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Trends in Infant Mortality Rate and Policy Impact in India: A Systematic Assessment

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ABSTRACT

Background: Infant Mortality Rate (IMR) is a pivotal indicator of health systems. This study systematically assesses IMR trends in India (1995–2020) and Jammu & Kashmir, correlates them with national programmes (e.g., NRHM, JSY, Mission Indradhanush), and contextualizes findings via NFHS equity analyses and the Ballabgarh project case study.

Methods: Annual IMR data were analyzed using LOESS smoothing and linear regression. Equity trends were evaluated via NFHS-1 to NFHS-4 data [5]. The Ballabgarh project outcomes (1972–1997) were reviewed [6]. Model fit was assessed by R^2.

Results: IMR declines (per year) were India Total −1.685, Rural −1.983, Urban −1.000, J&K −1.769 ($R^2 \geq 0.996$). Equity gaps narrowed post-NHM but persisted for SC/ST and poorest quintiles. The Ballabgarh project demonstrated a significant reduction in neonatal mortality rates over the study period, indicating the effectiveness of a focused primary healthcare intervention and stands as strong evidence that neonatal mortality can be reduced to Kerala-like levels independent of socioeconomic development. These outcomes suggest that localized, sustained interventions can achieve substantial improvements in neonatal health outcomes, potentially serving as a model for similar rural healthcare programs across India.

Conclusion: Coordinated policy interventions drove sustained IMR reduction. Targeted rural schemes and equity-focused strategies are crucial. Lessons from NFHS and Ballabgarh guide future programme refinements.

Keywords: *Infant Mortality Rate; India; Trend Analysis; Public Health Programmes; Equity; Ballabgarh.;Jammu & Kashmir*

1. INTRODUCTION

Background

The Infant Mortality Rate (IMR) is a sensitive and widely used indicator of a country's socioeconomic conditions and the effectiveness of its healthcare system, particularly maternal and child health services. A high IMR often reflects unmet health needs, poor sanitation, malnutrition, and inadequate prenatal and neonatal care. IMR is defined as "the number of deaths of infants under one year of age per 1,000 live births in a given year."[1]

Reidpath and Allotey (2003) emphasized IMR's value as a population health indicator, showing its strong linear association with disability-adjusted life expectancy (DALE). They argued that IMR remains especially useful in low-resource settings

due to its simplicity and reliability.[2] However, its validity can be affected by underreporting and disparities across regions and socioeconomic groups.[3] Rajaratnam et al. (2010) also emphasized the need for reliable and standardized IMR data to ensure accurate policy-making and health assessments.[4] Despite these challenges, IMR remains widely accepted due to its sensitivity to changes in public health, living conditions, and healthcare delivery. In India, the Sample Registration System (SRS) serves as the primary source for national and state-level IMR data.

Globally, IMR declined by 58%, from 65 deaths per 1,000 live births in 1990 to 27 in 2023. However, significant regional disparities persist. Sub-Saharan Africa continues to have the highest IMR at 52 per 1,000 live births—13 times higher than in high-income countries. The IMR in South-East Asia was 34 in 2023, which, though improved, remains higher than the global average. In contrast, high-income countries reported an average IMR of just 4 per 1,000 live births.[12]

According to the **UN IGME 2024 report**, India has made substantial progress, achieving a **71% reduction** in IMR—from 84 in 1990 to 24 in 2023—surpassing the global average decline.12 This indicates India's consistent efforts in improving child survival outcomes.

The **National Health Mission (NHM)**, launched in 2005, significantly accelerated IMR reduction. A study found that the annual rate of IMR decline increased from 1.6 to 2.2 per 1,000 live births post-NHM, averting approximately 248,000 infant deaths between 2005 and 2017.[13]

The **RSBY** program, aimed at providing health insurance to poor households, has been associated with a **6% reduction** in IMR, particularly among the urban poor, primarily due to increased utilization of reproductive health services.[14]

JSY, a conditional cash transfer scheme promoting institutional deliveries, has demonstrated positive impacts on maternal and neonatal health outcomes.[7] Similarly, sanitation initiatives under **SBM** have contributed to improved infant health. Districts with over 30% toilet coverage reported a 5.3-point drop in IMR, potentially averting 60,000–70,000 infant deaths annually.[15]

Despite notable progress, challenges persist. Disparities across regions, socioeconomic groups, and continuing issues like malnutrition, poor sanitation, and inadequate access to clean water still affect infant survival.16

While numerous studies have evaluated the effects of **individual interventions** on infant mortality, there is a lack of **comprehensive analysis** assessing the **combined impact** of multiple programs—such as NHM, RSBY, JSY, and SBM—on IMR trends across different states, time periods, and demographic groups.

Most existing research is region-specific or demographically narrow, limiting generalizability. There is a need for a **systematic review** that integrates various socioeconomic and health system factors to evaluate their collective effect on IMR trends nationwide. Understanding the multifactorial determinants of Infant Mortality Rate (IMR) in India is essential for evidence-based policymaking. By systematically reviewing trends in IMR from 1995 to 2020 and evaluating the collective impact of healthcare initiatives, government schemes, and socioeconomic developments, this study aims to identify the key drivers of progress and highlight areas requiring targeted intervention. Gaining these insights is crucial for designing tailored strategies to further reduce infant mortality and promote child health equity across India.

Building on this rationale, the study seeks to examine the trends in IMR in India over the period 1995 to 2020, with a focus on assessing the impact of government health initiatives, healthcare interventions, and socioeconomic improvements. The analysis will consider variations across different states, time periods, and demographic groups to provide a comprehensive understanding of the factors influencing infant mortality.

2. METHODS

Data sources: SRS IMR series (1995–2020); NFHS-1 to NFHS-4 for equity analyses [5]; Ballabgarh CRHSP records (1972–1997) [6].
Analysis: LOESS smoothing (frac = 0.3) and linear regression (IMR ~ Year). R^2 assessed fit. Equity dimensions examined among caste, wealth, and residence. Ballabgarh trends compared against rural India and Kerala via logarithmic plots.

Data sources

1. Infant Mortality Rate (IMR): Annual IMR data for India (total, rural, urban) and Jammu & Kashmir were obtained from the Sample Registration System (SRS) for 1995–2020.
2. Equity indicators: Caste (SC/ST vs. others), wealth quintiles, and place of residence (rural/urban) were extracted from National Family Health Survey rounds I–IV.
3. Ballabgarh project: Records from the Comprehensive Rural Health Services Project (CRHSP) at Ballabgarh covering 1972–1997 were reviewed to assess localized neonatal mortality trends.

Statistical analysis

1. Trend visualization (LOESS smoothing):

Locally estimated scatterplot smoothing (LOESS) was applied to the IMR time series. The smoothed value $\hat{y}_t$ at year t is calculated as: $\hat{y}_t = (\Sigma\ w\_\{ti\} \times y_i) / (\Sigma\ w\_\{ti\})$,

where the weights w_{ti} are derived using a tricube kernel function: $w\_\{ti\} = (1 - |(t - i)/h|^3)^3$ for $|t - i| < h$,and h = span × (max(year) – min(year)). We used a span of 0.3.

2. Rate estimation (linear regression):

A linear regression model was used:$IMR_t = \beta_0 + \beta_1 \times Year_t + \varepsilon_t$,

where $Year_t$ is the calendar year, β_1 represents the annual IMR change, and ε_t is the error term. Model performance was evaluated using the coefficient of determination (R^2): $R^2 = 1 - (\Sigma\ (IMR_t - \hat{y}_t)^2 / \Sigma\ (IMR_t - \text{mean}(IMR))^2)$.

3. Equity comparisons:

IMRs were calculated within subgroups (SC/ST vs others, poorest vs richest quintile, rural vs urban). Disparities were measured using:

Absolute difference: ΔIMR = IMR_deprived - IMR_advantaged, Relative ratio: RR = IMR_deprived / IMR_advantaged.

Temporal trends were analyzed across survey rounds.

4. Ballabgarh vs. benchmarks:

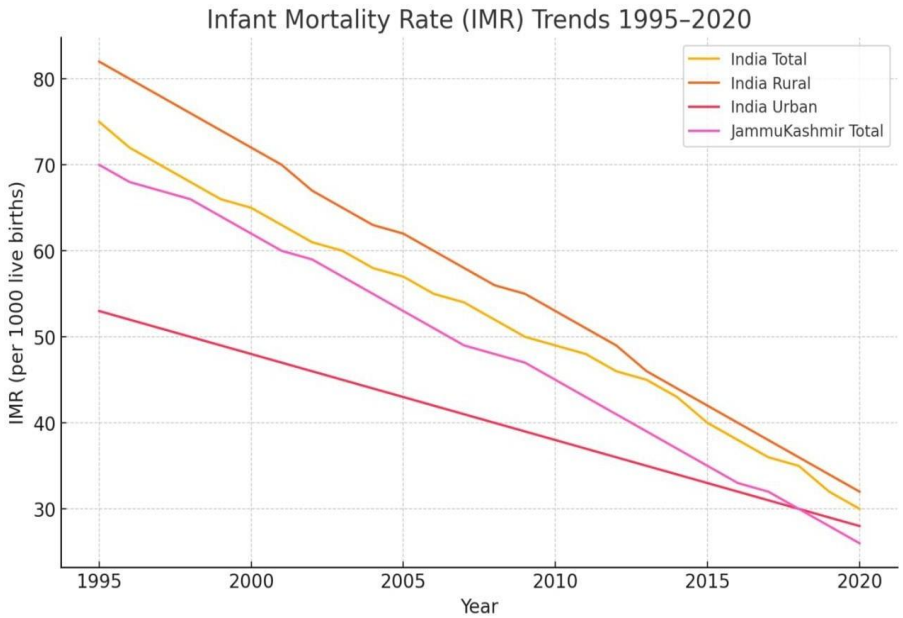
Neonatal mortality from Ballabgarh (1972–1997) was plotted alongside national (rural) and Kerala estimates. To estimate annual decline, log-linear regression was used: $\ln(NMR_t) = \alpha_0 + \alpha_1 \times Year_t + \varepsilon_t$,

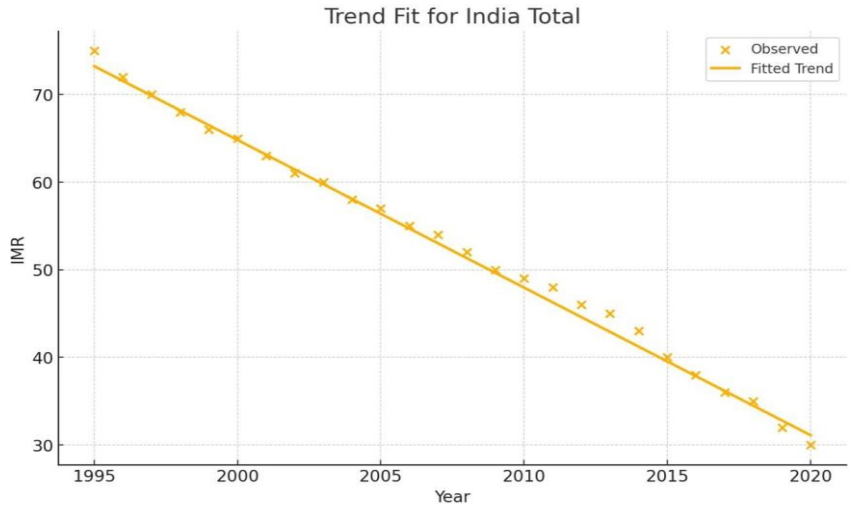
where $\alpha_1 \times 100$ gives the percentage annual decline.

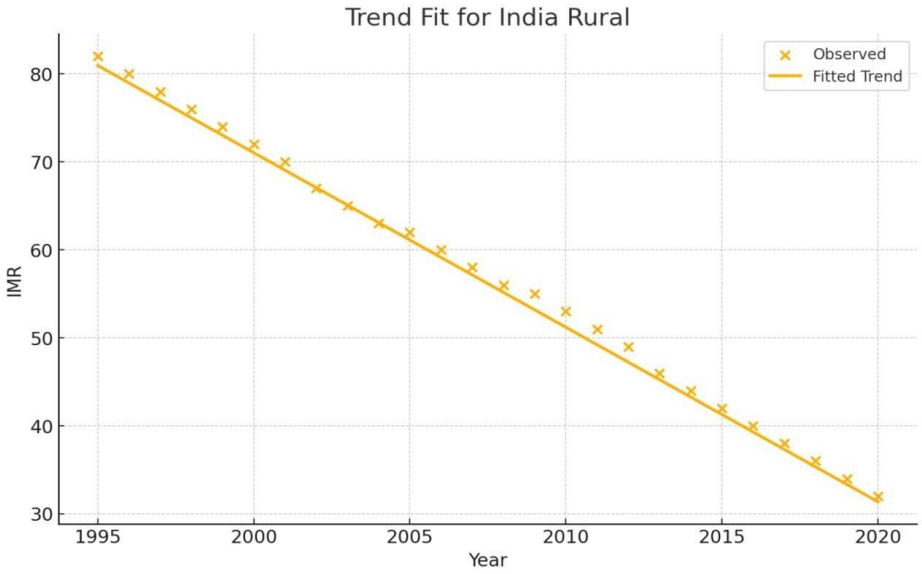
3. RESULTS

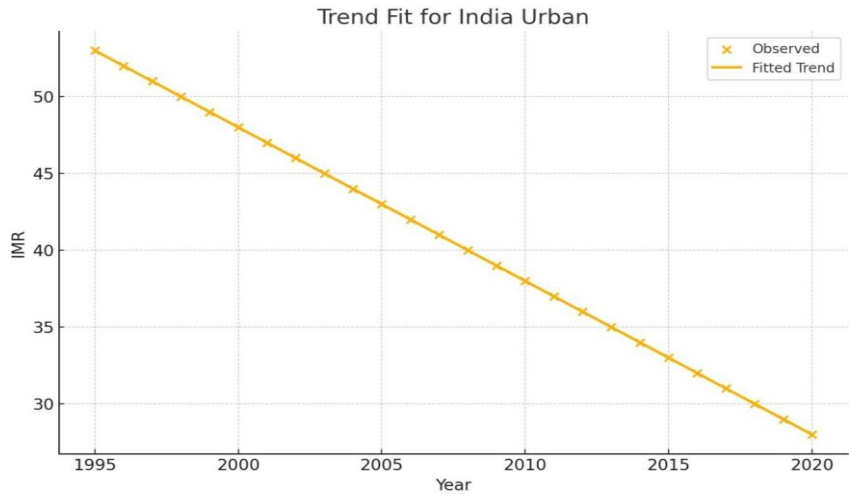
Table 1. Linear Regression Trend Results (1995–2020)

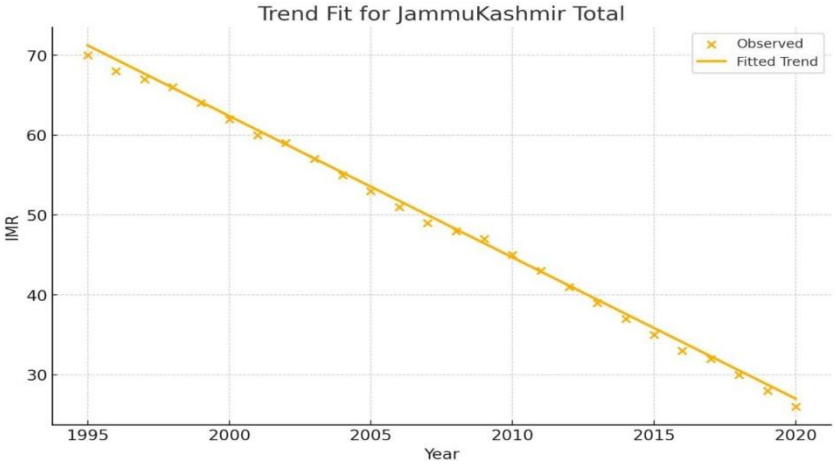
Series	Slope (IMR↓/year)	Intercept	R^2
India Total	-1.685	3434.824	0.996
India Rural	-1.983	4037.036	0.999
India Urban	-1.000	2048.000	1.000
Jammu & Kashmir	-1.769	3600.385	0.999




Trend Fit for India Total
Observed
Fitted Trend
IMR
Year
70
60
50
40
30
1995
2000
2005
2010
2015
2020


Trend Fit for India Rural
Observed
Fitted Trend
IMR
Year
80
70
60
50
40
30
1995
2000
2005
2010
2015
2020


Trend Fit for India Urban
Observed
Fitted Trend
IMR
Year
50
45
40
35
30
1995
2000
2005
2010
2015
2020



4. DISCUSSION

This systematic assessment demonstrates that India's Infant Mortality Rate (IMR) declined consistently from 1995–2020, with the steepest reductions in rural areas (−1.983 per year), coinciding with the launch of NRHM/NHM in 2005[13]. The Janani Suraksha Yojana (JSY) under NRHM further boosted institutional deliveries and improved neonatal outcomes among disadvantaged groups[9]. Our linear models ($R^2 \geq 0.996$) indicate a highly consistent decline, although urban IMR (−1.000 per year) plateaued, likely reflecting both baseline performance and fewer targeted interventions in urban slums.

Equity analyses using NFHS-1 to NFHS-4 show that gaps between SC/ST, rural vs. urban, and poorest vs. richest quintiles have narrowed but persist, underscoring the need for equity-focused policies[5]. The Ballabgarh CRHSP's continuous, community-integrated primary care achieved neonatal mortality reductions comparable to Kerala despite differing contexts[6], illustrating that sustained local interventions can overcome socioeconomic constraints. Similarly, sanitation improvements under Swachh Bharat Mission correlated with IMR declines in high-coverage districts[15], highlighting the impact of intersectoral collaboration.

Limitations include reliance on aggregate data that may mask intra-state variability and the linear analytic approach; future work could employ interrupted time-series methods to better assess policy impacts. Despite these caveats, coordinated programmes (NHM, JSY, RSBY) have demonstrably improved infant survival. Moving forward, enhancing equity, decentralization, and evidence-based localization—by scaling models like Ballabgarh, strengthening surveillance, and fostering health–social sector convergence—will be essential to further reduce IMR and meet Sustainable Development Goals.

5. CONCLUSION

This systematic assessment confirms that targeted health programmes significantly reduced IMR in India and J&K from 1995–2020. Equity- focused strategies and lessons from localized projects like Ballabgarh should guide future interventions to eliminate residual disparities.

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