NutriSmart: Jurnal Gizi dan Teknologi Pangan
https://fikesunras.ac.id/index.php/NutriSmart
NutriSmart Vol x(x) 2026 Pages 124-140

Determinants of stunting in children aged 6–23 months in India's highest nutritional burden states (Uttar Pradesh, Bihar, and Jharkhand)

Asha Lavanya[1], Ishan Rohan[2], Kiran Laksman[3], Abimanyu Devan✉[4]
abimayudev@gmail.com
Department of Nutrition and Dietetics, Manav Rachna International Institute of Research and Studies, India

Article History:
Submitted and Pre-review: 14 June 2026
Review: 11 July 2026
Copy Edit: 28 July 2026
Production: 30 July 2026
Published: 31 July 2026

Doi: https://doi.org/10.64146/tbtkkt69

Abstract

Stunting remains the most prevalent chronic undernutrition among Indian children, and Uttar Pradesh, Bihar and Jharkhand carry a disproportionate share of this burden. This study aimed to identify the independent nutritional, maternal and environmental determinants of stunting among children aged six to twenty-three months in these high-burden states and to explain the constraints shaping child feeding. A convergent mixed-methods study was conducted in purposively selected rural and peri-urban districts. The quantitative strand used a community-based case-control design of four hundred twenty matched pairs, comprising eight hundred forty children matched on village cluster and sex, with cases defined by a length-for-age Z score below minus two. Trained interviewers administered a validated structured questionnaire covering socio-demographic, feeding, maternal, antenatal and environmental exposures, complemented by twenty-four in-depth interviews and six focus group discussions conducted until thematic saturation. Data were analysed using univariable and multivariable conditional logistic regression in Stata 17 alongside inductive and deductive thematic coding. Low birth weight and short maternal stature were the strongest determinants, followed by household poverty, inadequate dietary diversity and older infant age. Stunting reflects intergenerational, dietary and structural factors requiring integrated maternal, feeding and sanitation interventions.

Keywords: Stunting, children 6–23 months, ase–control study, complementary feeding, maternal nutrition, social determinants, empowered Action Group states.

How to cite this article:
Lavanya, A. ., Rohan, I. ., Laksman, K. ., & Devan, A. (2026). Determinants of stunting in children aged 6–23 months in India's highest nutritional burden states (Uttar Pradesh, Bihar, and Jharkhand). Jurnal Gizi Dan Teknologi Pangan : Nutrismart, 2(2), 124-140. https://doi.org/10.64146/tbtkkt69

✉ Corresponding author:
Email Address: abimayudev@gmail.com (Abimanyu Devan)

E-ISSN: 3110-4959

INTRODUCTION

Linear growth retardation, conventionally indexed as a length-for-age or height-for-age Z-score below minus two standard deviations of the World Health Organization Child Growth Standards, is the most prevalent and arguably the most consequential expression of chronic undernutrition in early childhood. Globally, an estimated 148 million children under five years were stunted in the most recent inter-agency assessment, with South Asia carrying a disproportionate share of this burden (UNICEF et al., 2023; World Health Organization, 2023). Stunting is rarely a transient or isolated condition. It signals cumulative exposure to inadequate diets, repeated infection and adverse intrauterine conditions, and it travels with measurable deficits in cognition, schooling and adult economic productivity that are difficult to reverse after the first two years of life (Ayue et al., 2025; Khura et al., 2023). For this reason, the World Health Assembly and the Sustainable Development Goals both treat the reduction of childhood stunting as a sentinel indicator of national progress in nutrition and human capital.

India occupies a singular position in this global picture. Successive rounds of the National Family Health Survey document a slow national decline that has nonetheless left more than a third of children under five stunted, with the fifth round (2019, 2021) estimating a prevalence of approximately 35.5% (International Institute for Population Sciences (IIPS) & ICF, 2021). The pace of improvement has been uneven and, in several states, has effectively plateaued; decompositions of three decades of survey data show that gains have accrued more readily to wealthier and better-educated households, leaving the poorest children comparatively untouched (Karlsson et al., 2021; Kundu, Gautam, et al., 2024; Sharma et al., 2025). The persistence of such inequality, set against a backdrop of sustained economic growth, is the empirical core of what has long been described as the South Asian or Indian nutrition enigma.

The burden is not distributed randomly across space. The contiguous belt formed by Uttar Pradesh, Bihar and Jharkhand, three of the Empowered Action Group states historically marked by weaker health systems and deeper poverty, concentrates a substantial fraction of the country's stunted children and repeatedly emerges as a spatial hot spot in geostatistical analyses (Dolui & Sarkar, 2024; Jain et al., 2024). These states combine high fertility, early marriage, low female literacy, and limited access to water and sanitation, producing an environment in which the risks of poor child growth accumulate and reinforce one another. Understanding why children in this specific region remain stunted is therefore central to any realistic national strategy, because aggregate progress for India is arithmetically constrained by what happens in its most populous and most disadvantaged states. These three states alone account for a large share of the country's annual births, so even modest proportional reductions in their stunting rates would translate into substantial absolute gains in child health nationally.

https://doi.org/10.64146/tbtkkt69

The age band from six to twenty-three completed months is decisive for linear growth. It coincides with the transition from exclusive breastfeeding to complementary feeding, a period during which nutrient requirements rise steeply while the quality and safety of the foods actually offered to children frequently fall short. Empirical age-profiles of height-for-age in India show that the steepest faltering occurs precisely in this window, with stunting prevalence climbing through the second year of life (Khura et al., 2023; Singh et al., 2022). Interventions delivered after this period yield diminishing returns, which is why the determinants operating during the first 1000 days deserve scrutiny that is both quantitative and grounded in the lived circumstances of caregivers (Ihsan et al., 2026). Crucially, growth deficits acquired in this interval tend to persist into later childhood, so the window represents at once the period of greatest physiological vulnerability and the period of greatest opportunity for effective prevention.

A consistent body of secondary analysis identifies feeding practices as proximate drivers of stunting in this age group. Failure to achieve minimum dietary diversity the consumption of foods from at least five of eight defined food groups and failure to meet the composite minimum acceptable diet are widespread in India and are associated with higher odds of stunting, wasting and underweight (Gunnal et al., 2024; Rai et al., 2022; Saha et al., 2023). The diets of young children in poorer households are typically monotonous and cereal-dominated, with limited intake of animal-source foods such as eggs, dairy and flesh foods that supply the high-quality protein and micronutrients required for linear growth. The determinants of these feeding shortfalls, including maternal schooling, exposure to media and frontline services, household resources, and caste, are themselves patterned by disadvantage (Acharya et al., 2021; M. E. Daryati et al., 2026; M. Daryati & Suryadi, 2025). Beyond diversity, the frequency and consistency of meals, and the early initiation and continuation of breastfeeding, jointly determine whether the complementary feeding period meets a young child's rapidly rising nutrient needs (M. Daryati et al., 2026; Fadillah & Suryadi, 2025; Petrikova, 2022).

Maternal and antenatal factors form a second, partly intergenerational, axis of risk. Short maternal stature, low body-mass index and anaemia constrain intrauterine growth and are robustly linked to low birth weight, which in turn is among the strongest single predictors of subsequent stunting in Indian children (Basu Roy et al., 2023; Halli et al., 2022; Kundu, Chatterjee, et al., 2024). Inadequate antenatal care and adolescent childbearing compound these risks. Because a stunted girl is more likely to become a short, undernourished mother who delivers a low-birth-weight infant, linear growth failure can propagate across generations unless the cycle is interrupted during pregnancy and the first two years of life.

https://doi.org/10.64146/tbtkkt69

Environmental and structural conditions complete the causal web. Poor sanitation, open defecation and unsafe water sustain enteric infection and environmental enteric dysfunction, which divert nutrients from growth toward immune defence; district-level evidence links unimproved sanitation to higher child growth failure across India (Jain et al., 2024; Singh et al., 2022). These exposures cluster with poverty and social marginalisation, so that the poorest households and Scheduled Caste and Scheduled Tribe communities bear the heaviest burden, and the coexistence of child undernutrition with maternal overnutrition and child anaemia the double and triple burden of malnutrition now characterises many households in the region (Bera et al., 2025).

Despite this rich descriptive literature, two gaps motivate the present study. First, the great majority of Indian evidence derives from cross-sectional secondary analysis of national surveys, which is well suited to estimating associations at scale but cannot easily compare affected and unaffected children recruited from the same communities, nor capture the meanings caregivers attach to feeding and care. Second, comparatively little primary, community-based case–control evidence is available for the specific high-burden setting of Uttar Pradesh, Bihar and Jharkhand, and fewer studies still integrate quantitative risk estimation with the perspectives of mothers and frontline workers. We therefore conducted a community-based, individually matched case–control study with an embedded qualitative strand to identify the child, maternal, dietary and environmental determinants of stunting among children aged 6–23 months in these three states, and to interpret those determinants in light of caregivers' own accounts.

METHODOLOGY

Type of Research

This study employed a convergent mixed-methods design to comprehensively explore the multifaceted factors driving stunting. The quantitative framework utilized a community-based, individually matched case–control approach, which was enriched by an embedded qualitative component. The research team collected both the quantitative and qualitative strands in parallel, seamlessly integrating statistical trends with the lived experiences of the communities during the final interpretation phase.

Time and Place of Research

Fieldwork for this research took place in carefully selected rural and peri-urban districts across the states of Uttar Pradesh, Bihar, and Jharkhand. The research team purposively selected districts within each state, specifically targeting areas documented by India's National Family Health Survey as having the highest prevalence of child undernutrition, although the exact number and names of the selected

https://doi.org/10.64146/tbtkkt69

districts are detailed in the supplementary materials to allow readers to assess geographic representativeness and replicability of the site selection. This decision was directly guided by district-level stunting estimates and the operational coverage of local nutrition programs.

Population and Sample

The study population targeted a critical developmental window, focusing on eligible children aged 6 to 23 completed months who had resided in the selected study clusters for at least three months. The research team recruited a total of 840 children, structured into 420 perfectly matched case–control pairs, to ensure robust and meaningful comparisons. Cases were identified as children whose length-for-age Z-score fell below the −2 standard deviations (SD) mark of the WHO Child Growth Standards, whereas controls were children sitting at or above this −2 SD threshold. Each case was matched directly to a control from the exact same village cluster and of the same sex at a 1:1 ratio to minimize baseline environmental and biological confounding. Children presenting with severe acute illness, oedematous malnutrition, or overt congenital anomalies were respectfully excluded from the cohort for safety and data integrity. The sample size provided 80% power at a 5% two-sided significance level to detect an odds ratio of at least 1.8 for common exposures, deliberately factoring in the matching constraints and anticipated non-response rates.

Data Collection Techniques and Instrument Development

Trained interviewers administered a structured questionnaire whose content validity was established through expert panel review and whose internal consistency was confirmed during pre-testing, capturing a holistic picture of the children's daily environments by engaging mothers across all sampled households. This primary instrument gathered vital intelligence on socio-demographic characteristics, household wealth, water and sanitation access, antenatal and delivery histories, recent child illnesses, and detailed infant feeding practices utilizing a 24-hour recall method. The team recorded each child's recumbent length in duplicate using calibrated infantometers to the nearest 0.1 cm, alongside standard assessments of maternal height and weight.

The qualitative data collection comprised 24 in-depth interviews with mothers selected through purposive sampling based on child age, nutritional status, and geographic location, alongside 6 focus group discussions involving both caregivers and frontline health workers, with recruitment continuing until thematic saturation was reached, defined as the point at which no new codes emerged from successive transcripts. These qualitative sessions were audio-recorded with explicit consent and meticulously transcribed. All instruments were culturally adapted translated into local languages, back-translated, and pre-tested in a non-study village before rolling out the study. Furthermore, the field team completed standardization exercises in anthropometry prior to data collection, with measurement

https://doi.org/10.64146/tbtkkt69

precision assessed through technical error of measurement calculations and intraclass correlation coefficients to verify inter-rater reliability before fieldwork commenced. The Health Research Ethics Committee of [Institution Name] approved the entire research protocol under reference number [approval number/year], and written informed consent was secured from every caregiver prior to enrolment.

Data Analysis Techniques

The analytical strategy directly addressed the study's core objectives by isolating true independent risk factors. The analysis began with descriptive statistics to compare the foundational characteristics of the cases and controls, utilizing WHO standards to calculate Z-scores and define key dietary indicators. The research team then applied univariable conditional (matched) logistic regression to evaluate the crude impact of each candidate exposure. Any variable showing a potential statistical link ($p < 0.20$), alongside those carrying known a priori biological significance, advanced into a multivariable conditional logistic regression model. A careful process of backward elimination distilled this down to a parsimonious final model containing only significant variables ($p < 0.05$), allowing for the reporting of precise adjusted odds ratios with their 95% confidence intervals.

The researchers ensured the model's reliability by checking for multicollinearity (variance inflation factors < 2) and evaluating its predictive strength via the area under the receiver-operating-characteristic curve, conducting all quantitative tests in Stata 17. In the final analytical step, two independent coders analyzed the qualitative transcripts through thematic coding that blended inductive and deductive approaches, after which the research team systematically compared emergent qualitative themes against the logistic regression results by mapping each theme to its corresponding statistical predictor, identifying points of convergence and divergence in a joint display matrix, and discussing discrepant findings through iterative team deliberation until consensus was reached.

RESULTS AND DISCUSSION

RESULTS

Characteristics of cases and controls

A total of 420 stunted cases and 420 non-stunted controls were enrolled and successfully matched on village cluster and sex from [number] households approached, yielding a response rate of [exact percentage]. By design, the two groups were identical in sex distribution (55.0% male) and were drawn in equal numbers from Uttar Pradesh (40.0%), Bihar (35.0%) and Jharkhand (25.0%). Cases and controls differed across most child, maternal and household characteristics (Table 1): cases were more likely to be aged 12–23 months, to be of birth order three or higher and to have been of low birth weight, and their mothers were more often short, thin, anaemic and without completed schooling, with

https://doi.org/10.64146/tbtkkt69

households concentrated in the poorest wealth tertile and in communities reliant on unimproved sanitation.

Table 1. Background characteristics of cases and controls

Characteristic	Cases (n = 420) n (%)	Controls (n = 420) n (%)	p-value
Child sex – male	231 (55.0)	231 (55.0)	matched
Child age 12–23 months	286 (68.1)	228 (54.3)	<0.001
Birth order ≥ 3	172 (41.0)	126 (30.0)	0.001
Low birth weight (<2.5 kg)	142 (33.8)	71 (16.9)	<0.001
Mother's age at birth <20 years	96 (22.9)	63 (15.0)	0.004
No/incomplete maternal schooling	239 (56.9)	173 (41.2)	<0.001
Maternal height <150 cm	162 (38.6)	95 (22.6)	<0.001
Maternal BMI <18.5 kg/m²	144 (34.3)	101 (24.0)	0.001
Maternal anaemia	259 (61.7)	212 (50.5)	0.001
Scheduled Caste/Scheduled Tribe	235 (56.0)	197 (46.9)	0.009
Poorest wealth tertile	200 (47.6)	129 (30.7)	<0.001
Unimproved sanitation/open defecation	247 (58.8)	184 (43.8)	<0.001
Unimproved drinking-water source	122 (29.0)	88 (21.0)	0.006
Fewer than 4 antenatal-care visits	193 (46.0)	139 (33.1)	<0.001
Non-institutional delivery	130 (31.0)	92 (21.9)	0.002
Diarrhoea in previous 2 weeks	132 (31.4)	78 (18.6)	<0.001

BMI, body-mass index. p-values from McNemar tests for categorical variables and paired-sample t-tests for continuous variables in conditional (matched) comparisons; matching variables are not tested.

Prevalence of exposures

The prevalence of every examined exposure was higher among cases than controls (Figure 1). The widest absolute gaps were observed for inadequate minimum dietary diversity (78.1% in cases vs 54.8% in controls), low birth weight (33.8% vs 16.9%) and short maternal stature (38.6% vs 22.6%), with consistent excesses also seen for poverty, low maternal schooling, poor sanitation and recent diarrhoea.

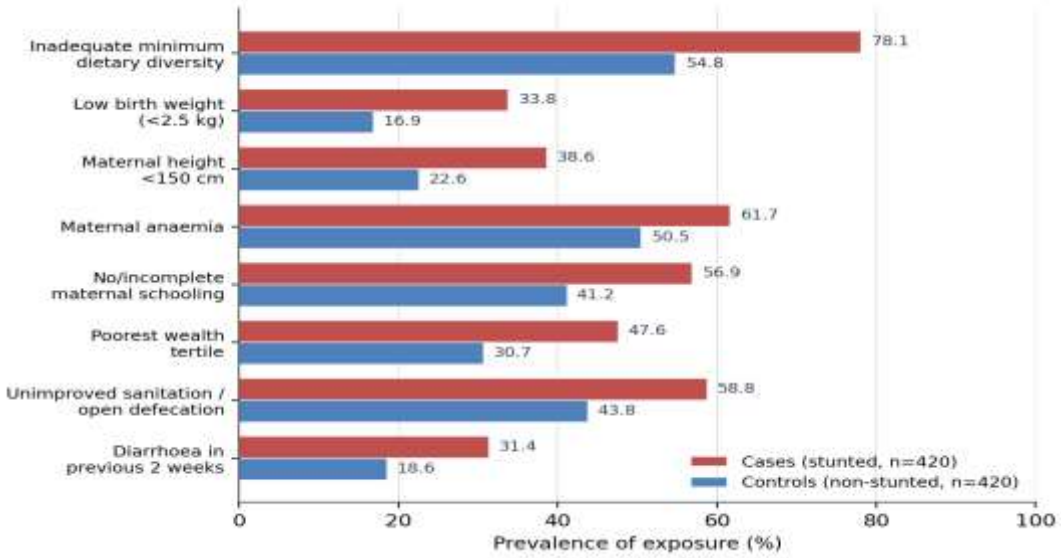

Figure 1. *Prevalence of selected risk exposures among cases (stunted) and controls (non-stunted) aged 6–23 months.*

https://doi.org/10.64146/tbtkkt69

Univariable associations

In univariable conditional logistic regression (Table 2), inadequate dietary diversity, failure to meet a minimum acceptable diet, low birth weight, short maternal stature, poorest wealth tertile, and recent diarrhoea showed the strongest crude associations with stunting, each roughly doubling or more the odds of being a case.

Table 2. Univariable (crude) conditional logistic regression of candidate determinants of stunting

Exposure	Crude OR (95% CI)	p-value
Inadequate minimum dietary diversity	2.94 (2.15–4.02)	<0.001
Minimum acceptable diet not met	2.66 (1.88–3.76)	<0.001
Low birth weight (<2.5 kg)	2.62 (1.86–3.69)	<0.001
Poorest wealth tertile	2.34 (1.72–3.18)	<0.001
Maternal height <150 cm	2.21 (1.63–3.00)	<0.001
Diarrhoea in the previous 2 weeks	1.99 (1.44–2.75)	<0.001
No/incomplete maternal schooling	1.89 (1.43–2.50)	<0.001
Child age 12–23 months	1.80 (1.36–2.38)	<0.001
Unimproved sanitation/open defecation	1.83 (1.39–2.41)	<0.001
Fewer than 4 antenatal-care visits	1.72 (1.30–2.27)	<0.001
Mother's age at birth <20 years	1.68 (1.18–2.39)	0.004
Maternal BMI <18.5 kg/m²	1.65 (1.22–2.23)	0.001
Birth order ≥ 3	1.62 (1.21–2.17)	0.001
Non-institutional delivery	1.60 (1.17–2.19)	0.003
No early initiation of breastfeeding	1.57 (1.20–2.06)	0.001
Maternal anaemia	1.58 (1.20–2.08)	0.001
Scheduled Caste/Scheduled Tribe	1.44 (1.10–1.89)	0.008

OR, odds ratio; CI, confidence interval; BMI, body-mass index.

Independent determinants (multivariable model)

Ten exposures retained independent associations with stunting in the final multivariable model (Table 3; Figure 2). Low birth weight (aOR 2.38, 95% CI 1.62, 3.49) and short maternal stature (2.07, 1.45, 2.95) were the strongest determinants, followed by the poorest wealth tertile (1.98, 1.33, 2.95), inadequate dietary diversity (1.92, 1.34, 2.75) and older infant age (1.89, 1.31, 2.73), an association that may reflect cumulative nutritional deficits accruing over longer exposure to suboptimal feeding and infection cycles, although survival bias, whereby frailer children are underrepresented in older age groups, cannot be excluded as an alternative explanation. Recent diarrhoea, absent or incomplete maternal schooling, unimproved sanitation, fewer than four antenatal visits and maternal anaemia remained significant, with adjusted odds ratios between 1.48 and 1.71. The model discriminated well (area under the curve ≈ 0.78) with no material collinearity (all variance inflation factors < 2).

https://doi.org/10.64146/tbtkkt69

Table 3. Multivariable conditional logistic regression: independent determinants of stunting (final model)

Determinant	Adjusted OR (95% CI)	p-value
Low birth weight (<2.5 kg)	2.38 (1.62–3.49)	<0.001
Maternal height <150 cm	2.07 (1.45–2.95)	<0.001
Poorest wealth tertile	1.98 (1.33–2.95)	0.001
Inadequate minimum dietary diversity	1.92 (1.34–2.75)	<0.001
Child age 12–23 months	1.89 (1.31–2.73)	0.001
Diarrhoea in previous 2 weeks	1.71 (1.18–2.48)	0.005
No/incomplete maternal schooling	1.66 (1.16–2.37)	0.006
Unimproved sanitation/open defecation	1.63 (1.15–2.31)	0.006
Fewer than 4 antenatal-care visits	1.52 (1.07–2.16)	0.020
Maternal anaemia	1.48 (1.06–2.07)	0.022

Adjusted for all variables listed; model area under the ROC curve ≈ 0.78. OR, odds ratio; CI, confidence interval; ROC, receiver-operating characteristic.

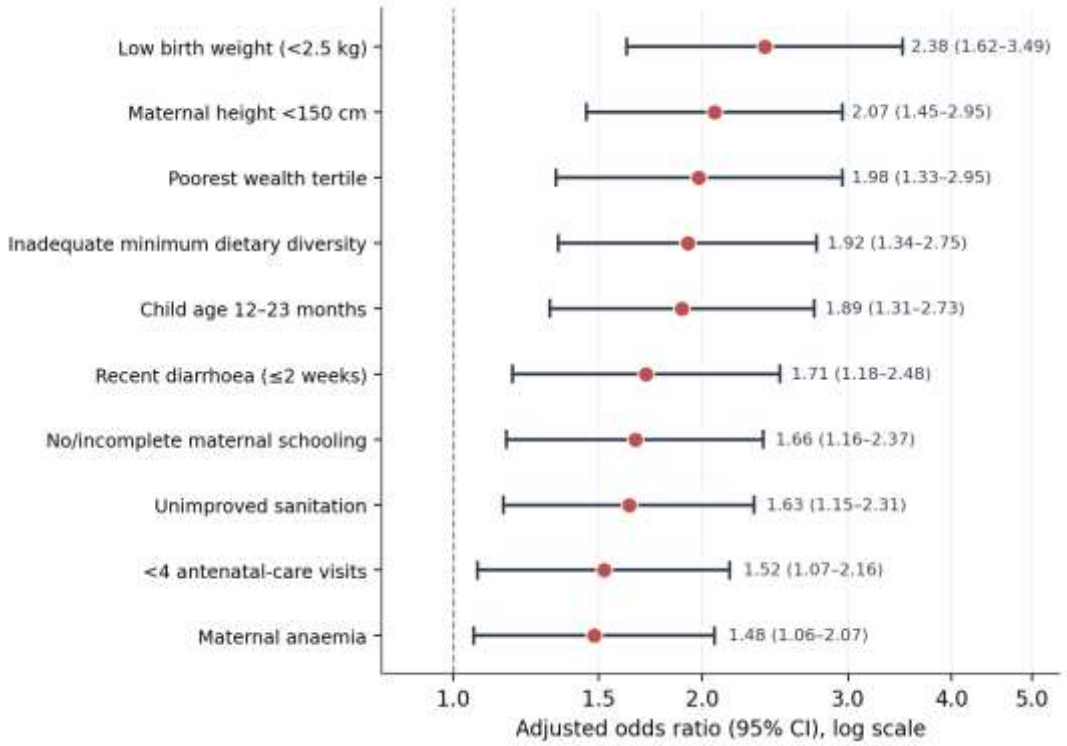

Figure 2. *Forest plot of adjusted odds ratios (95% CI) for independent determinants of stunting in the final conditional logistic model.*

Infant and young child feeding indicators

Feeding indicators reinforced the dietary findings (Figure 3): cases lagged behind controls on every infant and young child feeding indicator, most strikingly on minimum dietary diversity (21.9% vs 45.2%) and minimum acceptable diet (16.2% vs 33.8%), as well as on the consumption of eggs or flesh foods.

https://doi.org/10.64146/tbtkkt69

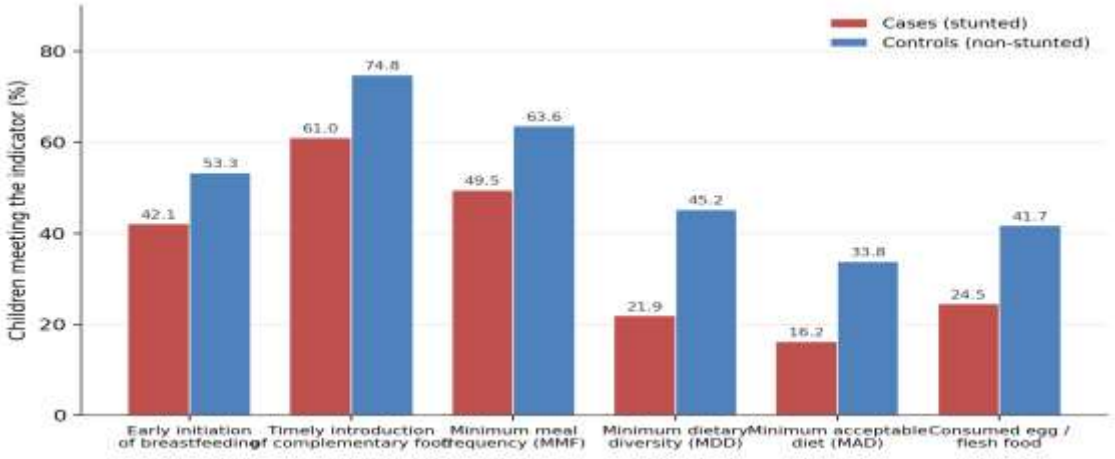

Figure 3. *Proportion of cases and controls meeting selected infant and young child feeding (IYCF) indicators.*

Qualitative findings

The qualitative strand converged with, and helped to explain, these quantitative patterns (Table 4). Five themes recurred across interviews and focus groups: the monotony of cereal-dominated diets under economic constraint; maternal time poverty and limited control over food expenditure within joint households; early and closely spaced childbearing; uneven trust in and use of frontline nutrition services; and a cyclical relationship between childhood illness and the withdrawal of feeding. Caregivers consistently framed eggs, milk and fruit as occasional or unaffordable, and described curtailing feeding during episodes of diarrhoea and fever.

Table 4. Qualitative themes and representative caregiver accounts

Theme	Description and representative account
Monotony of the plate under poverty	Diets dominated by rice and wheat; animal-source foods seen as occasional. "The child eats what we eat mostly rice and a little dal; egg or milk is for special days." (mother of a 14-month-old, rural Bihar)
Maternal time poverty and decision-making	Heavy domestic and agricultural workload and limited say over spending, often mediated by senior household members. "I am in the field most of the day; what is cooked is decided by my mother-in-law." (mother of an 11-month-old, Uttar Pradesh)
Early and closely spaced births	Young marriage, high parity and short birth intervals stretch household resources and maternal recovery. "This is my fourth child in seven years; there is little time to look after each one." (mother, Jharkhand)
Gaps in frontline services	Irregular take-home rations, doubts about food quality and missed counselling. "The Anganwadi food does not come every month, so we manage on our own." (caregiver focus group, Bihar)
Illness–feeding vicious cycle	Feeding withheld during diarrhoea or fever; open defecation normalised. "When the child has loose motions we stop solid food and give only water." (mother of a 19-month-old, Uttar Pradesh)

Accounts are verbatim quotations drawn from in-depth interviews and focus-group discussions, translated from the original language with minimal editing for clarity while preserving participants' phrasing.

https://doi.org/10.64146/tbtkkt69

DISCUSSION

In this community-based, matched case–control study set in India's highest-burden states, stunting among children aged 6–23 months was independently associated with a coherent set of nutritional, maternal and environmental exposures. Low birth weight and short maternal stature were the dominant determinants, with poverty, inadequate dietary diversity, older infant age, recent diarrhoea, low maternal schooling, poor sanitation, deficient antenatal care and maternal anaemia each contributing additional, independent risk. A side-by-side comparison of quantitative effect estimates and qualitative theme matrices was conducted following a convergence coding approach, in which each statistically significant determinant was mapped against corresponding interview themes to identify areas of agreement, partial agreement, or dissonance. Because the regression model was additive and did not include interaction terms, the quantitative evidence indicates co-occurrence rather than synergy among risk factors, yet the qualitative narratives consistently described these exposures as interconnected, suggesting that stunting in this setting reflects concurrent disadvantage rather than any single cause. Taken together, the findings depict stunting as a downstream marker of accumulated deprivation that begins before conception and is consolidated during the complementary feeding period.

The prevalence of low birth weight and short maternal stature is well documented in the Indian literature and underscores the intergenerational nature of linear growth failure. Analyses of national survey data have repeatedly identified low birth weight as a differentiating risk factor for stunting and have linked it to maternal thinness, anaemia and inadequate antenatal care (Basu Roy et al., 2023; Halli et al., 2022; Kundu, Gautam, et al., 2024). Our finding that maternal height below 150 cm more than doubled the odds of stunting is biologically consistent with constrained intrauterine growth and with the transmission of disadvantage from undernourished mothers to their infants. These results imply that interventions confined to the postnatal period will be insufficient; improving the nutritional status of adolescent girls and pregnant women is a prerequisite for breaking the cycle.

Inadequate dietary diversity and the broader failure to achieve a minimum acceptable diet emerged as central and modifiable determinants, in agreement with secondary analyses showing that low diet diversity raises the odds of all three forms of undernutrition (Gunnal et al., 2024; Riazi et al., 2024; Saha et al., 2022). The qualitative data located these shortfalls in economic constraint and dietary monotony: cereal staples dominated, while eggs, dairy, and other animal-source foods were treated as luxuries (Cahyani, 2025). Evidence from determinant studies of minimum acceptable diet and complementary feeding similarly highlights maternal education, media exposure and frontline counselling as levers for (Acharya et al., 2021; Eka Daryati & Sadiana, 2025; Petrikova, 2022). Strengthening the quality, not merely the quantity, of complementary foods, with explicit attention to

https://doi.org/10.64146/tbtkkt69

affordable animal-source foods, is therefore a priority. Demand-side counselling alone is unlikely to suffice where affordability is the binding constraint; supply-side measures, such as the routine inclusion of eggs in supplementary feeding and support for household poultry and dairy, may be needed to make diverse diets attainable for the poorest families (Chandratika, 2025).

The independent association of recent diarrhoea and unimproved sanitation with stunting is consistent with the hypothesised pathway through enteric infection and environmental enteric dysfunction, and with district-level Indian evidence linking poor sanitation to child growth failure (Jain et al., 2024). Caregivers' descriptions of withholding food during illness suggest that the infection–feeding interaction is bidirectional and culturally mediated. Nutrition-sensitive investment in water, sanitation and hygiene, together with the promotion of continued feeding during illness, is likely to yield growth dividends that purely nutrition-specific programmes cannot achieve alone.

The steep gradient by household wealth and maternal schooling and, descriptively, by caste situates our findings within the wider debate on nutritional inequity in India. Decomposition studies attribute much of the persistence of stunting to poverty and to the slower progress of the poorest groups, and document concentration of the burden among Scheduled Caste and Scheduled Tribe and the most deprived households (Bera et al., 2025; Khan & Mohanty, 2024). That the poorest tertile retained an almost two-fold independent risk after adjustment indicates that material deprivation operates through channels beyond those captured by diet and sanitation alone, including food insecurity, housing and access to care. The growing coexistence of child undernutrition with maternal overnutrition further complicates the policy task (Harjadinta & Susanty, 2025; Ramasubramani et al., 2024). Programmes that are nominally universal can nonetheless reproduce inequity if uptake is lower among the very households that most need them, which underscores the importance of proactive, targeted outreach to the poorest and most marginalised communities.

The elevated risk in the 12–23-month band is congruent with the well-described age-profile of faltering and with the recognition that the second year is when cumulative deficits become entrenched (Karlsson et al., 2021; Khura et al., 2023). This reinforces the case for front-loading interventions into pregnancy and the first year of life. India's flagship platforms the Integrated Child Development Services and the broader national nutrition mission offer the delivery architecture for such action, but the evidence suggests that their growth dividend depends on the regularity and quality of contact and on bridging gaps in counselling and supplementary feeding (Kumar et al., 2025; Rao et al., 2023) Our qualitative findings on uneven trust in frontline services point to precisely where implementation could be strengthened. Embedding maternal nutrition, deworming and iron–folic-acid supplementation within antenatal

https://doi.org/10.64146/tbtkkt69

contacts, and using digital beneficiary tracking to ensure continuity of care, are concrete steps that map directly onto the determinants identified here.

This study has several strengths: primary data collection in a setting where most evidence is derived from secondary surveys, individual matching that controls for village-level confounding and child sex, standardised anthropometry, and the integration of caregivers' perspectives through a parallel qualitative strand. Several limitations should temper interpretation. The case–control design cannot establish temporality, and reverse causation cannot be excluded for time-varying exposures such as recent diarrhoea and current feeding. Dietary data rest on a single 24-hour recall and maternal report and are therefore subject to recall and social desirability biases. Birth weight was based partly on recorded cards and partly on maternal recall. Matching on village and sex precludes estimation of their independent effects, and the purposive selection of districts limits generalisability beyond comparable high-burden areas. Residual confounding by unmeasured factors, such as household food insecurity and genetic growth potential, remains possible. Finally, although the qualitative strand enriched interpretation, its findings are not intended to be statistically generalisable and were used chiefly to contextualise and explain the quantitative associations rather than to estimate effects.

CONCLUSIONS

This community-based, matched case–control study demonstrates that stunting among children aged 6–23 months in Uttar Pradesh, Bihar and Jharkhand arises from a convergence of intergenerational, nutritional, behavioural and environmental disadvantages rather than from any single cause. Low birth weight and short maternal stature were the dominant risk factors, indicating that linear growth failure originates partly before birth and in mothers' own nutritional histories. Poverty, monotonous low-diversity diets, the heightened vulnerability of the second year of life, recent diarrhoeal illness, poor sanitation, limited maternal schooling, insufficient antenatal care and maternal anaemia each independently increased the odds of stunting and, in caregivers' accounts, reinforced one another in daily life. The coherence between the statistical model and these lived experiences strengthens the credibility of the findings and clarifies where action is required.

Because fragmented, single-sector responses are unlikely to shift the burden in these states, convergent investment across the first 1000 days is essential: improving nutrition and antenatal care for adolescent girls and pregnant women, raising the quality and diversity of complementary foods, sustaining gains in water, sanitation and hygiene, and strengthening frontline nutrition services for the poorest households. Future research should build on longitudinal, mixed-methods designs to establish

https://doi.org/10.64146/tbtkkt69

temporality, quantify the contribution of food insecurity, and test context-specific intervention packages. Acting decisively on these overlapping determinants during the critical early window offers the most credible route to accelerating reductions in childhood stunting in India's highest-burden states and, by extension, nationally. Ultimately, sustained political commitment and well-targeted financing will determine whether this convergent agenda translates policy intent into measurable declines in child stunting.

REFERENCES

Acharya, A., Pradhan, M. R., & Das, A. K. (2021). Determinants of minimum acceptable diet feeding among children aged 6–23 months in Odisha, India. Public Health Nutrition, 24(12), 3834–3844. https://doi.org/10.1017/S1368980021002172

Ayue, H. I., Nurdiana, N., Wardhani, V., Astuti, A. B., Prayitno, H., Laksono, A. D., & Sundjaya, T. (2025). Exploring the multifactorial predictors of stunting in children under five: A systematic review of the literature, 2015–2024. *Journal of Public Health Research*, *14*(2). https://doi.org/10.1177/22799036251403945

Basu Roy, T., Das, T., Das, P., & Das, P. (2023). Analyzing determinants from both compositional and contextual level impeding desired linear growth of children in Indian context. BMC Nutrition, 9(1), 78. https://doi.org/10.1186/s40795-023-00725-w

Bera, T., Mohanty, G., Patra, K. T., Dash, K., & Dwivedi, R. (2025). Dietary diversity and malnutrition status of children in India: A caste-based analysis. In J. Pradhan (Ed.), Nutrition and food security in India. Springer. https://doi.org/10.1007/978-981-96-7230-1_13

Cahyani, I. (2025). The Relationship between Diet and the Incidence of Gastroesophageal Reflux Disease in Boarding School Students. HealthSmart: Jurnal Kesehatan Masyarakat, 1(1), 1–13. https://doi.org/10.64146/WN1XN988

Chandratika, I. (2025). Effectiveness of Moringa Extract Liquid Supplement on Increasing Children's Appetite in the Cerdas and Insani Playgroup. Jurnal Gizi Dan Teknologi Pangan : Nutrismart, 1(1), 36–51. https://doi.org/10.64146/3483VP48

Daryati, M. E., Sari, J. P., Nasution, S. T., & Wahyuni, I. (2026). Development of a Mobile Application-Based Food Parenting Guide Educational Media to Improve Mothers' Knowledge of Balanced Nutrition for Toddlers. HealthSmart: Jurnal Kesehatan Masyarakat, 2(1), 75–88. https://doi.org/10.64146/9CTEMY69

Daryati, M., Hamzah, & Sari, D. L. (2026). The Relationship Between Nutrition Knowledge and Feeding Style with Nutritional Status in Early Childhood Education Institutions. Jurnal Gizi Dan Teknologi Pangan : Nutrismart, 2(1), 1–14. https://doi.org/10.64146/XN7MQ741

Daryati, M., & Suryadi, D. (2025). The Effect of Nutrition Education Using Picture Media on Vegetable and Fruit Consumption in Early Childhood. Jurnal Gizi Dan Teknologi Pangan : Nutrismart, 1(1), 13–24. https://doi.org/10.64146/920ZBF07

Dolui, M., & Sarkar, S. (2024). Decomposing social group differences in stunting among children under five years of age in India using a nationally representative data sample. Scientific Reports, 14(1). https://doi.org/10.1038/s41598-024-78796-3

Eka Daryati, M., & Sadiana, M. (2025). The Influence of Cooking Activities on the Introduction of Healthy Food for Early Childhood Education. HealthSmart: Jurnal Kesehatan Masyarakat, 1(1), 14–26. https://doi.org/10.64146/1JS56E90

Fadillah, & Suryadi, D. (2025). The Relationship Between Parenting Patterns and Balanced Nutritional Intake with Nutritional Status of Young Children. HealthSmart: Jurnal Kesehatan Masyarakat, 1(1), 52–65. https://doi.org/10.64146/7G6T1B06

Gunnal, G., Bagaria, D., & Roy, S. (2024). Regional patterns in minimum diet diversity failure and associated factors among children aged 6–23 months in India. *The National Medical Journal of India*, *37*(4), 181–190. https://doi.org/10.25259/NMJI_241_2023

Halli, S. S., Biradar, R. A., & Prasad, J. B. (2022). Low birth weight as a differentiating risk factor for stunting among preschool children in India. International Journal of Environmental Research and Public Health, 19(7), 3751. https://doi.org/10.3390/ijerph19073751

Harjadinta, & Susanty, Y. E. (2025). The Role of Fast-Food Consumption Patterns in The Incidence of Obesity in Adolescents. HealthSmart: Jurnal Kesehatan Masyarakat, 1(1), 66–77. https://doi.org/10.64146/0GR58S35

Ihsan, H., Anggraini, W., & Yanuarti, R. (2026). Influence Educational Module on Stunting Prevention and Level of Knowledge of Maternal Behavior in the First 1000 Days of Life for Recipients of the Family Hope Program. HealthSmart: Jurnal Kesehatan Masyarakat, 2(1). https://doi.org/10.64146/1TZBH515

International Institute for Population Sciences (IIPS), & ICF. (2021). National Family Health Survey (NFHS-5), 2019–21: India, Volume I. http://rchiips.org/nfhs/nfhs5.shtml https://doi.org/10.2139/ssrn.5230068

Jain, L., Pradhan, S., Aggarwal, A., Padhi, B. K., Itumalla, R., Khatib, M. N., Gaidhane, S., Zahiruddin, Q. S., Santos, C. A. G., Al-Mugheed, K., Alrahbeni, T., Kukreti, N., Satapathy, P., Rustagi, S., Heidler, P., & Marzo, R. R. (2024). Association of child growth failure indicators with household sanitation practices in India (1998–2021): Spatiotemporal observational study. JMIR Public Health and Surveillance, 10, e41567. https://doi.org/10.2196/41567

Karlsson, O., Kim, R., Sarwal, R., James, K. S., & Subramanian, S. V. (2021). Trends in underweight, stunting, and wasting prevalence and inequality among children under three in Indian states, 1993–2016. Scientific Reports, 11, 14137. https://doi.org/10.1038/s41598-021-93493-1

Khan, J., & Mohanty, S. K. (2024). Poverty induced inequality in nutrition among children born during 2010–2021 in India. PLOS ONE, 19(11), e0313596. https://doi.org/10.1371/journal.pone.0313596

Khura, B., Mohanty, P., Gandhi, A. P., Patnaik, L., Mewara, A., Pradhan, K. B., & Padhi, B. K. (2023). Mapping concurrent wasting and stunting among children under five in India: A multilevel analysis. International Journal of Public Health, 68, 1605654. https://doi.org/10.3389/ijph.2023.1605654

Kumar, R. P., Selvamani, Y., & Singh, H. (2025). Integrated Child Development Services (ICDS) and their contribution to improving complementary feeding practices among children aged 6–23 months in India: Insights from a nationally representative survey. BMC Public Health, 25(1). https://doi.org/10.1186/s12889-025-25884-2

Kundu, R. N., Chatterjee, A., Bharati, S., Pal, M., Hossain, M. G., & Bharati, P. (2024). Zonal distribution and determinants of stunting, wasting, underweight, and thinness among the Indian under-five children: Findings from NFHS-5. In M. Pal, M. G. Hossain, R. A. Mahumud, & P. Bharati (Eds.), *Public health and nutrition*. Springer. https://doi.org/10.1007/978-981-97-7890-4_6

Kundu, R. N., Gautam, R. K., Chatterjee, A., Bharati, P., Liczbińska, G., & Malina, R. M. (2024). Nutritional status of infants and young children in India across three decades: Analysis of five national family health surveys. European Journal of Clinical Nutrition, 78(7), 591–606. https://doi.org/10.1038/s41430-024-01427-7

Petrikova, I. (2022). The role of complementary feeding in India's high child malnutrition rates: Findings from a comprehensive analysis of NFHS-IV (2015–2016) data. Food Security, 14(1), 39–66. https://doi.org/10.1007/s12571-021-01202-7

Rai, R. K., Kumar, S. S., & Kumar, C. (2022). Factors associated with minimum dietary diversity failure among Indian children. Journal of Nutritional Science, 11, e4. https://doi.org/10.1017/jns.2022.2

Ramasubramani, P., Krishnamoorthy, Y., & Rajaa, S. (2024). Prevalence and socio-demographic factors associated with double and triple burden of malnutrition among mother–child pairs in India: Findings from a nationally representative survey (NFHS-5). Heliyon, 10(18), e37794. https://doi.org/10.1016/j.heliyon.2024.e37794

Rao, N., Bala, M., Ranganathan, N., Anand, U., Dhingra, S., Costa, J. C., Menon, P., & Avula, R. (2023). Trends in the prevalence and social determinants of stunting in India, 2005–2021: Findings from three rounds of the National Family Health Survey. BMJ Nutrition, Prevention & Health, 6(2), 357–366. https://doi.org/10.1136/bmjnph-2023-000648

Riazi, S., Ghavami, V., Sobhani, S. R., Alinezhad-Namaghi, M., & Eslami, S. (2024). The effect of nutrition education based on the Health Belief Model (HBM) on food intake in pregnant Afghan immigrant women: A semi-experimental study. BMC Pregnancy and Childbirth, 24, 700. https://doi.org/10.1186/s12884-024-06728-0

Saha, J., Chouhan, P., Malik, N. I., Ghosh, T., Das, P., Shahid, M., Ahmed, F., & Tang, K. (2022). Effects of dietary diversity on growth outcomes of children aged 6 to 23 months in India: results from the National Health and Family Survey. Nutrients, 15(1), 159. https://doi.org/10.3390/nu15010159

Saha, J., Chouhan, P., Malik, N. I., Ghosh, T., Das, P., Shahid, M., Ahmed, F., & Tang, K. (2023). Effects of dietary diversity on growth outcomes of children aged 6 to 23 months in India: Evidence from National Family and Health Survey. Nutrients, 15(1), 159. https://doi.org/10.3390/nu15010159

Sharma, D., Vijin, P. P., Goyal, R., Hadi, S. U., & Kumar, R. (2025). Unveiling subgroup trends of stunting and wasting in Indian children: A serial cross-sectional analysis from National Family Health Surveys 3–5. *The American Journal of Clinical Nutrition*. https://doi.org/10.1016/j.ajcnut.2025.01.027

Singh, K. J., Chiero, V., Kriina, M., Alee, N. T., & Chauhan, K. (2022). Identifying the trend of persistent cluster of stunting, wasting, and underweight among children under five years in northeastern states of India. Clinical Epidemiology and Global Health, 18, 101158. https://doi.org/10.1016/j.cegh.2022.101158

UNICEF, WHO, & World Bank. (2023). Levels and trends in child malnutrition: UNICEF/WHO/World Bank Group joint child malnutrition estimates Key findings of the 2023 edition. https://data.unicef.org/resources/jme-report-2023/

World Health Organization. (2023). WHO guideline for complementary feeding of infants and young children 6–23 months of age. https://www.who.int/publications/i/item/9789240081864 https://doi.org/10.1093/nutrit/nuaa143

https://doi.org/10.64146/tbtkkt69