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Original Research Article

Patterns and determinants of child mortality in India: a multistate analysis using National Family Health Survey data

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ABSTRACT

Background: This paper, utilizing data from several rounds of the National Family Health Survey, investigated long-term differentials in child mortality rates across caste groups and seeked to identify the principal determinants of child survival.
Methods: Trends in child mortality rates were analyzed by using all five rounds of NFHS. Survival analysis and regression analysis were performed by using NFHS-5 (2019-2021). The study included children aged 1-59 months born in the five years preceding the survey, excluding infant deaths. Kaplan-Meier survival analysis, log-rank tests, and binary logistic regression models were used, taking into account the survey design. State-level analysis was performed for Uttar Pradesh, Madhya Pradesh, and Maharashtra.
Results: At the national level, the rate of child mortality was highest among Scheduled Tribes (9.03 per 1,000), followed by Scheduled Castes (8.58 per 1,000), compared with non-SC/ST children (6.04 per 1,000). The survival analysis revealed significant caste differentials in child survival (χ^2=28.47, p<0.001), with the gap increasing at older ages of childhood. In unadjusted regression models, Scheduled Castes (OR=1.38; 95% CI: 1.16-1.65) and Scheduled Tribes (OR=1.56; 95% CI: 1.32-1.85) had significantly higher odds of child mortality. These associations were reduced and rendered non-significant after adjusting for proximate determinants, indicating mediation by maternal and health-related variables. Maternal education had a strong protective effect, with higher education being associated with significantly lower odds of child mortality (OR=0.27).
Conclusions: Although there has been a steady decline in child mortality rates across NFHS cycles, caste and geographic inequities in India.

Keywords: Child mortality, Malnutrition, Social determinants of health, Caste, National Family Health Survey, India

INTRODUCTION

The major public health challenges in many low-middle income group countries are Child malnutrition and Child mortality, and India captures most of this share. Even though the survival rate of child continuously improved over the last 20 years, the progress is not uniform within regions, socio-economic groups, and social categories.[1-3]

Malnutrition, such as stunting, wasting, and being underweight, is very dangerous for children. It reduces their immune system; therefore, they can catch infections easily and harm their physical and mental growth.[4-6] Therefore, it is very important to understand how malnutrition and socio-economic factors related to malnutrition affect the survival of a child.

Malnutrition is caused by not eating enough good food, getting sick often, poor health of mothers, and family poverty. Early studies show that the risk of children getting sick or dying can greatly increase due to not getting enough nutrients and vitamins.[4,7] Poverty further makes these risks worse by reducing access to enough food, clean water, sanitation, and healthcare services.[8,9] Studies from India show that children have worse nutrition and health if they are from poor families. This is true to a great extent if their mothers have minimal education.[9-11]

Child mortality is caused by both health problems and social issues. Many studies have found that malnutrition is a major cause of child deaths. It works together with diseases like diarrhea and pneumonia.[12-14] Children with more than one growth problem have a much higher risk of dying than those with just one nutrition issue.[15,16] These combined risks are found in the socially disadvantaged communities and the places where health services are poor.

The differences in child malnutrition and death rates in different regions and social groups are still big, as per the data from India's National Family Health Surveys (NFHS). States with less economic development have higher child death rates. Even within the same state, some districts have much higher rates than others.[17-19] Malnutrition and death rates are associated with poverty, the education of mothers, sanitation, and health services. This shows that planning policies using only national or state averages are not enough.[18,20]

Family and maternal factors are important for child survival. A mother's education is linked to better child feeding, more use of health services, and lower chances of child death.[9,11] Factors like high birth order and short birth intervals create problems like mothers becoming weak and babies being born with low weight.[21,22] Gender norms can affect children's health in some places. Girls might not get the same care as boys.[23]

It is easier to study the factors affecting child mortality using large surveys, as there are improvements in statistical methods. Using regression-based methods, we can assess different factors such as socio-economic, demographic, and maternal factors simultaneously. This enables the detection of relations to child mortality and sees if social differences remain after making adjustments.[24-26] Such approaches are particularly useful for nationally representative surveys like NFHS and provide evidence that can guide targeted public health interventions.

Multiple maternal and child health programs have been started in India to improve the survival outcomes. Programs like Janani Suraksha Yojana give funds to encourage institutional deliveries, but the benefits do not reach the society equally.[27,28] At the same time, shortcomings in death reporting and data quality continue to create obstacles for monitoring progress, highlighting the importance of improving health information and civil registration systems.[29,30]

Nutrition programs, regular health services, and family incomes were interrupted due to the COVID-19 pandemic. New evidence shows that because of these interruptions' reduction in child malnutrition and mortality might slow down, especially in the groups that are already at risk.[31,32]

METHODS

Data source and study design

The study utilized data from all five rounds of the National Family Health Survey (NFHS-1 [1992–93], NFHS-2 [1998–99], NFHS-3 [2005–06], NFHS-4 [2015–16], and NFHS-5 [2019–21]). NFHS is a nationally representative survey conducted under the Ministry of Health and Family Welfare, Government of India, and implemented by the International Institute for Population Sciences (IIPS). The survey follows the Demographic and Health Survey framework and provides standardized information on population and health indicators across India.[33]

Study population and outcome variable

The study population comprised children aged 1-59 months born during the five years preceding each survey, based on complete birth histories collected from women aged 15-49 years. To focus on child mortality, deaths occurring before one year of age were excluded. The outcome variable was defined as death between ages 1 and 5 years (1=died; 0=alive). Restricting the analysis to the most recent five-year period minimizes recall bias and follows established demographic practices.[34,35]

Selection of states

State-level analyses were conducted for Uttar Pradesh, Madhya Pradesh, and Maharashtra. These states were selected to represent varying levels of child mortality, socio-economic development, and health system performance. Uttar Pradesh represents a high-mortality and socio-economically disadvantaged setting, Madhya Pradesh represents a high-mortality state with a substantial Scheduled Tribe population, and Maharashtra represents a relatively better-performing state with lower mortality levels.[36-38]

Explanatory variables

The primary explanatory variable was social group, categorized as Scheduled Caste (SC), Scheduled Tribe (ST), and Non-SC/ST. Socio-economic variables included place of residence, religion, household wealth status, and maternal education. Proximate determinants included maternal age at birth, birth order, sex of the

child, antenatal care (ANC) utilization, and place of delivery. Wealth status was based on the NFHS wealth index.[39]

Statistical analysis

The analysis was conducted in three stages. First, descriptive statistics were used to estimate child mortality rates according to socio-economic and demographic characteristics at the national and state levels. Second, Kaplan-Meier survival curves and cumulative hazard functions were estimated for SC, ST, and Non-SC/ST children, and differences in survival distributions were assessed using the log-rank test.40 Third, binary logistic regression models were fitted sequentially: unadjusted model; socio-economic model; proximate determinants model; and fully adjusted model. Results are presented as odds ratios (ORs) with 95% confidence intervals (CIs). Survey weights and clustering at the PSU level were accounted for in all analyses.

Ethical considerations

The study was based on secondary analysis of anonymized, publicly available NFHS data. Ethical approval and informed consent were obtained by the survey implementing agencies during data collection; therefore, no additional ethical approval was required.

RESULTS

There is a significant reduction in child mortality rates in India from 1992-93 to 2019-21. In the early 1990s, child mortality rates were highest in ST, followed by SC, while non-SC/ST children had the lowest rates. Although there was a significant reduction in child mortality rates for all communities by 2019-21, child mortality rates in ST and SC communities remained higher than those of non-SC/ST children.

Table 1: Child Mortality rates by mother's socio-economic and demographic characteristics in Uttar Pradesh, Madhya Pradesh, Maharashtra.

Background characteristics	India	Uttar Pradesh	Madhya Pradesh	Maharashtra
Residence				
Urban	5.0301	8.0749	4.527	5.7694
Rural	7.6235	10.4937	9.4045	4.2772
Religion				
Hindu	7.1504	10.2538	8.6635	4.3779
Muslim	6.1381	8.9383	2.5673	4.4892
Christian	3.8612	0	0	0
Others	6.6025	0	4.5184	13.1163
Caste				
Scheduled caste	8.5795	12.946	12.984	7.3052
Scheduled tribe	9.0329	6.8549	13.8633	6.435
Non-SC/STs	6.0365	8.9653	4.7585	4.0096
Wealth quintile				
Poor	9.6496	13.4511	11.6242	6.7153
Middle	5.6316	8.6179	4.0969	6.9686
Rich	3.795	4.4217	3.4201	2.9719
Mother's education				
No education	11.7866	14.966	13.0197	12.1244
Primary	7.9184	11.7382	7.8672	3.2722
Secondary	4.9258	6.3399	5.9536	4.1248
Higher	2.8726	3.8844	7.1145	5.4217
Mother's age (years)				
15-24	7.3361	9.048	7.4531	7.707
25-34	6.1875	9.1711	7.7411	3.8118
35-49	9.38	13.5862	12.5278	6.6175
Birth order				
1	5.0497	5.6966	7.0206	5.3239
2-3	6.8219	10.4726	7.9523	3.2015
4 or more	12.6831	15.2637	12.8138	15.3415
Sex of child				
Male	6.4548	9.1258	8.6881	5.1085
Female	7.3922	10.9098	7.7801	4.7235

Continued.

Background characteristics	India	Uttar Pradesh	Madhya Pradesh	Maharashtra
ANC visit				
No ANC	12.4322	37.9458	10.8363	0
Partial (1-3)	8.3442	12.4561	7.1505	3.2501
4+ ANC	4.8204	5.8715	4.2053	5.9237
Place of delivery				
Home	17.2216	27.1534	18.3323	9.4826
Institutional	6.4079	8.9693	7.9895	4.6893

Table 2: The following tables show the results of the log-rank test assessing the equality of survivor functions for CMR across SC, ST, and Non-SC/ST populations in India and various states, 2019-21.

Caste	Event observed	Event expected
India		
Scheduled Caste	186	159.36
Scheduled Tribe	207	162.49
Non-SC/STs	358	429.15
Total	751	751
Note	$\chi2$ (1)=28.47, p=0	
Madhya Pradesh		
Scheduled Caste	11	10.99
Scheduled Tribe	29	18.08
Non-SC/STs	24	34.93
Total	64	64
Note	$\chi2$ (1)=10.03, p=0.0066	
Uttar Pradesh		
Scheduled Caste	56	46.52
Scheduled Tribe	1	3.33
Non-SC/STs	117	124.16
Total	174	174
Note	$\chi2$ (1)=3.98, p=0.1367	
Maharashtra		
Caste	Event observed	Event Expected
Scheduled Caste	2	2.84
Scheduled Tribe	5	3.18
Non-SC/STs	10	10.98
Total	17	17
Note	$\chi2$ (1)=1.39, p=0.4998	

Table 3: Association (odds) and logit estimate of child death risk by different characteristics in India, 2019-21.

Variables	Model-I (unadjusted OR)		Model-II socio-economic (adjusted OR)		Model-III proximate (adjusted OR)		Model-IV- full model (adjusted OR)	
Place of residence								
Urban®								
Rural			0.99	[0.93,1.05]			0.74	[0.54,1.00]
Caste								
Non-SC/ST®								
SC	1.38***	[1.16,1.65]	1.18***	[1.13,1.24]	1.27	[0.98,1.64]	1.19	[0.91,1.55]
ST	1.56***	[1.32,1.85]	1.20***	[1.14,1.27]	1.24	[0.97,1.60]	1.26	[0.94,1.70]
Religion								
Hindu®								
Muslim			0.77***	[0.72,0.82]			0.73	[0.50,1.04]
Christian			0.92*	[0.84,0.99]			0.71	[0.47,1.09]

Continued.

Variables	Model-I (unadjusted OR)		Model-II socio-economic (adjusted OR)		Model-III proximate (adjusted OR)		Model-IV- full model (adjusted OR)	
Others			0.82***	[0.74,0.91]			0.83	[0.48,1.41]
Wealth status								
Poor®								
Middle			0.70***	[0.66,0.73]			0.75	[0.54,1.04]
Rich			0.64***	[0.60,0.68]			0.72	[0.51,1.02]
Maternal age (years)								
15-24®								
25-34					1.71***	[1.25,2.35]	1.75***	[1.27,2.40]
35-49					3.02***	[2.06,4.43]	3.18***	[2.16,4.69]
Maternal education level								
No education®								
Primary			0.67***	[0.63,0.70]	0.61**	[0.45,0.84]	0.63**	[0.46,0.87]
Secondary			0.38***	[0.36,0.40]	0.42***	[0.32,0.54]	0.46***	[0.35,0.60]
Higher			0.21***	[0.18,0.25]	0.24***	[0.15,0.39]	0.27***	[0.16,0.45]
Birth order								
1®								
2-3					1.22	[0.90,1.65]	1.2	[0.88,1.63]
4 or more					1.24	[0.85,1.80]	1.23	[0.84,1.79]
Sex of child								
Male®								
Female					1.05	[0.85,1.29]	1.06	[0.86,1.30]
ANC visits								
No ANC®								
Partial					0.91	[0.66,1.27]	0.87	[0.63,1.21]
4+ANC					0.72	[0.52,1.02]	0.70*	[0.50,0.98]
Place of delivery								
Home®								
Institutional					0.66**	[0.51,0.86]	0.65**	[0.50,0.85]

Note: ## denote low sample either no sample.

Table 4: Association (odds) and logit estimate of child death risk by different characteristics in Uttar Pradesh 2019-21.

Variables	Model-I (unadjusted OR)		Model-II socio-economic (adjusted OR)		Model-III proximate (adjusted OR)		Model-IV- full model (adjusted OR)	
Place of residence								
Urban®								
Rural			0.73	[0.45,1.18]			0.86	[0.42,1.78]
Caste								
Non-SC/ST®								
SC	1.26	[0.91,1.73]	1.05	[0.75,1.47]	0.92	[0.56,1.53]	0.82	[0.49,1.40]
ST	0.34	[0.05,2.44]	0.25	[0.04,1.81]	##	##	##	##
Religion								
Hindu®								
Muslim			0.86	[0.57,1.31]			0.62	[0.32,1.17]
Christian								
Others								
Wealth status								
Poor®								
Middle			0.95	[0.63,1.42]			1.02	[0.53,1.97]
Rich			0.42**	[0.24,0.73]			0.96	[0.46,2.01]
Maternal age (years)								
15-24®								
25-34					3.69*	[1.26,10.83]	3.69*	[1.26,10.84]

Continued.

Variables	Model-I (unadjusted OR)		Model-II socio-economic (adjusted OR)		Model-III proximate (adjusted OR)		Model-IV- full model (adjusted OR)	
35-49					10.75***	[3.41,33.92]	10.79***	[3.42,34.08]
Maternal education level								
No education®								
Primary			0.58*	[0.37,0.91]	0.74	[0.39,1.41]	0.73	[0.38,1.40]
Secondary			0.41***	[0.29,0.60]	0.40**	[0.22,0.74]	0.38**	[0.20,0.71]
Higher			0.28***	[0.14,0.56]	0.11**	[0.03,0.49]	0.10**	[0.02,0.47]
Birth order								
1®								
2-3					1.87	[0.70,4.98]	1.86	[0.70,4.94]
4 or more					1.29	[0.45,3.72]	1.31	[0.45,3.77]
Sex of child								
Male®								
Female					1.4	[0.89,2.20]	1.41	[0.89,2.21]
ANC visits								
No ANC®								
Partial					0.76	[0.36,1.59]	0.76	[0.36,1.59]
4+ANC					0.59	[0.26,1.30]	0.59	[0.26,1.32]
Place of delivery								
Home®								
Institutional					0.65	[0.39,1.08]	0.65	[0.39,1.08]

Note: ## denote low sample either no sample.

Table 5: Association (odds) and logit estimate of child death risk by different characteristics in Madhya Pradesh 2019-21.

Variables	Model-I (unadjusted OR)		Model-II socio-economic (adjusted OR)		Model-III proximate (adjusted OR)		Model-IV- full model (adjusted OR)	
Place of residence								
Urban®								
Rural			1.37	[0.47,4.01]			1.48	[0.32,6.92]
Caste								
Non-SC/ST®								
SC	1.39	[0.68,2.85]	1.11	[0.53,2.29]	0.85	[0.24,3.10]	0.71	[0.19,2.59]
ST	2.39**	[1.39,4.11]	1.47	[0.82,2.64]	2.83*	[1.22,6.55]	2.12	[0.90,5.04]
Religion								
Hindu®								
Muslim			1.08	[0.23,4.32]			1.10	[0.13,8.34]
Christian			##	##			##	##
Others			##	##			##	##
Wealth status								
Poor®								
Middle			0.64	[0.28,1.48]			0.77	[0.24,2.46]
Rich			0.14*	[0.03,0.64]			0.11	[0.01,1.01]
Maternal age (years)								
15-24®								
25-34					1.56	[0.52,4.64]	1.78	[0.59,5.31]
35-49					4.50*	[1.13,17.91]	5.50*	[1.35,22.37]
Maternal education level								
No education®								
Primary			0.52	[0.23,1.14]	0.71	[0.22,2.26]	0.73	[0.23,2.34]
Secondary			0.56*	[0.32,0.98]	0.65	[0.25,1.69]	0.77	[0.30,1.99]
Higher			0.92	[0.26,3.33]	1.2	[0.28,5.05]	3.07	[0.68,13.90]
Birth order								
1®								

Continued.

Variables	Model-I (unadjusted OR)	Model-II socio-economic (adjusted OR)	Model-III proximate (adjusted OR)	Model-IV- full model (adjusted OR)
2-3			1.73 [0.53,5.67]	1.62 [0.49,5.37]
4 or more			2.47 [0.58,10.59]	2.14 [0.50,9.23]
Sex of child				
Male®				
Female			0.47 [0.21,1.07]	0.48 [0.21,1.09]
ANC visits				
No ANC®				
Partial			0.26* [0.09,0.78]	0.27* [0.09,0.82]
4+ANC			0.26* [0.09,0.74]	0.29* [0.10,0.83]
Place of delivery				
Home®				
Institutional			1.4 [0.45,4.31]	1.41 [0.46,4.32]

Note: ## denote low sample either no sample.

Table 6: Association (odds) and logit estimate of child death risk by different characteristics in Maharashtra, 2019-21.

Variables	Model-I (unadjusted OR)	Model-II socio-economic (adjusted OR)	Model-III proximate (adjusted OR)	Model-IV- full model (adjusted OR)
Place of residence				
Urban®				
Rural		0.65 [0.17,2.52]		1.42 [0.23,8.89]
Caste				
Non-SC/ST®				
SC	0.75 [0.16,3.41]	0.26 [0.04,1.85]	1.51 [0.29,7.86]	1.18 [0.15,9.06]
ST	1.74 [0.60,5.11]	0.93 [0.28,3.06]	1.68 [0.34,8.24]	1.3 [0.24,6.99]
Religion				
Hindu®				
Muslim		0.55 [0.06,4.79]		1.52 [0.15,15.47]
Christian				
Others		4.06 [0.61,27.10]		1.55 [0.12,20.16]
Wealth status				
Poor®				
Middle		0.09* [0.01,0.75]		0.25 [0.03,2.25]
Rich		0.15* [0.03,0.72]		0.42 [0.06,2.74]
Maternal age (years)				
15-24®				
25-34			0.96 [0.21,4.35]	1 [0.22,4.56]
35-49			1.11 [0.09,13.15]	1.2 [0.10,14.43]
Maternal education level				
No education®				
Primary		4.36 [0.48,39.55]	2.77 [0.22,34.23]	2.77 [0.22,34.06]
Secondary		2.12 [0.25,17.74]	1.18 [0.10,13.60]	1.39 [0.12,15.77]
Higher		5.32 [0.43,65.79]	2.24 [0.13,38.82]	3.53 [0.18,67.96]
Birth order				
1®				
2-3			1.1 [0.23,5.25]	1.02 [0.21,4.98]
4 or more			2.62 [0.29,24.06]	2.11 [0.22,20.08]
Sex of child				
Male®				
Female			0.5 [0.13,1.95]	0.5 [0.13,1.94]
ANC visits				
No ANC®				
Partial			0.8 [0.17,3.79]	0.75 [0.16,3.59]

Continued.

Variables	Model-I (unadjusted OR)	Model-II socio-economic (adjusted OR)	Model-III proximate (adjusted OR)		Model-IV- full model (adjusted OR)	
4+ANC			##	##	##	##
Place of delivery						
Home®						
Institutional			0.23	[0.04,1.33]	0.28	[0.05,1.60]

Note: ## denote low sample either no sample.

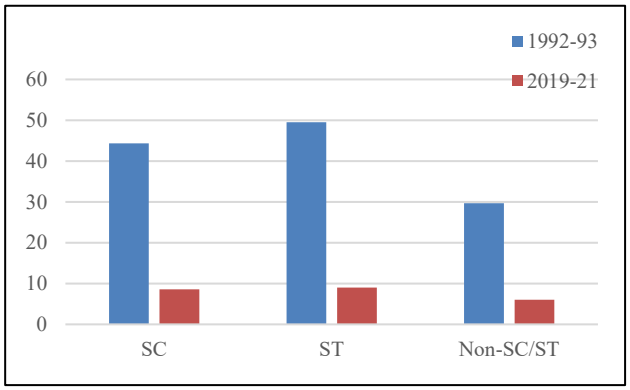

Figure 1: Child mortality rate in India from 1992-93 to 2019-21.

Figure 1 shows the trends by state, which reveal a substantial degree of variation across the states. Uttar Pradesh and Madhya Pradesh had higher rates of child mortality compared to Maharashtra in all rounds of the survey. Although all three states have shown a steady decline in child mortality, the decline was steeper and earlier in Maharashtra, which has maintained the lowest rates of child mortality.

Examining the rate of change in child mortality between 1992-93 and 2019-21, there has been a large reduction in all groups and states; however, the reduction has been larger in non-SC/STs than in SC and STs, especially in Uttar Pradesh and Madhya Pradesh. Overall, the results show that there has been substantial progress, but also continuing inequalities by caste and state, as has been seen in previous three-state analyses.

Table 1 shows substantial socio-economic and demographic differentials in child mortality across India and the selected states. Child mortality was generally higher in rural than urban areas, particularly in Uttar Pradesh, although Maharashtra showed a reverse pattern. Mortality was highest among children from poorer households and among those born to mothers with no formal education. Higher maternal age and birth order were also associated with increased mortality. In addition, children whose mothers received no antenatal care and those born at home experienced higher mortality rates, with the greatest disadvantages observed in Uttar Pradesh and Madhya Pradesh.

Figure 2 presents Kaplan-Meier survival estimates by social group for India, Uttar Pradesh, Madhya Pradesh, and Maharashtra. At the national level, non-SC/ST children exhibited the highest survival probabilities, while ST children had the lowest survival, followed by SC children. The differences became more apparent at older childhood ages.

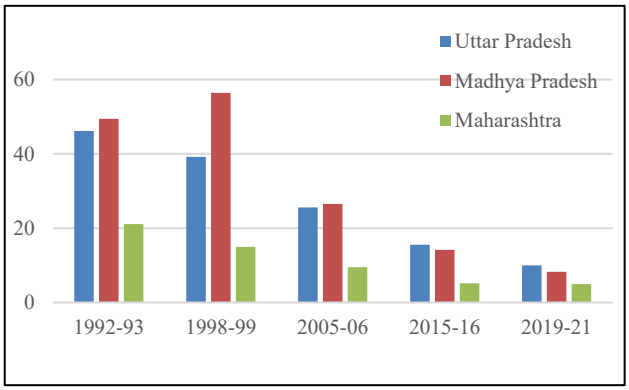

Figure 2: Level and trends of CMR in Uttar Pradesh, Madhya Pradesh, Maharashtra.

State-level patterns varied. In Uttar Pradesh, survival differences between social groups were relatively small during early childhood but widened after 35–40 months. Madhya Pradesh showed the most pronounced caste disparities, with ST children experiencing the lowest survival probabilities throughout the observation period. In Maharashtra, survival remained high across all groups, with relatively smaller differences between SC and non-SC/ST children.

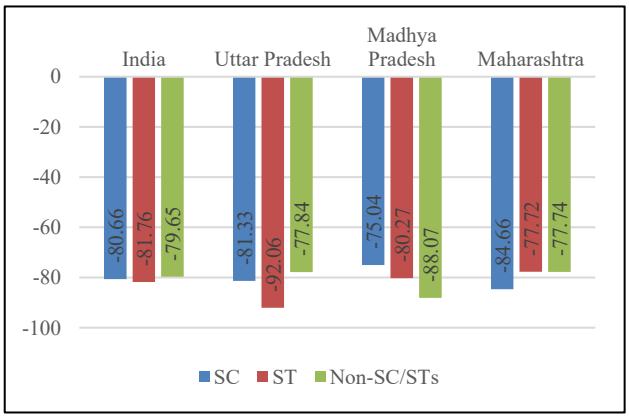

Figure 3: Rate of change in CMR in Uttar Pradesh, Madhya Pradesh, Maharashtra among social groups from 1992-93 to 2019-21.

The log-rank test results (Table 2) confirmed significant differences in child survival among social groups at the national level (χ^2=28.47, p<0.001). Observed deaths were higher than expected among SC and ST children and lower than expected among non-SC/ST children, indicating significant caste-based disparities in child survival.

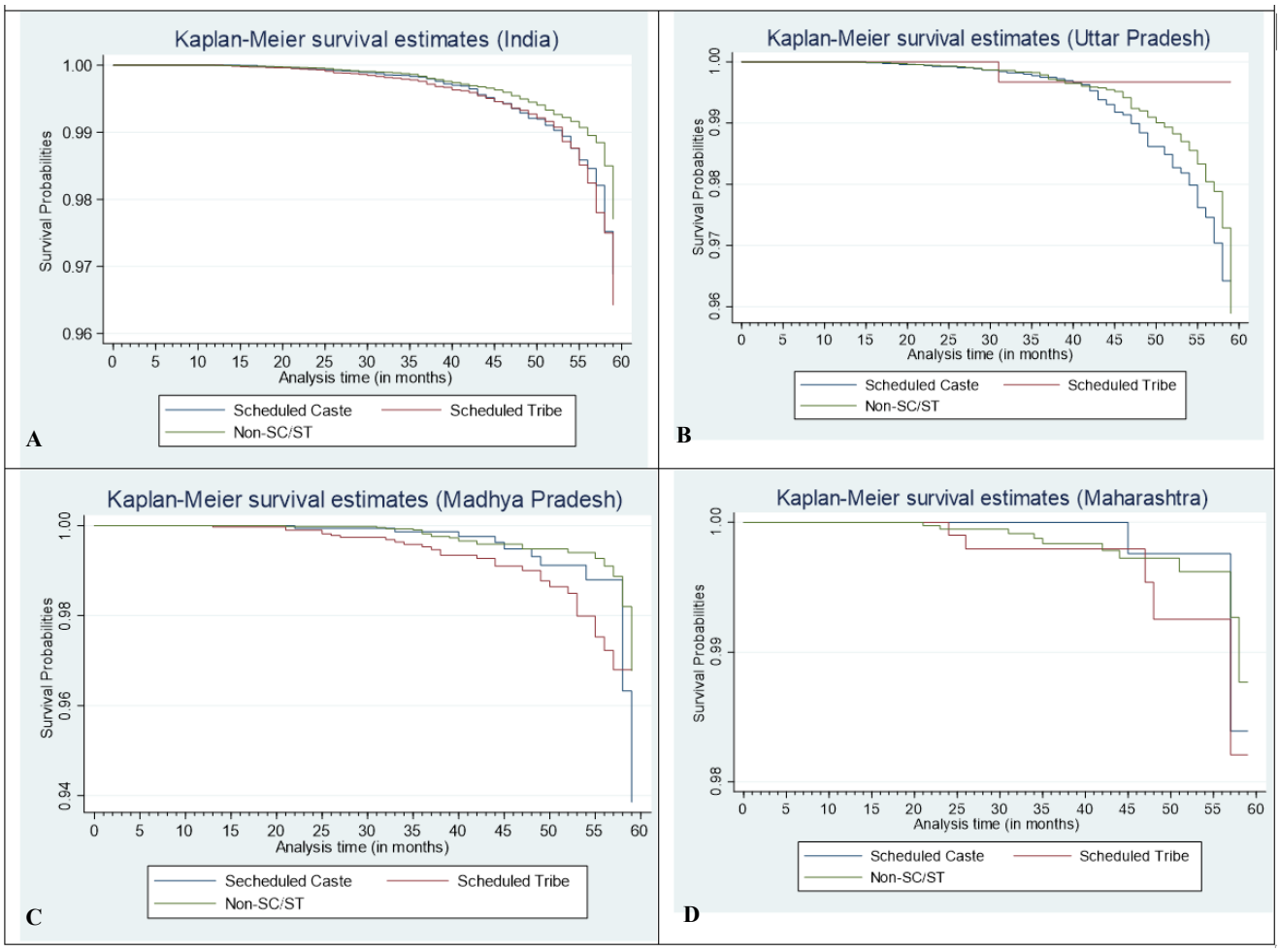

Figure 4 (A-D): Cumulative hazard functions (child mortality) for SC, ST, and non-SC/ST populations in India, Uttar Pradesh, Madhya Pradesh, and Maharashtra, NFHS-5, 2019–21.

In Uttar Pradesh the difference between the observed and expected cases of Scheduled Castes were not statistically significant (χ^2=3.98, p=0.1367) although the difference between the observed and expected cases of Scheduled Castes was higher. The lack of statistical significance can be in part attributed to a very small number of ST events (1 observed).

Conversely, Madhya Pradesh indicates caste difference in child survival is statistically significant (χ^2=10.03, p=0.0066). Children of Scheduled Tribe had significantly increased mortality than expected (29 observed vs. 18.08 expected), and non-SC/ST had lower mortality than expected (24 vs. 34.93), which confirms the strong social inequality.

In the case of Maharashtra, the caste-related disparities in child survival did not exhibit a statistically significant difference (χ^2=1.39, p=0.4998), which is rather comparable to the survival pattern across the social groups.

Table 3 shows that caste differentials in child mortality were significant at the national level in the unadjusted and socio-economic models. Compared with non-SC/ST children, the odds of child mortality were higher among SC (OR=1.38, 95% CI: 1.16-1.65) and ST children (OR=1.56, 95% CI: 1.32-1.85). However, these associations became non-significant after adjustment for proximate determinants. Maternal education was strongly protective, while maternal age remained a significant risk factor. Institutional delivery (OR=0.65) and four or more

ANC visits (OR=0.70) were associated with lower odds of child mortality.

In Uttar Pradesh, caste differentials were not statistically significant across models. Maternal age was the strongest predictor of child mortality, whereas maternal education showed a significant protective effect. Other variables were not significant in the fully adjusted model.

In Madhya Pradesh, ST children had higher odds of mortality in the unadjusted model (OR=2.39). Maternal age remained a significant risk factor, while both partial and four or more ANC visits were associated with lower odds of child mortality. Other covariates showed no significant association in the fully adjusted model.

In Maharashtra, caste was not significantly associated with child mortality. Although wealth status was protective in the unadjusted model, the association did not persist after adjustment. No other covariates showed significant associations in the fully adjusted model.

DISCUSSION

This study shows that child mortality in India has decreased remarkably in the last three decades, though significant social and regional disparities remain. There is evidence of similar declines in child mortality as measured by NFHS and Sample Registration System data, which can be attributed to better maternal and child health services, improved immunization, and economic growth.[2,3,36] However, there are still disparities in child mortality among social and geographical groups.[37,38]

In terms of the nation as a whole, SCs and STs had higher mortality rates and lower survival rates compared to non-SC/STs. This finding corroborates earlier research which showed that socially vulnerable groups suffer from adverse child health status due to poor health facilities, inadequate sanitation, nutrition, and education.[18,19] Nonetheless, the differences in mortality rates were statistically not significant after controlling for socio-economic and proximate variables, indicating that the social vulnerability to child mortality was largely driven by lack of access to resources and health care. This finding is in line with earlier NFHS results.[17,18]

The most prominent protective factor associated with lower risk of child mortality was maternal education. In comparison with the children of mothers who did not have any formal education, those with mothers possessing secondary and higher education were at significantly reduced risk of death. This finding is supported by previous research indicating that educationally advantaged mothers were more likely to seek medical care, use proper infant feeding techniques, and treat childhood illnesses promptly.[9-11]

Another significant determinant of child mortality was economic status. The highest rates of mortality were recorded in the poor children, consistent with the findings of previous Indian studies showing negative influence of poverty on nutrition, health conditions, and health-seeking behaviors of children.[8,9,19] Although economic status lost its significance after adjusting for other variables, it should be recognized as a key underlying determinant of child survival.

The association between mother's age and child mortality was also established as children born to women aged between 35-49 years had higher risks of mortality compared to other children born to mothers who were younger. Previous demographic studies have found similar results where the older age of mothers increases the likelihood of having negative outcomes in pregnancy and childbirth.[21,22] Moreover, children who were the fourth-born children or higher-order births also exhibited an increased risk of mortality due to repeated childbirths among mothers and limited resources in households.[21,22]

Moreover, the study results indicate the importance of the use of maternal health services in promoting the survival of children. The children whose mothers visited antenatal clinics at least four times during their pregnancy recorded low risks of mortality when compared to those whose mothers never visited antenatal facilities. Additionally, institutional delivery was also associated with lower child mortality rates. This can be attributed to the early identification of complications during pregnancy through antenatal care and provision of emergency obstetric care.[27,28]

Variations in state-level effects were noted. The Scheduled Tribe children in Madhya Pradesh continued to exhibit a significant disadvantage in survival, possibly due to sustained social exclusion, geographical isolation, and inadequate health service utilization among the tribes. Other researches on health disparities in central India also made the same observation.[36,37] On the other hand, there were fewer differences in castes within Maharashtra wherein the general mortality rate was relatively low. This is in line with the notion that states characterized by strong health systems and good socio-economic status have low child mortality and less social inequality.[38]

Thus, from the findings, it can be deduced that future declines in child mortality in India would be made possible through strategies addressing the need for improving maternal education, poverty reduction, and antenatal care as well as provision of healthcare services.

The study was restricted to selected socio-economic, demographic, and maternal healthcare characteristics available in the NFHS dataset. Other factors that may influence child survival, including environmental, nutritional, and healthcare system-related factors, were not examined and warrant further investigation.

CONCLUSION

Even though there has been significant reduction in mortality rates of children over the last 30 years, this paper has indicated that social and regional disparities in child survival remain apparent in India. The increased mortality of SCs and STs, especially in later ages of childhood, is the cumulative effect of socio-economic disadvantage and is not in isolation as the result of biological vulnerability at an early age. This observation aligns with the traditional child survival paradigm, which highlights the importance of the social and environmental pathways in the determination of post infancy mortality. The decrease in the effects of caste after conditioning on the maternal education, fertility, and use of healthcare indicates that caste inequalities are more processes that lead to unequal resource and service accessibility than caste status. Other equity-based studies have also found the same results, revealing that only the most disadvantaged groups do not necessarily experience child survival improvements unless specially targeted. Significant state-based heterogeneity is another factor that emphasises the context. The enduring disadvantage of the Scheduled Tribe children in Madhya Pradesh is perhaps indicative of structural limitations like geographic remote locations, less robust health delivery system, and lower coverage of the services, which are well reported in previous child health evaluation in India. Conversely, the lack of strong caste distributions on Maharashtra is consistent with the findings in environments that have further developed into a higher level of health transition, where the general mortality is low and the social inequalities are slim. On the whole, the results point out that additional child mortality decline in India will necessitate state-specific and equity-based interventions, which will target maternal education, fertility control, and long-term access to quality health care.

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