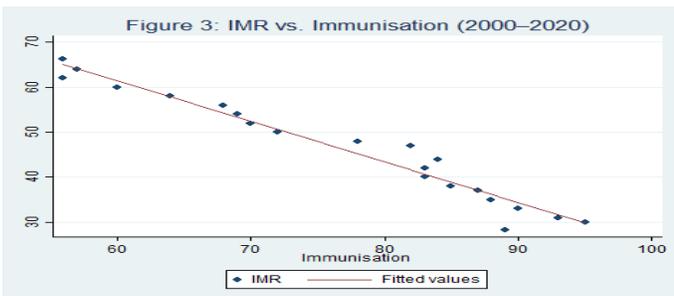
Model Diagnostics and Robustness:

Diagnostic results indicate that the preferred model performed well after addressing multicollinearity and autocorrelation. The mean Variance Inflation Factor (VIF) dropped from 7,901 in the baseline model to 21.6 in the preferred specification. The Durbin–Watson statistic (0.907) and Breusch–Pagan test (p = 0.041) confirmed initial autocorrelation and heteroskedasticity, both corrected using Newey–West robust standard errors. Robustness tests in Appendix A2 show that the results remained stable across alternative specifications, including lagged and principal component models.
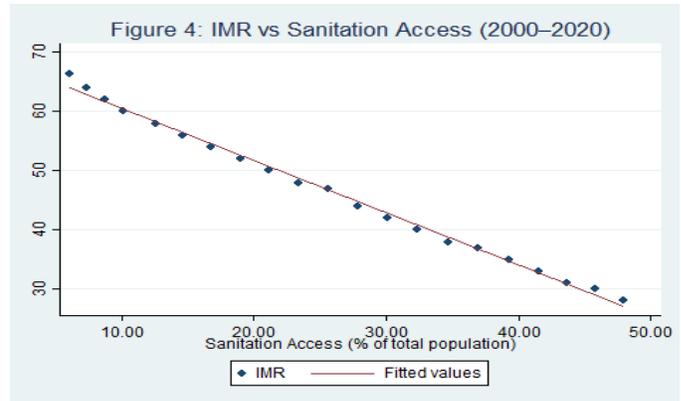

Figure 4: IMR vs Sanitation Access (2000–2020)

Source: Author's calculations based on World Bank (2024) data.

Figure 1: Trend of Infant Mortality Rate in India, 2000–2020

Source: Author's calculations based on World Bank (2024) data.

Figure 2: IMR vs. AntenatalCareofwomen (2000–2020)

Source: Author's calculations based on World Bank (2024) data.

Figure 3: IMR vs. Immunisation (2000–2020)

Source: Author's calculations based on World Bank (2024) data.

Figure 5 : IMR vs Female Literacy (2000–2020)
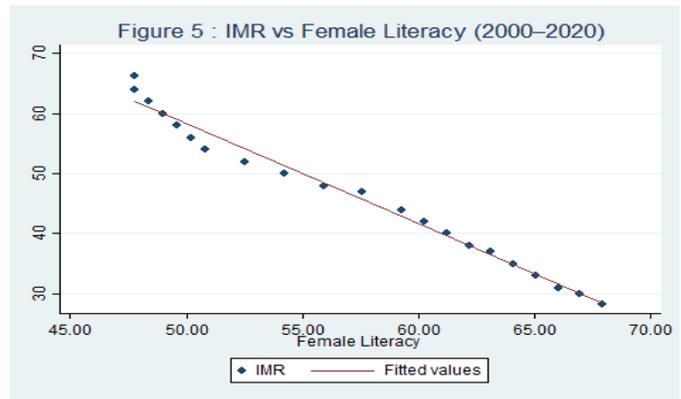
Source: Author's calculations based on World Bank (2024) data

Table 2: Top 10 Causes of Death for the age group below one year in India: 2020-2022

			% Proportion of Death	
Rank	Cause of Death	Male	Female	Person
1	Prematurity & low birth weight	31.4	32.2	31.6
2	Pneumonia	16.1	16.2	16.2
3	Birth asphyxia & birth trauma	11	9.2	10.2
4	Other Non-Communicable Diseases	7.6	8.1	7.8
5	Congenital anomalies	5.7	4.9	5.3
6	Sepsis	4.4	3.8	4.1
7	Fever of unknown origin	3.3	4.5	3.9
8	Diarrhoeal diseases	3.4	3.9	3.6
9	Injuries	3.1	2.5	2.8
10	Ill-defined or cause unknown	11.7	11.2	11.5

Source: SRS Cause of Death Statistics Report 2020-22

Table 3. Regression Results for Infant Mortality Rate (IMR) Decline in India (2000–2020)

Variable	(1) Baseline OLS	(2) Preferred Model
Immunisation Coverage (%)	0.0849 (0.0514)	-0.222** (0.0760)
Health Expenditure (% of GDP)	3.827 (5.010)	6.624 (6.190)
Female Literacy Rate (%)	-0.131 (0.206)	-
Sanitation Access (Total Population, %)	-5.188*** (1.007)	-
Antenatal Care Coverage (%)	-0.162 (0.371)	-1.518*** (0.201)
Urban Sanitation Access (%)	0.310 (0.581)	-
Rural Sanitation Access (%)	3.400*** (0.708)	-
Constant	93.53*** (14.50)	127.9*** (2.772)
Observations	21	21
R^2	0.999	0.995
Adjusted R^2	0.999	0.994

Notes: Standard errors in parentheses. $* p < 0.05$, $** p < 0.01$, $*** p < 0.001$. The Baseline OLS includes all predictors but suffers from severe multicollinearity (mean VIF = 7,901.26), leading to counterintuitive coefficients. The Preferred Model excludes female literacy and sanitation variables, reducing multicollinearity (mean VIF = 21.60) and yielding significant, theoretically consistent coefficients for immunisation and antenatal care. The Preferred Model's Durbin–Watson statistic (0.907) suggests positive autocorrelation, and the Breusch–Pagan test (p = 0.0414) indicates heteroskedasticity, both addressed in robustness checks. Source: Author's calculations using World Bank World Development Indicators (2000- 2020).

Table 4. Key Determinants of Infant Mortality Reduction in India (2000–2020): Regression-Based Evidence

Variable	Coefficient	p-value	IMR Cause Addressed	Deaths (%)
Immunisation Coverage (%)	-0.222	0.009	Pneumonia	16.2
Antenatal Care Coverage (%)	-1.518	<0.001	Prematurity	31.6
Health Expenditure (% of GDP)	6.624	0.112	-	-

Notes: Coefficients and p-values are from the preferred Newey–West regression specification (Appendix A2, Table 5, Column 5), addressing autocorrelation and heteroskedasticity. IMR causes and death shares are based on 2020–2022 data (Table 2). Source: Author's calculations using World Bank World Development Indicators (2000–2020).

Policy Interpretation:

The synthesis of regression outcomes and mortality patterns, summarised in Table 4, reinforces the importance of maternal and preventive care. Antenatal care directly addresses prematurity and perinatal conditions (31.6% of deaths), while immunisation prevents pneumonia-related deaths (16.2%). Improvements in sanitation reduce exposure to enteric infections, and female literacy enhances care-seeking behaviour and nutrition practices. Although public health expenditure was not statistically significant, its indirect role in strengthening service delivery remains important.

Overall, the findings demonstrate that India's decline in infant mortality was primarily driven by the expansion of antenatal care and immunisation coverage, supported by gains in sanitation and female education. Public spending contributed indirectly by improving the reach and quality of these services. Sustaining progress will require continued emphasis on these determinants to achieve India's Sustainable Development Goal targets for child survival.

DISCUSSION

This study set out to identify the main determinants of infant mortality decline in India between 2000 and 2020. The regression results showed that antenatal care, immunisation, sanitation, and female literacy were the most consistent and significant predictors of IMR reduction, while public health expenditure had weaker and less consistent effects. These findings are largely consistent with earlier research. The strong influence of antenatal care echoes findings by Sharma (2008) and Srivastava et al. (2021), who linked adequate maternal care to lower risks of neonatal death. The significance of immunisation aligns with Lahariya and Paul (2010), who highlighted its role in preventing pneumonia and diarrhoeal deaths. Sanitation's impact is supported by Geruso and Spears (2018), who found that open defecation was a strong predictor of infant mortality. The role of female literacy confirms insights from Jain et al. (2025), who documented persistent socioeconomic inequalities in child survival. By contrast, the limited effect of public health expenditure reflects mixed findings in the literature: Barenberg et al. (2016) found strong effects, while Kaushal et al. (2013) suggested fiscal inputs alone may not translate into improved outcomes without strong governance.

Mechanistically, the results align with proximate causes of infant deaths. As shown in Tables 2 and 4, antenatal care reduces perinatal and neonatal risks, immunisation addresses infectious disease deaths, sanitation lowers enteric infection risks, and literacy influences care-seeking and nutritional practices. These relationships explain why these predictors were statistically significant in regression models.

PERSISTENT INEQUALITIES REMAIN A CHALLENGE.

Research shows that mortality risks are higher among Scheduled Castes, Scheduled Tribes, poorer households, and girls (Ram et al., 2019; Singh et al., 2011). Jain et al. (2025) demonstrate that inequality has widened, with children of uneducated mothers remaining at higher risk. This reflects the importance of focusing not only on overall service coverage but also on equity.

From a policy perspective, the results underscore that while India has made remarkable progress, further gains will depend on improving the quality of antenatal and newborn care, sustaining high immunisation coverage, expanding sanitation, and reducing educational and economic inequalities. As Subramanian et al. (2024) and Bora & Saikia (2018) note, without addressing neonatal stagnation and inequalities, India may struggle to meet its Sustainable Development Goal target of reducing neonatal mortality to 12 per 1,000 by 2030.

Overall, this study reinforces the argument that maternal and preventive health interventions, combined with social development policies, are the key drivers of India's infant mortality decline. It highlights the need for a multidimensional approach that integrates health system investments with broader efforts to improve sanitation, education, and equity.

CONCLUSION

This study examined the drivers of India's infant mortality rate (IMR) decline between 2000 and 2020 using World Bank data and regression analysis. The results show that antenatal care, immunisation, sanitation access, and female literacy were the most significant contributors to reducing infant deaths during this period. Public health expenditure, while generally negative in sign, was not consistently significant, suggesting that spending alone did not directly lower mortality but worked indirectly through service expansion and improvements in delivery.

The findings reinforce earlier evidence that maternal health care and preventive services are central to child survival in India. Improvements in antenatal care reduced risks associated with pregnancy and delivery (Sharma, 2008; Srivastava et al., 2021), while immunisation directly lowered deaths from pneumonia and diarrhoeal disease (Lahariya & Paul, 2010). Gains in sanitation supported reductions in infection-related mortality (Geruso & Spears, 2018), and female literacy influenced both care-seeking and nutritional practices (Jain et al., 2025). Together, these drivers explain much of the sustained decline in IMR over the last two decades.

Despite this progress, inequalities remain a major challenge. Mortality risks continue to be concentrated among poorer households, Scheduled Caste and Tribe populations, and girls, who face disadvantages in care and nutrition (Ram et al., 2019; Singh et al., 2011). Neonatal mortality in particular has declined more slowly than post-neonatal mortality, and recent evidence points to stagnation in some states (Subramanian et al., 2024). These disparities highlight that further reductions in IMR will depend not only on expanding coverage but also on improving the quality of maternal and newborn care and addressing social and economic inequities.

From a policy perspective, the results have direct implications for achieving the Sustainable Development Goal of reducing neonatal mortality to 12 per 1,000 live births by 2030. India has made substantial progress, but at its current trajectory, it is unlikely to meet the target in all regions and social groups. Expanding high-quality antenatal and delivery care, sustaining immunisation coverage, improving sanitation and hygiene, and investing in women's education remain essential. Public spending continues to matter, but the focus should be on ensuring that resources translate into effective and equitable service delivery.

This study is not without limitations. It relies on aggregate national data, which may mask subnational differences, and multicollinearity among predictors limited the precision of some estimates. Future research should extend the analysis to disaggregated data by state, district, caste, and gender to capture variation more accurately.

In sum, India's experience between 2000 and 2020 demonstrates that reducing infant mortality requires a combination of health system investments and broader social progress. Sustaining this momentum will depend on ensuring equitable access to high-quality maternal and child health services while addressing structural determinants such as sanitation and education. Only by linking programme coverage with social development can India close the remaining gaps and meet its child survival goals.

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