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Childhood Stunting in High-Burden Indian States: Socio-economic Determinants and POSHAN Abhiyaan Exposure

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Abstract

India records the largest absolute number of stunted children worldwide, yet evidence jointly examining socioeconomic determinants and national nutrition programme exposure in the highest-burden states remains limited. Objective: To identify socioeconomic determinants of stunting and to assess whether residence in districts with high POSHAN Abhiyaan implementation intensity is associated with lower odds of stunting among children under five. This cross-sectional study analysed secondary data from the National Family Health Survey (NFHS-5, 2019-2021) for 92,431 children aged 0-59 months in Bihar, Uttar Pradesh, Jharkhand, Madhya Pradesh, and Meghalaya. Stunting was defined as a height-for-age z-score below -2 SD of the WHO Child Growth Standards. Chi-square tests and multivariable binary logistic regression estimated adjusted odds ratios (AOR) with 95% confidence intervals (CI) using survey weights. Stunting prevalence was 41.6%. Low birth weight (AOR = 1.92; 95% CI 1.77-2.08), poorest wealth quintile (1.71; 1.58-1.85), short maternal height (1.63; 1.50-1.77), no maternal schooling (1.46; 1.34-1.59), inadequate dietary diversity (1.34; 1.24-1.45), and unimproved sanitation (1.28; 1.19-1.38) independently increased the odds of stunting, whereas high POSHAN Abhiyaan exposure was protective (0.86; 0.80-0.93). Stunting reflects converging household poverty, low maternal human capital, and intergenerational biological disadvantage; strengthening frontline nutrition services in low-coverage districts is essential.

Keywords: Child stunting, dietary diversity, NFHS-5, POSHAN Abhiyaan, socioeconomic determinants

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INTRODUCTION

Early childhood stunting remains one of the most persistent public health problems in India. National estimates for the 2019 to 2021 survey period indicate that among children under five, the prevalence was 35.5 percent for stunting, 32.1 percent for underweight, and 19.3 percent for wasting. Consequently, India continues to have the largest absolute number of stunted children in the world (International Institute for Population Sciences & ICF, 2021). Chronic malnutrition on this scale undermines cognitive development, weakens immune capacity, and suppresses work capacity in adulthood, transmitting disadvantages across generations (Park, 2021; Rai et al., 2022).

Aggregate national statistics on childhood stunting often conceal substantial geographic heterogeneity. Subnational analyses consistently identify a high-burden cluster of states, including Bihar, Uttar Pradesh, Jharkhand, and Madhya Pradesh, where stunting prevalence can reach 40% (Pooja & Guddattu, 2022). Within these regions, a substantial body of research has established the primary socioeconomic and environmental determinants of chronic malnutrition. Factors such as parental education, household wealth, and sanitation quality are well-documented predictors of stunting, and their statistical significance persists even after controlling for confounders and when using composite anthropometric measures (Menon et al., 2018; Shah et al., 2024; Singha et al., 2026a)

Several pathways link budget situations to linear growth. Maternal education shapes nutritional knowledge, service seeking, and hygiene behavior, all of which directly affect a child's height at age (Nambiar & Arunachalam, 2025). Household poverty affects food quality, and children in the poorest wealth quintile bear a disproportionate share of anthropometric failures (Khan & Mohanty, 2024). Water, sanitation, and hygiene conditions influence intestinal infections and environmental enteropathy that suppress nutrient absorption during the critical first thousand days (Roy et al., 2026; Srilakshmi, 2018). Birth weight and maternal height continue the intergenerational footprints of malnutrition, with low birth weight becoming a key precursor to stunting later in life (Halli et al., 2022; Jana, 2023). Partner feeding practices, dietary diversity, and vaccination status increase the risk profile (Dhami et al., 2019; Saha et al., 2022), and incomplete vaccination has been associated with a measurable proportion of the burden of stunting (Banerjee et al., 2021; Khan et al., 2025a).

The government's response is focused on POSHAN Abhiyaan, the national nutrition mission launched in 2018 with the core objective of reducing stunting and underweight by two percentage points annually through convergence, technology tracking and community mobilization. Evaluations of the initial implementation phase found uneven progress at the district level, with the greatest gains focused on frontline services through integrated child development services (Das, 2025; Singh et al., 2023). There remains little evidence to separate the program's exposure from broader socioeconomic

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realities, particularly in states that bear the greatest burden. Most of the existing literature treats all of India as a single image, obscuring the unique dynamics of the most affected regions (Dolui & Sarkar, 2024).

Although research has examined the socioeconomic determinants of child nutrition and the effects of large-scale interventions separately, to our knowledge, few studies have simultaneously analyzed their interplay within the POSHAN Abhiyaan framework across India's highest-burden states. A critical evidence gap therefore persists for integrated analyses that can inform targeted policy. The high prevalence of stunting in these states jeopardizes India's national nutrition goals and its commitment to Sustainable Development Goal 2.2, creating an urgent need for such evidence (Sk & Banu, 2026). This study aims to quantify the association between the district-level implementation intensity of POSHAN Abhiyaan and stunting in children under five, after controlling for key maternal and household characteristics. We hypothesize that residence in a district with greater program implementation intensity is associated with a lower prevalence of stunting.

METHODOLOGY

Type of research

This quantitative observational study used a cross-sectional, explanatory design using secondary analysis of nationally representative survey microdata, appropriate for a problem concerned with population-level associations at a single point in time. Reporting follows the STROBE recommendations.

Time and place of research

NFHS-5 fieldwork was conducted across India during 2019-2021 by the International Institute for Population Sciences (IIPS) under the Ministry of Health and Family Welfare; this secondary analysis was performed in 2025. The setting was five high-burden states selected on stunting prevalence rather than geographical contiguity: Meghalaya (46.5%, the highest in India), Bihar (42.9%), Uttar Pradesh (39.7%), Jharkhand (39.6%), and Madhya Pradesh (35.7%), all at or above the national average of 35.5% (International Institute for Population Sciences & ICF, 2021). Meghalaya adds a predominantly tribal, hill-district context to the four large north-central states.

Population and sample

The target population was all living children aged below 60 months in the five states. The sample is the NFHS-5 probability sample, drawn through a stratified two-stage design (primary sampling units selected with probability proportional to size, then systematic household selection), supporting state- and district-level representativeness. Children aged 0-59 months with complete anthropometric and covariate data were included; records with missing key variables or implausible z-scores were excluded, yielding an analytic sample of 92,431 children. Sampling weights were applied throughout.

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Data collection techniques and instrument development

Data were collected through structured interviews and direct anthropometric measurement. The standardised NFHS-5 Household, Woman's, and Biomarker questionnaires, adapted from the validated Demographic and Health Survey instruments, were pre-tested and translated into regional languages with back-translation, then administered by trained teams using computer-assisted personal interviewing. Height or length was measured to 0.1 cm (Seca board or stadiometer) and weight to 0.1 kg (calibrated digital scale) following WHO protocols (WHO Multicentre Growth Reference Study Group, 2006). No new instrument was developed; existing variables were re-operationalised. The dependent variable was stunting (height-for-age z-score below -2 SD). Independent variables were maternal education, wealth quintile, place of residence, sanitation facility, maternal height, birth weight, child sex, dietary diversity (Longvah et al., 2017), and district-level POSHAN Abhiyaan implementation intensity (high versus low).

Data analysis techniques

Analyses were run in IBM SPSS Statistics version 27 in three stages matched to the study objectives: univariate frequency distributions described the magnitude of stunting; Pearson chi-square tests identified characteristics associated with stunting; and multivariable binary logistic regression estimated adjusted odds ratios (AOR) with 95% confidence intervals (CI), entering programme exposure with socioeconomic and biological variables to isolate its independent contribution. Logistic regression suited a dichotomous outcome requiring simultaneous adjustment of correlated determinants. Multicollinearity was checked, and model performance assessed with the omnibus test, Nagelkerke R-square, Hosmer-Lemeshow test, and classification accuracy. Significance was set at $p < 0.05$ (two-tailed).

RESULTS AND DISCUSSION

The analysis follows the sequence specified in the methods section, proceeding from univariate description to bivariate testing and multivariable modelling.

Characteristics of the study population

Of the 92,431 children in the pooled sample, 41.6% were stunted, a level well above the national average and consistent with the classification of these five states as high-burden settings. Table 1 presents the frequency distribution of the outcome and of each explanatory variable. Rural residence (78.6%), unimproved sanitation (52.3%), inadequate dietary diversity (61.4%), and absence of maternal schooling (34.2%) were highly prevalent, and 56.9% of children lived in districts with low POSHAN Abhiyaan implementation intensity.

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Table 1. Frequency distribution of the study variables

Variable	Category	n	%
Stunting status	Stunted	38,451	41.6
	Not stunted	53,980	58.4
Household wealth quintile	Poorest	26,250	28.4
	Poorer	22,276	24.1
	Middle	18,763	20.3
	Richer	14,419	15.6
	Richest	10,723	11.6
Maternal education	No schooling	31,611	34.2
	Primary	15,528	16.8
	Middle	35,586	38.5
	Higher	9,706	10.5
Place of residence	Rural	72,651	78.6
	Urban	19,780	21.4
Sanitation facility	Unimproved	48,341	52.3
	Improved	44,090	47.7
Birth weight	Low (<2,500 g)	18,209	19.7
	Normal (≥2,500 g)	74,222	80.3
Maternal height	<145 cm	10,907	11.8
	≥145 cm	81,524	88.2
Dietary diversity	Inadequate	56,753	61.4
	Adequate	35,678	38.6
POSHAN Abhiyaan exposure	High	39,838	43.1
	Low	52,593	56.9
Child sex	Male	47,694	51.6
	Female	44,737	48.4

Bivariate associations

Table 2 cross-tabulates each characteristic against stunting status and reports the Pearson chi-square statistic with the corresponding p-value. All characteristics were significantly associated with stunting at the $p < 0.05$ level. The prevalence of stunting declined monotonically across wealth quintiles, from 49.8% in the poorest quintile to 29.7% in the richest quintile, and from 48.9% among children of mothers with no schooling to 27.4% among children of mothers with higher education. Children in districts with high programme exposure showed a lower prevalence of stunting than those in low-exposure districts (37.8% versus 44.5%).

Table 2. Cross-tabulation of study variables by stunting status

Characteristics	Category	Not stunted		Stunted		Total	X^2	*p*
		n	%	n	%			

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Household wealth quintile	Poorest	13,177	50.2	13,073	49.8	26,250	1,287.412	<0.001
	Poorer	12,051	54.1	10,225	45.9	22,276		
	Middle	11,033	58.8	7,730	41.2	18,763		
	Richer	9,214	63.9	5,205	36.1	14,419		
	Richest	7,538	70.3	3,185	29.7	10,723		
Maternal education	No schooling	16,153	51.1	15,458	48.9	31,611	1,563.907	<0.001
	Primary	8,649	55.7	6,879	44.3	15,528		
	Middle	23,273	65.4	12,313	34.6	35,586		
	Higher	7,047	72.6	2,659	27.4	9,706		
Place of residence	Rural	40,902	56.3	31,749	43.7	72,651	642.118	<0.001
	Urban	13,015	65.8	6,765	34.2	19,780		
Sanitation facility	Unimproved	26,056	53.9	22,285	46.1	48,341	587.334	<0.001
	Improved	27,865	63.2	16,225	36.8	44,090		
Birth weight	Low (<2,500 g)	8,686	47.7	9,523	52.3	18,209	981.642	<0.001
	Normal (≥2,500 g)	45,350	61.1	28,872	38.9	74,222		
Maternal height	<145 cm	4,832	44.3	6,075	55.7	10,907	724.856	<0.001
	≥145 cm	49,404	60.6	32,120	39.4	81,524		
Dietary diversity	Inadequate	31,101	54.8	25,652	45.2	56,753	415.229	<0.001
	Adequate	22,905	64.2	12,773	35.8	35,678		
POSHAN Abhiyaan exposure	High	24,779	62.2	15,059	37.8	39,838	118.703	<0.001
	Low	29,189	55.5	23,404	44.5	52,593		
Child sex	Male	27,519	57.7	20,175	42.3	47,694	22.147	<0.001
	Female	26,484	59.2	18,253	40.8	44,737		

Figure 1 displays the wealth gradient and illustrates the gap of approximately twenty percentage points between the poorest and the richest quintiles.

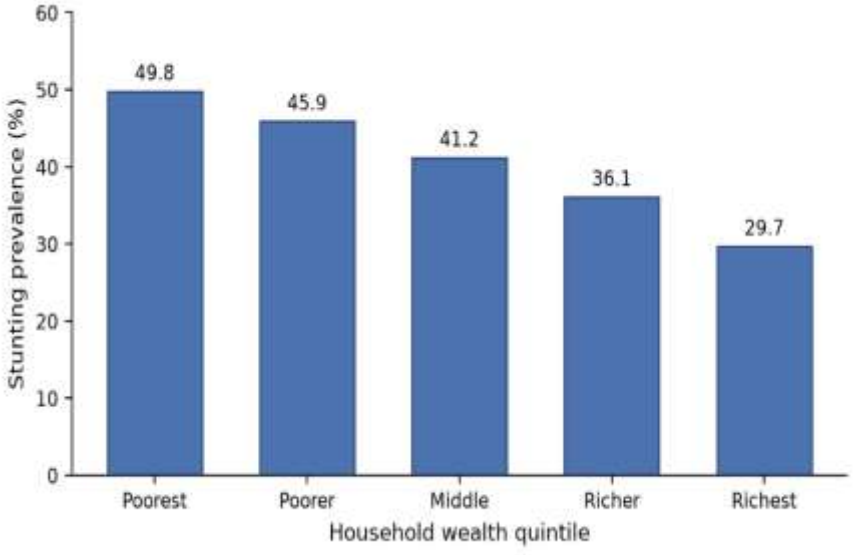

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Figure 1. Prevalence of stunting by household wealth quintile in high prevalence states

Multivariable analysis

Characteristics that were significant at the bivariate stage were entered into a binary logistic regression model. Table 3 reports the regression coefficients, standard errors, Wald statistics, degrees of freedom, p-values, adjusted odds ratios, and the lower and upper bounds of the 95% confidence interval for each predictor.

Table 3. Multivariable binary logistic regression of factors associated with stunting

Predictor (reference category)	B	SE	Wald	df	p	AOR	95% CI lower	95% CI upper
Poorest wealth quintile (richest)	0.536	0.040	177.2	1	<0.001	1.71	1.58	1.85
No maternal schooling (secondary or higher)	0.378	0.044	75.3	1	<0.001	1.46	1.34	1.59
Low birth weight (normal birth weight)	0.652	0.041	250.7	1	<0.001	1.92	1.77	2.08
Short maternal height <145 cm (≥145 cm)	0.489	0.042	134.1	1	<0.001	1.63	1.50	1.77
Unimproved sanitation (improved)	0.247	0.038	42.6	1	<0.001	1.28	1.19	1.38
Inadequate dietary diversity (adequate)	0.293	0.040	53.8	1	<0.001	1.34	1.24	1.45
Rural residence (urban)	0.174	0.043	16.4	1	<0.001	1.19	1.09	1.29
Male sex (female)	0.077	0.033	5.4	1	0.020	1.08	1.01	1.15
High POSHAN Abhiyaan exposure (low exposure)	-0.151	0.038	15.4	1	<0.001	0.86	0.80	0.93
Constant	-1.842	0.048	1,472.4	1	<0.001	0.158		

The model was statistically significant in the omnibus test of coefficients (chi-square = 6,482.3; df = 9; $p < 0.001$). The Nagelkerke R-square was 0.187, the Hosmer-Lemeshow test was non-significant (chi-square = 7.42; df = 8; $p = 0.492$), indicating adequate calibration, and overall classification accuracy was 64.8%. Low birth weight showed the strongest independent association with stunting (AOR = 1.92; 95% CI 1.77-2.08), followed by membership of the poorest wealth quintile (AOR = 1.71; 95% CI 1.58-1.85) and short maternal height (AOR = 1.63; 95% CI 1.50-1.77). High POSHAN Abhiyaan exposure remained inversely associated with stunting after adjustment (AOR = 0.86; 95% CI 0.80-0.93), corresponding to a 14% lower odds of stunting relative to low-exposure districts.

DISCUSSION

This analysis confirms that stunting among children under five in India's highest-burden states is shaped by the joint operation of household resources, maternal human capital, and intergenerational biological disadvantage rather than by any single proximate cause. The steep

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wealth gradient observed here is consistent with decomposition analyses attributing a large share of nutritional inequality to the unequal distribution of household wealth and maternal education, a pattern also evident in comparative state-level work (Khan et al., 2025b; Shirisha et al., 2022).

The prominence of low birth weight aligns with studies identifying it as a discriminating risk factor between stunted and non-stunted preschool children (Halli et al., 2022). Short maternal height exerted a comparable effect, consistent with earlier national analyses and with the biological transmission of growth deficits across generations (Sk & Banu, 2026). Sanitation retained an independent association after adjustment, supporting evidence that environmental enteric dysfunction contributes to linear growth faltering (Mustika, 2025). Dietary diversity and the quality of complementary feeding likewise shaped the risk profile, in line with regional analyses of infant and young child feeding practices (Chakrabarti et al., 2020)

The protective association observed in districts with high POSHAN Abhiyaan implementation was modest but statistically robust, and it is consistent with evaluations linking more fully integrated child development services to better anthropometric outcomes (Verma & Joe, 2025). Earlier assessments similarly found that gains during the first mission cycle were concentrated where service coverage was densest, suggesting that implementation intensity, rather than the nominal existence of the programme, drives measurable improvement. Restricting the analysis to five high-burden states strengthens the policy relevance of these findings, since pooled national estimates tend to attenuate the severity concentrated in these regions (Dhami et al., 2019; Saha et al., 2022)

Policy implications follow directly from the configuration of determinants. Investments that raise maternal education, extend cash and food assistance to the poorest households, and strengthen sanitation infrastructure address the determinants with the strongest adjusted associations. Consolidating frontline service delivery under POSHAN Abhiyaan, with priority given to districts with weak coverage, offers a credible route towards the annual reduction target. Convergent action across nutrition, health, water and sanitation, and social protection is therefore likely to be more effective than any single vertical(Let et al., 2024; Puranik & Shreya, 2022; Singha et al., 2026b)

The finding that low birth weight is a key differentiating risk factor for stunting is consistent with the work of Halli et al (2022). Similarly, the influence of maternal height suggests an intergenerational transmission of growth potential, a pattern documented in previous national analyses (Sk & Banu, 2026). This transmission may be mediated by specific biological pathways. Furthermore, sanitation maintained an independent association with stunting after adjustment, which corroborates findings reported by Chakrabarti et al. (2020).

Dietary diversity and quality of complementary foods shape risk profiles, consistent with regional analyses of nutritional practices (Dhami et al., 2019; Saha et al., 2022). The protective relationship observed in districts with high implementation of POSHAN Abhiyaan is modest but significant and is reflected in evaluations linking more integrated child development services with

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better anthropometric outcomes (Chudasama et al., 2014; Praveen Kumar et al., 2025; Singha et al., 2026b). Das. (2025) also found that the results of early missions were concentrated where service coverage was densest, suggesting that the intensity of implementation, not just the existence of the program, led to measurable improvements.

Limiting the analysis to five high-burden states strengthens the policy relevance of these results, as overall national estimates tend to attenuate the severity concentrated in these regions. The disparities observed between social groups in this study parallel those documented by Dolui & Sarkar (2024). The broader burden of anemia documented in several recent surveys exacerbates nutritional deficiencies and suggests a common set of baseline determinants (Puranik & Shreya, 2022).

Several caveats temper interpretation. The cross-sectional design excludes causal conclusions, so the relationships reported here are correlations and not proven mechanisms. Program impact is estimated based on the intensity of district-level implementation rather than verified individual participation, which may mitigate actual impact. Despite standardized protocols, anthropometric measurement errors and biases in recall of reported birth weight remain possible. Unmeasured confounders cannot be excluded, including maternal mental health and local food price shocks.

The configuration of determinants identified in this study suggests several policy-relevant associations. The relationships observed between the outcome and factors such as maternal education, financial and food assistance for the poorest households, and sanitation infrastructure indicate these areas warrant further investigation. While this cross-sectional analysis cannot establish causality, the findings are consistent with the multi-sectoral approach of the POSHAN Abhiyaan initiative. This alignment suggests that consolidating frontline services with a focus on weaker districts may be a relevant strategy. The results lend empirical support to the hypothesis that convergent actions across nutrition, health, water, and social protection could be more effective than isolated vertical programs.

CONCLUSION

This study confirms that child stunting in India's worst-affected states is driven by a combination of immediate socioeconomic deprivation and intergenerational biological disadvantage. Specifically, the adjusted analysis identified household poverty and low maternal education as primary socioeconomic correlates, alongside the biological factors of low birth weight and maternal short stature. While these factors increase risk, residence in a district with high implementation of the POSHAN Abhiyaan mission was associated with a modest protective effect. These findings suggest that accelerating progress against stunting requires integrated policies that simultaneously address household poverty, support maternal health and education, and strengthen the delivery of frontline nutrition services. The cross-sectional design of this study is a key limitation, precluding

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the establishment of causal relationships. Therefore, future research should use longitudinal designs to track cohorts of children in high-burden districts from birth. Such studies could clarify causal pathways by examining the association between verified participation in specific program components and growth trajectories during the critical first 1000 days.

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