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## Research Article

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# Socioeconomic inequality of child nutrition in northeast India using cross-sectional data

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## Abstract

**Background:** Child undernutrition remains a major public health challenge in India despite sustained economic growth. The northeastern region, characterized by diverse socio-cultural settings, difficult terrain, and unequal access to health services, continues to experience substantial nutritional disparities. Evidence on long-term trends and socioeconomic inequalities in child undernutrition across the eight northeastern states remains limited. This study assessed the trends, determinants, and socioeconomic inequalities in undernutrition among children aged under five years in northeastern India.

**Methods:** Data from successive rounds of the National Family Health Survey (NFHS-1 to NFHS-5; 1992–93 to 2019–21) were analysed. Stunting, wasting, and underweight were defined according to the WHO Child Growth Standards. Descriptive analyses and chi-square tests examined temporal and state-level variations. Multivariable logistic regression identified maternal, child, household, and healthcare-related determinants of undernutrition. Socioeconomic inequalities were assessed using concentration curves and concentration indices based on household wealth and maternal education.

**Results:** Although modest improvements were observed over time, child undernutrition remained substantial across northeastern India with pronounced inter-state variation. During 2019–21, stunting ranged from 22% in Sikkim to 46% in Meghalaya, wasting from 10% to 21%, and underweight from 13% to 35%. Maternal underweight was the strongest predictor of undernutrition, increasing the odds of stunting (OR = 1.377; 95%CI: [1.261,1.503],  $p < 0.001$ ) and underweight (OR = 1.626; 95%CI: [1.489,1.775],  $p < 0.001$ ), whereas maternal overweight/obesity was associated with significantly lower odds of all three nutritional outcomes. Higher birth order, lower maternal education, and household poverty independently increased the likelihood of undernutrition; children from the richest households had substantially lower odds of stunting than those from the poorest (OR = 0.467; 95%CI: [0.373,0.584],  $p < 0.001$ ). Concentration indices demonstrated marked pro-poor inequalities for stunting and underweight, while wealth-related disparities in wasting were comparatively weaker and less consistent across states.

**Conclusion:** Child undernutrition in northeastern India remains unequally distributed, driven by maternal nutritional status, socioeconomic disadvantage, and considerable inter-state heterogeneity. Integrated, equity-oriented, and state-specific nutrition strategies that prioritize maternal nutrition, education, and poverty reduction are essential to accelerate progress toward achieving the Sustainable Development Goals and reducing regional health inequalities.

**Keywords:** Undernutrition, Northeastern states, NFHS, India, Inequality

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## **Introduction**

Child undernutrition remains one of the most pressing public health challenges worldwide despite substantial improvements in economic development and healthcare. According to the Joint Child Malnutrition Estimates by UNICEF, WHO, and the World Bank, approximately 150 million children under five are stunted and 43 million experience wasting, underscoring chronic and acute forms of undernutrition that threaten child survival and development (1). While global underweight rates have declined, undernutrition remains widespread, with the highest burdens concentrated in South Asia and Sub-Saharan Africa(2). Asia bears a disproportionate share of this burden, accounting for nearly 70% of children affected by wasting globally (3). Malnutrition contributes to approximately five million deaths among children under five each year, with India accounting for a substantial proportion of these preventable deaths (4). More recent estimates indicate that, in 2020, 22% of children under five years globally were stunted and 6.7% were wasted, with Asia remaining the epicentre of childhood undernutrition(5). In India, undernutrition continues to represent a major public health concern, contributing to nearly 45% of deaths among children under five years (6). Findings from the National Family Health Survey (NFHS-5) further demonstrate that 36% of children under five are stunted, 19% are wasted, and 32% are underweight (7). Low birth weight further increases the risk of undernutrition and child mortality(8), while persistent malnutrition adversely affects cognitive development, educational attainment, and long-term human capital formation (9).

Recognizing the profound health and socioeconomic consequences of undernutrition, the United Nations incorporated improved nutrition and reduced inequalities into the Sustainable Development Goals (SDGs), including SDG 10.2(8). Similarly, the World Health Organization established the Global Nutrition Targets, aiming to reduce childhood stunting by 40% and lower wasting to below 5% by 2025 (10). In response, the Government of India launched POSHAN Abhiyaan in 2018, intending to achieve a "Malnutrition-Free India" through annual reductions in childhood stunting and underweight (11). Although measurable progress has been achieved, improvements remain modest, with reductions of only about three percentage points in stunting and four percentage points in underweight between NFHS-4 and NFHS-5, indicating that substantial challenges persist (11,12).

68

69 A considerable body of research has documented a strong socioeconomic gradient in  
70 child undernutrition in India, consistently demonstrating that children from  
71 socioeconomically disadvantaged households experience disproportionately higher  
72 risks of stunting, wasting, and underweight(13). These anthropometric indicators  
73 remain the internationally accepted measures for assessing childhood nutritional  
74 status(14). However, socioeconomic inequalities cannot be adequately understood  
75 through household wealth alone. Educational attainment, maternal characteristics,  
76 healthcare utilization, and regional context interact with economic conditions to shape  
77 nutritional outcomes, and national-level analyses frequently mask important  
78 subnational heterogeneity(13).

79

80 Despite sustained economic growth, India continues to experience persistently high  
81 levels of childhood undernutrition, reflecting deep-rooted structural inequalities that  
82 extend beyond income deprivation(15). These inequalities are particularly evident in  
83 the northeastern region, comprising Assam, Arunachal Pradesh, Manipur, Meghalaya,  
84 Mizoram, Nagaland, Sikkim, and Tripura. The region is characterized by difficult  
85 terrain, dispersed populations, ethnic diversity, limited transport connectivity, and  
86 uneven access to healthcare services, all of which influence maternal and child health  
87 outcomes(16). These distinctive demographic, geographic, and socio-cultural  
88 characteristics make the Northeast fundamentally different from most other regions of  
89 India and warrant separate investigation.

90

91 Previous studies have documented substantial nutritional deprivation within individual  
92 northeastern states. In Assam, the prevalence of stunting, wasting, and underweight  
93 has been reported at 36.4%, 15.5%, and 30.2%, respectively(17). Similarly, children  
94 in Manipur experience high levels of undernutrition, with corresponding prevalence  
95 estimates of 32.4%, 12.9%, and 32.7%(18). Recent NFHS-5 findings further reveal  
96 considerable variation across northeastern states, with Meghalaya and Assam  
97 reporting among the highest levels of childhood undernutrition nationally, whereas  
98 Sikkim demonstrates comparatively favourable nutritional outcomes(12). Such  
99 disparities underscore substantial intra-regional heterogeneity that is often obscured  
100 in national analyses (19).

101

Although previous research has identified several determinants of child undernutrition, relatively few studies have comprehensively examined long-term trends, socioeconomic inequalities, and maternal determinants simultaneously across all eight northeastern states. Most existing studies either focus on individual states or present national estimates that overlook the region's considerable diversity. Consequently, the extent to which socioeconomic disadvantage, maternal characteristics, and healthcare factors contribute to interstate disparities in child nutrition remains insufficiently understood.

Generating region-specific evidence is particularly important because effective policy interventions require an understanding of how nutritional inequalities differ across local contexts. The northeastern states face unique developmental constraints, including geographical isolation, limited health infrastructure, and varying cultural practices, which may modify the effects of socioeconomic and maternal determinants on child nutrition(20). Identifying these context-specific patterns is essential for designing equitable and targeted interventions, improving resource allocation, and reducing persistent nutritional inequalities across the region.

Against this background, the present study investigates the trends, socioeconomic inequalities, and determinants of child undernutrition among children under five years of age across the eight northeastern states of India using nationally representative NFHS data. By integrating temporal trend analysis, multivariable modelling, and inequality assessment, this study provides a comprehensive regional evidence base to inform equity-oriented nutrition policies and support progress towards achieving India's nutrition goals and the WHO Global Nutrition Targets(10).

## **Methods and Materials**

### **Data Source**

The study used data from NFHS surveys. To determine the trends in nutritional status, we used data from the NFHS1 (conducted in 1992-93) to NFHS5 (conducted in 2019-21) rounds. To assess the determinants associated with nutritional status, we concentrated only on five rounds of NFHS data, which included information for all states and union territories of India. The NFHS is a large-scale, cross-sectional, multi-round survey. The NFHS5 provides state-, district-, and national-level estimates of demographic and health variables as well as data on various socioeconomic

dimensions, which are critical for implementing appropriate changes in demographic and health parameters. Both rural and urban populations were covered through a stratified two-stage sampling framework. In rural areas, villages formed the first-stage units and were selected with probability proportional to their population size, after which 22 households were drawn at random within each chosen village at the second stage. Urban sampling mirrored this design, with Census Enumeration Blocks (CEBs) serving as the first-stage units and 22 households then selected at random from every selected block. The details about the sampling and data collection methodology can be found in a previous report (12).

## **Methodology**

### **Anthropometric indices**

Child malnutrition, measured by stunting, wasting, and underweight status, was considered the dependent variable for this study. There are various means of measuring the nutritional status of children and anthropometric indices, but weight-for-height, height-for-age, and weight-for-age are the most effective measures of undernutrition in children in terms of growth status. All these indices provide different information about the nutritional status of children. The World Health Organization's (1995) interpretation of those indices is as follows: Height-for-age captures stunting, a deficit in linear growth that emerges under prolonged or suboptimal nutritional conditions and is therefore read as a marker of chronic undernutrition. Weight-for-height, in contrast, identifies wasting or thinness, which in most cases signals a rapid and recent process of weight loss associated with acute food shortage or severe illness. This index is a relative measure of body mass and body weight, primarily reflecting chronic undernutrition. Wasting can be defined as the percentage of children whose weight-for-height is less than -2 SD below the median. A healthy child gains 2 to 3 kilograms each year, which runs the risk of wasting. This may be because of less nutritional food intake (21). In northeast India, more than 8% of children under age five experience moderate wasting, and more than 6% are severely wasting (less than -3 SD). This is more than the acceptable range of less than 5% (22) as defined by the World Health Organization. Weight-for-age (underweight) expresses a child's body mass in relation to their age. Because it is shaped by both height and weight, it is commonly treated as a composite indicator that draws on the two preceding measures and captures elements of both chronic and acute malnutrition.

## **Covariates**

Several sociodemographic factors contribute to differences in child malnutrition. This study is based on the review of the determinants of child malnutrition highlighted in the introduction section and considers the relevance in the context of NE India. The study divided the predictors into four groups. 1) Maternal factors 2) Socioeconomic factors 3) Child-related factors 4) Health-seeking factors. Maternal factors included age (15–20, 21–24, 25–29 and 30–49 years), age at first birth (< 18, 18–30, and > 30 years), birth order (1, 2, 3, 4+) and maternal BMI status (normal, underweight and obese). Socioeconomic factors include religion (Hindu, Muslim, Christian, and Others), caste (SC, ST, and Others), wealth status (Poorest, Poorer, Middle, Richer, and Richest), mother's education (No education, Primary, Secondary, Higher), type of place of residence (Urban and Rural), and no media access (Yes, and No). Child factors include age (0–23, 24–47 months, and 47–59 months) and the sex of the child (male or female). Health-seeking factors included the place of delivery (home or institution), distance to a health facility (no problem, some problem, or a large problem), and transportation problems related to seeking medical help (no problem, some problem, or a large problem). The categorisation of covariates follows groupings that are standard in NFHS-based child nutrition studies in India. The child age brackets (0–23, 24–47, and 47–59 months) capture the distinct growth phases in which undernutrition risk is highest during the first two years of life and then plateaus, and are consistent with the age groupings used in the NFHS and prior Indian nutrition analyses (8,13). Similarly, the categories for maternal age, birth order, maternal BMI, wealth quintiles, and maternal education correspond to the standard classifications adopted in NFHS reports and comparable studies of child undernutrition in India (6,12,16).

## **Statistical analysis**

The WHO Child Growth Standards provide the universally accepted anthropometric benchmarks (Z-scores) for diagnosing undernutrition and are used throughout this study (23). However, no single anthropometric indicator fully captures the diverse dimensions and functional consequences of malnutrition. Different measures: stunting, wasting, and underweight reflect distinct aspects and durations of nutritional deprivation, and some relate more closely to body composition and clinical outcomes than others. We therefore assess all three indicators to provide a comprehensive picture of child undernutrition in the region.

For the calculation of stunting, wasting, and underweight in children under five years, we categorized children whose Z scores were less than -2 SDs as "1-yes" and "0-no" otherwise. A chi-square test was carried out to test the associations among the variables, and further logistic regression analysis was performed by adjusting for different socioeconomic and demographic characteristics. The logistic regression estimates are presented with odds ratios (ORs) and their significance levels and corresponding 95% confidence intervals (CIs). Additionally, to address the inequality aspect, the concentration curve and concentration index were used to assess and measure the degree of socioeconomic imbalance in the geographical regions of Northeast India.

### ***Logistic regression model***

Logistic regression is a statistical model used to estimate the effect of factors when we have a categorical response. In this study,  $Y_{1i}$ ,  $Y_{2i}$ , and  $Y_{3i}$  were binary responses of stunting, underweight, and wasting of the  $i^{th}$  under-five children, respectively. For binary response  $Y_{ji}$  and a vector of explanatory variables  $X$ , the logistic regression model is given by

$$\pi_j(X) = \frac{e^{\beta_j0 + \beta_j1\chi_1 + \beta_j2\chi_2 + \dots + \beta_jp\chi_p}}{1 + e^{\beta_j0 + \beta_j1\chi_1 + \beta_j2\chi_2 + \dots + \beta_jp\chi_p}} = \frac{e^{X\beta_j}}{1 + e^{X\beta_j}} \quad j = 1, 2, 3 \quad (1)$$

where  $\pi_j(X) = P(Y_{ji} = 1|X)$ , the probability of the  $i^{th}$  child being stunted ( $Y_{1i}$ ), underweight ( $Y_{2i}$ ) and/or wasting ( $Y_{3i}$ ) given other covariates  $X$ .

Equivalently, the logit (log odds) that manifests a linear relationship with explanatory variables can be expressed as:

$$\text{logit}[\pi_j(X)] = \text{logit}[P(Y_{ji} = 1|X)] = \beta_j0 + \beta_j1x_1 + \beta_j2x_2 + \dots + \beta_jpx_p = X\beta_j \quad (2)$$

In the logistic regression model, the null hypothesis ( $H_0: \beta = 0$ ) states that the probabilities of success are independent of covariate  $X$ . The significance of each covariate is detected using the Wald test statistic given by  $\beta/se(\beta)$ , which has a standard normal distribution for large samples. According to the logistic regression model, the most common type of association between categorical variables was the odds ratio. It is the ratio of odds defined as

$$OR_j = Odds_j1 / Odds_j2 = \pi_j(X1) / (1 - \pi_j(X1)) \pi_j(X2) / (1 - \pi_j(X2)) \quad (3)$$

An odds ratio that departs or varies from 1 indicates less dependency between the two categorical variables.

To perform separate analyses of stunting, underweight, and wasting of under-five children, applying ordinary logistic regression is sufficient. However, doing so would ignore the dependency between the three anthropometric indicators. To address this and account for the correlation between the anthropometric indicators and the effects of other covariates, multivariable logistic regression is a more plausible alternative. Multivariable logistic regression was chosen because our primary aim was to model the correlation between the three anthropometric outcomes while adjusting for shared covariates, making it well suited to capturing their interdependence. This statistical model serves to model two or more categorical outcomes of interest at a time and assess their association given that of other covariates. It enables the modelling of the marginal probabilities as a function of a set of child and household characteristics and, at the same time, accounts for the correlation among the three anthropometric indicators. The data were analysed using STATA software version 17.

### ***Concentration index (CI)***

The concentration curve is obtained by plotting the cumulative proportion of outcome variables (either stunting, underweight, or wasting) on the y-axis against the increasing percentage of the population ranked by the socioeconomic indicator (wealth index) on the x-axis. The curves show whether the socioeconomic status-related inequality in the outcome variable (on the x-axis) prevails. If the curve is above the line of equality (45-degree line), the index value is negative; hence, the outcome variable is disproportionately concentrated among the poor and vice versa. Income-related inequality in stunting, underweight, and wasting was measured by the concentration index (CI) and the concentration curve (CC), using the wealth score as the socioeconomic indicator and binary outcomes as stunting, underweight, and wasting, respectively. Numerically, the index corresponds to twice the area lying between the concentration curve and the diagonal line of equality, and it summarises how a given outcome is distributed across children ranked by household wealth. Its values fall between -1 and +1, with zero denoting the absence of wealth-related inequality; positive values point to an outcome concentrated among richer households (pro-rich), while negative values indicate concentration among poorer households. Additionally, on either scale, the greater the value, the greater the extent of socioeconomic

inequality. This study used the Wagstaff criteria to normalize concentration indices for bounded variables, as well as distributionally sensitive extended and symmetric concentration indices.

Equivalently, the index can be written as twice the covariance between an individual child's health outcome (for instance, stunting) and that child's rank in the socioeconomic distribution, scaled by the mean of the health outcome ( $\mu$ ):  $CI = \frac{2}{\mu} (Cov(y_i, r_i))$

This is a widely used measure because it ranks individuals across SESs, is sensitive to changes in population distribution across SESs, and can assess relative and absolute socioeconomic inequality.

## Results

### *Change in the prevalence of undernutrition from 1992-93 to 2019-21*

Figures 1-3 show the change in the prevalence of nutritional status according to three anthropometric measures of children aged 5 years in northeastern India. Over the last three decades, the prevalence of stunting has decreased in all eight states. In 2019-2021, its prevalence ranged from a minimum of 22.3% to a maximum of 46.5%. With a significant increase since the previous round, Meghalaya has the highest prevalence of stunting among children under the age of five. Moreover, with a prevalence of 35%, Assam has a comparatively higher prevalence. Sikkim exhibits the lowest prevalence of stunting among the northeastern states, at a relatively low 22%.

In addition to stunting, wasting also plays a significant role in determining the level of undernutrition in a region. Its prevalence in 2019-21 ranged from a minimum of 9.8% to a maximum of 21%. The level of wasting for Mizoram, Manipur, Tripura, Nagaland, and Assam increased over time. In 2015-16, Mizoram had a prevalence of wasting at 6.1%, and Arunachal Pradesh had the highest prevalence of wasting, at 17.3%.

The prevalence of underweight among children under the age of five is highest in Assam, and it has increased significantly since the previous round. Meghalaya and Nagaland each have a comparatively higher prevalence of approximately 27%. Among

the northeastern states, Mizoram has the lowest prevalence of underweight, at a mere 12.7% per NFHS 5.

**Fig. 1 Prevalence of stunting by north-eastern states, NFHS 1 to NFHS 5**

**Fig. 2 Prevalence of wasting by north-eastern states, NFHS 1 to NFHS 5**

**Fig. 3 Prevalence of underweight by north-eastern states, NFHS 1 to NFHS 5**

***Distribution of three anthropometric undernutrition indicators by the selected background characteristics of the Northeastern states of India***

Table 1 presents the prevalence of stunting in children under five years of age across eight northeastern states in India by different background characteristics obtained from the NFHS-5 data. The prevalence of stunting concerning maternal age, age at first birth, birth order, body mass index (BMI), mother's education, and type of place of residence was examined. In general, the prevalence of stunting is higher among children born to younger mothers, particularly those who have their first child at a younger age, have higher birth orders, lower BMI, lower levels of education, and reside in rural areas. The study explored the prevalence of stunting in terms of religion, caste, wealth index, and type of place of residence. The prevalence of stunting varies significantly across different religious and caste groups, with higher rates among certain groups, such as SC and ST. It also varies based on economic status, with a greater prevalence among poorer and poorest sections. The prevalence of stunting concerning the child's age in months and sex is also shown. The prevalence of stunting was relatively greater among younger children (0-23 months) than among older children (47-59 months). There was a slight difference in the prevalence between male and female children, with slightly higher rates among males. The analysis revealed that the prevalence of stunting concerned the place of delivery, the distance to the health facility, and transportation problems related to medical help. Compared with those born through institutional delivery, children born through home delivery have a greater prevalence of stunting. Accessibility issues to health facilities and transportation problems also impact stunting prevalence, with higher rates observed where these issues are more significant. Overall, the table provides detailed insight into the various factors associated with stunting prevalence among children under five

years in the northeastern states of India, highlighting the complex interplay of socioeconomic, maternal, child-related, and health-seeking factors.

**[Table 1 is about here]**

Table 2 presents the prevalence of wasting among children under five in the northeastern states, derived from the NFHS-5 dataset, showing how wasting rates vary across background characteristics. Key findings include higher wasting rates among children of older mothers, those with early first births, and firstborns. Additionally, children of underweight or normal-weight mothers tend to exhibit greater wasting rates than those of obese mothers. Socioeconomic disparities manifest in varied wasting rates across religious, caste, wealth, and educational categories, with Muslim children and those from wealthier, more educated households demonstrating lower rates. Rural areas consistently reported a greater waste prevalence than did their urban counterparts. Moreover, children with regular media access and those born in institutional settings tend to have lower wasting rates, while proximity to health facilities is associated with reduced wasting prevalence.

**[Table 2 is about here]**

Table 3 shows the prevalence of underweight among children under five years across various background characteristics in the northeastern states of India. Maternal factors, including age, age at first birth, birth order, and BMI, revealed significant variations in underweight prevalence. Younger mothers and those with higher birth orders tend to have higher rates of underweight children. Socioeconomic factors such as religious affiliation, caste, wealth index, mother's education, and type of residence also influence the prevalence of underweight. Children from economically disadvantaged backgrounds and mothers lacking formal education are more likely to be underweight. Child-related factors such as age and sex, along with health-seeking factors such as place of delivery and accessibility to health facilities, play crucial roles in the prevalence of underweight. Children who delivered at home or who resided farther from health facilities were more likely to be underweight.

**[Table 3 is about here]**

## ***Determinants associated with stunting, wasting, and underweight among under-five children in northeast India***

Table 4 provides the results of a multivariable logistic regression analysis examining the association between various factors and three anthropometric measures of undernutrition among children in northeastern India from 2019 to 2021: stunting, wasting, and underweight. The table includes odds ratios (ORs) and 95% confidence intervals (CIs) for each factor, along with p values indicating the significance of the associations.

### **Maternal Factors**

The maternal factors provide critical insights into their influence on childhood malnutrition in northeastern India. The mother's age did not show any statistically significant differences in the likelihood of stunting, wasting, or underweight across different age groups when compared to the reference group of mothers aged 30-49 years. However, the mother's age at first birth is significantly associated with the risk of stunting and wasting in children. Mothers who had their first child at ages 30-49 had lower odds of stunting in their children (OR = 0.853, 95% CI [0.744, 0.979],  $p < .01$ ) compared to those who gave birth before the age of 20. Conversely, mothers who had their first child between the ages of 21-24 were more likely to have wasted children (OR = 1.099, 95% CI [1.005, 1.201],  $p < .01$ ).

Birth order also played a significant role, with children of higher birth orders facing greater risks of stunting and underweight. Specifically, third-order children had increased odds of stunting (OR = 1.115, 95% CI [1.017, 1.222],  $p < .01$ ) and underweight (OR = 1.2, 95% CI [1.089, 1.322],  $p < .001$ ), while children of even higher birth orders had similarly elevated odds of both stunting (OR = 1.216, 95% CI [1.101, 1.343],  $p < .001$ ) and underweight (OR = 1.21, 95% CI [1.089, 1.345],  $p < .001$ ), compared to firstborns.

Maternal BMI was a strong predictor of child malnutrition. Underweight mothers had significantly higher odds of having children who were stunted (OR = 1.377, 95% CI [1.261, 1.503],  $p < .001$ ), wasted (OR = 1.241, 95% CI [1.11, 1.387],  $p < .001$ ), and underweight (OR = 1.626, 95% CI [1.489, 1.775],  $p < .001$ ) compared to mothers with normal BMI. In contrast, obese mothers exhibited protective effects, with lower odds of stunting (OR = 0.918, 95% CI [0.846, 0.996],  $p < .01$ ), wasting (OR = 0.729, 95%

CI [0.65, 0.818],  $p < .001$ ), and underweight (OR = 0.775, 95% CI [0.708, 0.847],  $p < .001$ ) among their children compared to mothers with normal BMI.

### **Socioeconomic Factors**

The analysis of socioeconomic factors reveals significant associations between household wealth, maternal education, and childhood malnutrition in northeastern India. Children from wealthier households exhibited considerably lower odds of stunting, wasting, and being underweight compared to those from the poorest households. Specifically, children from the richest households had the lowest odds of stunting (OR = 0.467, 95% CI [0.373, 0.584],  $p < .001$ ) and underweight (OR = 0.501, 95% CI [0.392, 0.641],  $p < .001$ ), suggesting that economic status plays a protective role against malnutrition. However, the association between household wealth and wasting was not statistically significant for the richest households (OR = 1.023, 95% CI [0.782, 1.338]).

Maternal education also emerged as a strong predictor of improved child nutritional outcomes. Mothers with higher levels of education were significantly less likely to have stunted or underweight children compared to mothers with no education. Secondary education reduced the odds of stunting (OR = 0.86, 95% CI [0.791, 0.936],  $p < .001$ ) and underweight (OR = 0.872, 95% CI [0.799, 0.953],  $p < .001$ ), while mothers with higher education experienced even greater reductions in the odds of stunting (OR = 0.736, 95% CI [0.633, 0.857],  $p < .001$ ) and underweight (OR = 0.67, 95% CI [0.569, 0.79],  $p < .001$ ).

### **Child-Related Factors**

The analysis reveals notable age and gender differences in the odds of stunting, wasting, and being underweight among children in northeastern India. Older children (aged 24-47 months and 47-59 months) exhibited significantly higher odds of stunting and being underweight compared to children aged 0-23 months. Specifically, children aged 24-47 months had higher odds of stunting (OR = 1.188, 95% CI [1.114, 1.267],  $p < .001$ ) and underweight (OR = 1.566, 95% CI [1.463, 1.675],  $p < .001$ ), while those aged 47-59 months showed even greater odds of stunting (OR = 1.477, 95% CI [1.371, 1.591],  $p < .001$ ) and underweight (OR = 1.405, 95% CI [1.297, 1.523],  $p < .001$ ). However, older children (aged 47-59 months) had significantly lower odds of wasting (OR = 0.733, 95% CI [0.661, 0.814],  $p < .001$ ) compared to younger children (0-23

months). In terms of gender, female children were found to have lower odds of stunting (OR = 0.916, 95% CI [0.867, 0.968],  $p < .001$ ) and wasting (OR = 0.903, 95% CI [0.838, 0.972],  $p < .001$ ) compared to male children, indicating that boys are more likely to experience these forms of malnutrition. However, there was no significant difference between female and male children in terms of underweight status. These findings suggest that both age and gender play important roles in influencing nutritional outcomes, with older children and male children being more vulnerable to certain forms of malnutrition.

### **Health-Seeking Factors**

The analysis of health-seeking factors indicates that institutional deliveries are linked to lower odds of stunting compared to home deliveries (OR = 0.923, 95% CI [0.861, 0.99],  $p < .01$ ), suggesting the importance of professional healthcare during childbirth in reducing malnutrition. Additionally, transportation difficulties in accessing medical care significantly increased the odds of wasting (OR = 1.188, 95% CI [1.011, 1.396],  $p < .01$ ) and being underweight (OR = 1.111, 95% CI [1.003, 1.232],  $p < .01$ ), highlighting the critical role that access to healthcare services plays in preventing child malnutrition.

### **Regional Differences**

The regional analysis reveals significant disparities in child malnutrition across northeastern states. Children from Meghalaya had the highest odds of stunting (OR = 1.936, 95% CI [1.496, 2.505],  $p < .001$ ) and being underweight (OR = 2.443, 95% CI [1.802, 3.313],  $p < .001$ ) compared to those from Arunachal Pradesh. Similarly, Tripura and Assam displayed higher odds of stunting, wasting, and underweight, while Nagaland also showed elevated odds for underweight. These findings emphasize the need for region-specific interventions to address malnutrition in the most affected states.

**[Table 4 is about here]**

***Inequality in undernutrition among the northeastern region by wealth and maternal education***

The concentration index (CI) is also widely used and pervasive to reflect the concentration of inequality. The convention is that the index value takes a negative sign when the curve lies above the line of equality, indicating the disproportionate concentration of the health variable among the poor. Here, for all the indicators, the generated sign is negative for stunting, wasting, and underweight, reflecting the concentration of high undernutrition among poor children whose mothers are less educated.

Table 5 presents the concentration index values for three anthropometric indicators of undernutrition (stunting, wasting, and underweight) across the northeastern states of India, categorized by wealth and mother's education. The results show that in the case of Stunting, negative CI values indicate a concentration of stunting among children from households with lower wealth or mothers with lower education levels. Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, and Assam all show negative CI values for stunting, indicating varying degrees of inequality favouring children from wealthier households or mothers with higher education.

Similar to stunting, negative CI values for wasting suggest a concentration of wasting among children from households with lower wealth or mothers with lower education levels. However, the magnitude of inequality varies across states, with Manipur, Tripura, Mizoram, Nagaland, and Assam exhibiting more pronounced inequalities in waste than other states.

The negative CI values for underweight also signify a concentration of underweight children among those from households with lower wealth or mothers with lower education levels. Again, Manipur, Tripura, Mizoram, Nagaland, and Assam display significant inequalities in underweight, indicating a greater prevalence of underweight children from disadvantaged socioeconomic backgrounds.

Overall, the table indicates a consistent pattern of socioeconomic inequality in childhood malnutrition across the northeastern states of India. Children from households with lower wealth or mothers with lower education levels are disproportionately affected by stunting, wasting, and underweight, highlighting the need for targeted interventions to address underlying disparities and improve nutritional outcomes in the region.

518

519 The concentration curves displayed in Figure 4(a-b) illustrate the relationships  
520 between stunting among children under five years old and two socioeconomic  
521 indicators - mother's education and household wealth - in northeastern India from 2019  
522 to 2021. The first panel shows the cumulative share of stunted children plotted against  
523 the cumulative share of mothers' education. The concentration curve ( $L(p)$ ) lies above  
524 the line of equality (the 45-degree line), indicating that stunting is more concentrated  
525 among children whose mothers have lower levels of education. The gray area  
526 represents the 95% confidence interval. The second panel displays the cumulative  
527 share of stunted children against the cumulative share of wealth. Similar to the  
528 education curve, the wealth concentration curve lies above the line of equality,  
529 suggesting that stunting is more prevalent among poorer households. Both panels  
530 indicate that stunting is disproportionately concentrated among children from lower  
531 socioeconomic backgrounds, as evidenced by the curves lying above the line of  
532 equality. This implies that policies aimed at reducing stunting should particularly focus  
533 on improving educational and economic conditions in these disadvantaged groups.

534

535 Figure 5 (a-b) presents concentration curves that depict the cumulative share of  
536 children under-five years experiencing wasting, in relation to the cumulative share of  
537 mothers' education and wealth in northeastern India from 2019 to 2021. Both curves  
538 ( $L(p)$ ) closely follow the 45-degree line of perfect equality, indicating a relatively equal  
539 distribution of wasting across varying levels of maternal education and household  
540 wealth. For wasting, the concentration curves lie close to the line of equality, revealing  
541 a more varied socioeconomic pattern than for stunting and underweight. Several  
542 states show a distinct pro-poor concentration- most clearly Assam (wealth-based CI  
543  $-0.08$ , SE  $0.01$ ) while the gradient is more modest elsewhere. This state-level variation  
544 highlights that acute undernutrition responds to a wider range of determinants,  
545 underscoring the value of tailored, region-specific strategies. Thus, the data imply that  
546 wasting among children under five years is equally distributed regardless of maternal  
547 education level and household wealth in this region during the studied period.

548

549 Figure 6 (a-b) presents concentration curves illustrating the cumulative distribution of  
550 underweight children under five years in relation to mothers' education and household  
551 wealth. In both panels, the curves lie above the 45-degree line, indicating a greater  
552 concentration of underweight children among those with less educated mothers and

from poorer households. The 95% confidence intervals, shaded in gray, suggest statistical certainty around these estimates. These findings highlight significant socioeconomic disparities in underweight prevalence, emphasizing the need for targeted nutritional interventions and policies to address these inequities in northeastern India.

[Table 5 is about here]

**Fig. 4 Concentration curves for stunting among children under five years in north-eastern India (2019-2021)**

**Fig. 5 Concentration curves for wasting among children under five years in north-eastern India (2019-2021)**

**Fig. 6 Concentration curves for underweight among children under five years in north-eastern India (2019-2021)**

## **Discussion:**

This study examined long-term trends, determinants, and socioeconomic inequalities in undernutrition among children aged under five years across the eight northeastern states of India using nationally representative NFHS data. Despite gradual improvements over time, undernutrition remains a major public health challenge, with substantial interstate and socioeconomic disparities. The findings demonstrate that child undernutrition in the region is strongly associated with maternal nutritional status, household socioeconomic disadvantage, maternal education, and demographic characteristics. Furthermore, inequality analyses revealed that stunting and underweight remain disproportionately concentrated among socioeconomically disadvantaged households, highlighting persistent inequities in child nutrition. These findings underscore the need for equity-oriented, state-specific interventions rather than uniform regional strategies.

The observed burden of stunting, wasting, and underweight reflects the complex interaction of poverty, maternal disadvantage, limited healthcare access, and the distinctive geographical and sociocultural characteristics of northeastern India. At the same time, the region is increasingly experiencing the coexistence of undernutrition

and childhood overweight, representing a growing triple burden of malnutrition that requires integrated nutrition policies (24). State-level analyses further demonstrate that treating the Northeast as a homogeneous region obscures substantial variation in both the magnitude and determinants of undernutrition. Such heterogeneity reinforces the importance of locally tailored interventions based on state-specific epidemiological profiles.

Maternal nutritional status emerged as one of the strongest predictors of child undernutrition. Children born to underweight mothers were significantly more likely to experience stunting and underweight, whereas maternal overweight or obesity was associated with lower risks. These findings are consistent with previous evidence demonstrating the close intergenerational relationship between maternal and child nutrition(25,26). Maternal undernutrition contributes to adverse pregnancy outcomes, low birth weight, and impaired breastfeeding, thereby increasing children's vulnerability to growth failure(27). Strengthening maternal nutrition through improved antenatal and postnatal care, nutritional supplementation, and early identification of nutritionally at-risk women should therefore remain a public health priority.

Maternal education also demonstrated a consistent protective association with child nutritional status. Children whose mothers had secondary or higher education were substantially less likely to experience undernutrition than those born to mothers with no formal education. Similar findings have been reported elsewhere(28–31). Educated mothers are more likely to access health services, adopt appropriate infant and young child feeding practices, maintain better hygiene, and make informed healthcare decisions. These findings reinforce the importance of investing in girls' education and women's empowerment as long-term strategies for improving child nutrition.

Household socioeconomic status remained an important determinant of nutritional inequality. Children from poorer households experienced substantially higher risks of stunting and underweight, while concentration indices confirmed that these outcomes remain concentrated among disadvantaged populations. These findings agree with previous studies demonstrating that poverty restricts access to nutritious food, healthcare, sanitation, and other essential resources required for healthy child growth (32–35). The persistence of pro-poor inequalities indicates that economic growth alone is unlikely to eliminate nutritional disparities without targeted social protection and nutrition-sensitive interventions.

623

624 Marked interstate variation was evident throughout the northeastern region.  
625 Meghalaya and Assam continued to report among the highest levels of child  
626 undernutrition, whereas Sikkim consistently demonstrated more favourable nutritional  
627 outcomes. These differences likely reflect variation in socioeconomic development,  
628 health infrastructure, maternal characteristics, and access to basic services rather  
629 than geographic location alone. Consequently, policy responses should be adapted to  
630 local conditions instead of relying on uniform regional approaches.

631

632 The northeastern states also differ considerably in their social organisation, cultural  
633 norms, and gender relations, which may influence child nutrition through pathways  
634 that extend beyond conventional socioeconomic indicators. Evidence from India  
635 suggests that patriarchal norms influence fertility behaviour, household resource  
636 allocation, and child wellbeing(36). Conversely, studies from matrilineal Meghalaya  
637 indicate that women's ownership of household assets is associated with improved  
638 maternal nutrition and healthcare utilisation(37). Ethnographic research further  
639 demonstrates important differences in caregiving practices and gender roles between  
640 matrilineal and patrilineal communities(38). Although these mechanisms were not  
641 directly examined in the present study, they provide important contextual explanations  
642 for the observed interstate heterogeneity and should be considered when designing  
643 culturally appropriate nutrition interventions.

644

645 The findings have several important policy implications. First, interventions should  
646 prioritise maternal nutrition throughout the life course by strengthening antenatal care,  
647 nutritional supplementation, and counselling. Second, improving girls' education and  
648 women's empowerment is likely to generate sustained improvements in child nutrition.  
649 Third, programmes should prioritise socioeconomically disadvantaged households  
650 through nutrition-sensitive social protection, food security initiatives, and strengthened  
651 primary healthcare services. Existing national initiatives, including POSHAN Abhiyaan  
652 and ICDS, should be adapted to address the unique geographical and cultural  
653 contexts of the northeastern states. Community-based approaches, including nutrition  
654 gardens and locally led nutrition programmes implemented in Assam and Mizoram,  
655 represent promising models that could be expanded across the region(39–42). Finally,  
656 state-specific targets that explicitly address socioeconomic inequalities would facilitate  
657 more equitable allocation of limited public health resources.

658

659 The study has some strengths and limitations. This study used nationally  
660 representative NFHS data spanning nearly three decades, allowing comprehensive  
661 assessment of temporal trends, determinants, and socioeconomic inequalities in child  
662 undernutrition across all eight northeastern states. The large sample size and  
663 standardized anthropometric measurements enhance the reliability and  
664 generalisability of the findings. However, the cross-sectional design precludes causal  
665 inference, and residual confounding from unmeasured factors such as dietary  
666 diversity, household food security, sanitation, and local health system characteristics  
667 cannot be excluded. Despite these limitations, the study provides robust evidence to  
668 inform region-specific nutrition policies.

669

670 Future studies should employ longitudinal and multilevel approaches to establish  
671 causal pathways and examine district-level variation in child undernutrition. Evaluating  
672 the effectiveness of existing nutrition programmes and incorporating information on  
673 dietary practices, food security, and health system performance would further  
674 strengthen evidence for context-specific interventions and progress towards the  
675 Sustainable Development Goals.

676

## 677 **Conclusion**

678

679 Child undernutrition remains a significant public health challenge in northeastern India  
680 despite gradual improvements over time. Maternal nutritional status, maternal  
681 education, household socioeconomic disadvantage, and marked interstate disparities  
682 are key determinants of poor child nutritional outcomes. The persistence of pro-poor  
683 inequalities highlights the need for equity-oriented, state-specific interventions that  
684 strengthen maternal health, improve educational opportunities, and reduce  
685 socioeconomic disadvantage. Tailoring existing nutrition programmes to local contexts  
686 and prioritising vulnerable populations will be essential for accelerating progress  
687 towards national nutrition targets and the Sustainable Development Goals.

688

689

## 690 **List of Abbreviations**

691 BMI: Body Mass Index

692 CC: Concentration Curve

693 CEB: Census Enumeration Block  
694 CI: Concentration Index  
695 CDR: Crude Death Rate  
696 CBR: Crude Birth Rate  
697 IMR: Infant Mortality Rate  
698 NFHS: National Family Health Survey  
699 OR: Odds Ratio  
700 PDS: Public Distribution System  
701 POSHAN: Prime Minister's Overarching Scheme for Holistic Nutrition (Abhiyaan)  
702 PSU: Primary Sampling Unit  
703 SC: Scheduled Caste  
704 SD: Standard Deviation  
705 SDG: Sustainable Development Goal  
706 SES: Socioeconomic Status  
707 ST: Scheduled Tribe  
708 UN: United Nations  
709 UNICEF: United Nations Children's Fund  
710 WHO: World Health Organization

711

712

713 **Declaration of Generative AI and AI-assisted technologies in the writing process**

714 *During the preparation of this work, the author(s) used ChatGPT to improve the writing*  
715 *of the paper. After using this tool/service, the author(s) reviewed and edited the content*  
716 *as needed and take(s) full responsibility for the content of the publication.*

717

718

**Declarations**

**Ethics approval and consent to participate**

719 Not applicable: The study is based on data available in the public domain; therefore,  
720 no ethical issues are involved.

721

722 **Clinical trial number:** not applicable.

**Consent for publication**

Not applicable

## Availability of data and materials

All data are available publicly on the website <https://dhsprogram.com/data/available-datasets.cfm>

## Competing interests

The authors declare no competing interests in the manuscript.

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## Authors' contributions

AS contributed to Data curation, Formal analysis, Methodology, Writing – original draft, and writing – review and editing, including Stata and R analysis, interpretation of findings, and preparation and revision of the final manuscript.

VK conceived the study, analysed the data and wrote the final paper

JKB conceived the study, supervised and performed the research, analysed the data, and wrote the final paper

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851

**Table 1 Prevalence of stunting in children under five years of age by background characteristics among northeastern states, NFHS 5**

| States                            | Sikkim                                     | Arunachal Pradesh | Nagaland | Manipur | Mizoram | Tripura | Meghalaya | Assam | Sample size<br>N |
|-----------------------------------|--------------------------------------------|-------------------|----------|---------|---------|---------|-----------|-------|------------------|
|                                   | (%)                                        | (%)               | (%)      | (%)     | (%)     | (%)     | (%)       | (%)   |                  |
| <b>Maternal Factors</b>           |                                            |                   |          |         |         |         |           |       |                  |
| <b>Mother' age</b>                | <b>Pearson chi2 = 192.9628 Pr = 0.000</b>  |                   |          |         |         |         |           |       |                  |
| 15-20                             | 4.43                                       | 5.51              | 3.18     | 4.54    | 3.2     | 14.06   | 6.45      | 8.67  | 1,385            |
| 21-24                             | 17.19                                      | 16.89             | 15.55    | 14.62   | 15.11   | 24.33   | 15.95     | 25.22 | 4,019            |
| 25-29                             | 37.5                                       | 34.71             | 36.14    | 30.56   | 31.85   | 32.54   | 33.45     | 35.32 | 7,146            |
| 30-49                             | 40.89                                      | 42.89             | 45.12    | 50.28   | 49.84   | 29.07   | 44.16     | 30.79 | 8,432            |
| <b>Mother' age at first birth</b> | <b>Pearson chi2 = 408.6097 Pr = 0.000</b>  |                   |          |         |         |         |           |       |                  |
| less than 20                      | 36.1                                       | 44.6              | 35.2     | 37.7    | 42.6    | 64.1    | 58.3      | 57.9  | 4,681            |
| 21-24                             | 33                                         | 33.1              | 33.1     | 33.6    | 33.5    | 22.7    | 28.8      | 27.8  | 2,656            |
| 25-29                             | 22.7                                       | 14.6              | 22.5     | 20.3    | 17.2    | 10.7    | 10        | 11.6  | 1,202            |
| 30-49                             | 8.2                                        | 7.8               | 9.2      | 8.4     | 6.8     | 2.5     | 3         | 2.7   | 414              |
| <b>Birth order</b>                | <b>Pearson chi2 = 800.4064 Pr = 0.000</b>  |                   |          |         |         |         |           |       |                  |
| Firstborn                         | 49.5                                       | 35.6              | 30.6     | 29.2    | 29.8    | 45.7    | 22        | 39.5  | 2,918            |
| 2nd order                         | 36.1                                       | 28.3              | 27       | 27.4    | 27      | 34.9    | 21.1      | 32.6  | 2,494            |
| 3rd order                         | 6.2                                        | 17.2              | 18.7     | 17.6    | 19.6    | 12.6    | 16.3      | 15.1  | 1,453            |
| higher order                      | 8.2                                        | 18.9              | 23.7     | 25.8    | 23.6    | 6.8     | 40.6      | 12.8  | 2,088            |
| <b>Body mass index</b>            | <b>Pearson chi2 = 580.2476 Pr = 0.000</b>  |                   |          |         |         |         |           |       |                  |
| normal                            | 61.1                                       | 69                | 79.1     | 70.2    | 74.1    | 62.5    | 76.7      | 70.5  | 6,470            |
| underweight                       | 3.2                                        | 5.5               | 9.7      | 7.5     | 8.6     | 24.3    | 14.3      | 21.7  | 1,327            |
| Obese                             | 35.8                                       | 25.5              | 11.2     | 22.3    | 17.3    | 13.2    | 9.1       | 7.8   | 1,136            |
| <b>Socio-economic factors</b>     |                                            |                   |          |         |         |         |           |       |                  |
| <b>Religion</b>                   | <b>Pearson chi2 = 8100.0000 Pr = 0.000</b> |                   |          |         |         |         |           |       |                  |
| Muslims                           | 2.06                                       | 1.39              | 0.64     | 11.03   | 0.53    | 14.15   | 1.45      | 44.3  | 1,463            |
| Hindu                             | 52.58                                      | 21.7              | 1.27     | 17.79   | 1.05    | 75.78   | 2.42      | 52.27 | 2,348            |
| Christians                        | 13.4                                       | 46.08             | 98.09    | 65.3    | 90.19   | 5.23    | 87.25     | 3.25  |                  |
| Others                            | 31.96                                      | 30.84             | 0        | 5.87    | 8.23    | 4.84    | 8.87      | 0.17  | 5,142            |
| <b>Caste</b>                      | <b>Pearson chi2 = 3580.2088 Pr = 0.000</b> |                   |          |         |         |         |           |       |                  |
| others                            | 44.2                                       | 10.5              | 0.3      | 27.9    | 1.6     | 26.7    | 2.3       | 56.3  | 1,427            |
| SC                                | 5.8                                        | 7                 | 1.2      | 5       | 3.3     | 29.9    | 0.7       | 18.8  | 596              |
| ST                                | 50                                         | 82.6              | 98.6     | 67.1    | 95.1    | 43.4    | 97        | 24.8  | 5,511            |
| <b>Wealth index</b>               | <b>Pearson chi2= 1250.3280 Pr = 0.000</b>  |                   |          |         |         |         |           |       |                  |
| poorest                           | 4.1                                        | 28.8              | 54.6     | 36.3    | 17      | 47.3    | 52.1      | 53.2  | 4,104            |
| poorer                            | 28.9                                       | 33.9              | 24.8     | 40.2    | 23.3    | 32.4    | 33.9      | 31.2  | 2,849            |
| middle                            | 43.3                                       | 23.5              | 12.4     | 15.7    | 30.6    | 16.5    | 11.5      | 10.6  | 1,328            |
| richer                            | 22.7                                       | 12.3              | 6.6      | 5.9     | 19.8    | 3.5     | 2.4       | 4     | 543              |
| richest                           | 1                                          | 1.6               | 1.5      | 2       | 9.3     | 0.4     | 0.1       | 1.1   | 129              |
| <b>Mother' education</b>          | <b>Pearson chi2 = 262.3407 Pr = 0.000</b>  |                   |          |         |         |         |           |       |                  |
| No education                      | 8.25                                       | 27.05             | 14.27    | 14.41   | 11.73   | 13.18   | 21.06     | 21.22 | 1,758            |
| primary                           | 21.65                                      | 13.67             | 19.75    | 16.9    | 19.09   | 19.77   | 30.82     | 18.18 | 3,672            |

|                                               |              |              |                                            |           |              |              |             |              |              |
|-----------------------------------------------|--------------|--------------|--------------------------------------------|-----------|--------------|--------------|-------------|--------------|--------------|
| secondary                                     | 57.73        | 52.17        | 60.38                                      | 60.85     | 63.75        | 64.34        | 44.57       | 57.27        | 4,876        |
| higher                                        | 12.37        | 7.11         | 5.61                                       | 7.83      | 5.43         | 2.71         | 3.55        | 3.32         | 405          |
| <b>Type of place of residence</b>             |              |              | <b>Pearson chi2 = 473.5198 Pr = 0.000</b>  |           |              |              |             |              |              |
| urban                                         | 10.3         | 18.2         | 16.6                                       | 18.5      | 32.7         | 12.2         | 6.3         | 6.8          | 1,040        |
| rural                                         | 89.7         | 81.8         | 83.4                                       | 81.5      | 67.3         | 87.8         | 93.7        | 93.2         | 7,913        |
| <b>No media access at least once a week</b>   |              |              | <b>Pearson chi2 = 435.4218 Pr = 0.000</b>  |           |              |              |             |              |              |
| No                                            | 53.6         | 40.8         | 22.8                                       | 37.9      | 65           | 40.3         | 31.5        | 25.8         | 2,984        |
| Yes                                           | 46.4         | 59.2         | 77.2                                       | 62.1      | 35           | 59.7         | 68.5        | 74.2         | 5,969        |
| <b>Child-related factors</b>                  |              |              |                                            |           |              |              |             |              |              |
| <b>Child's age in months</b>                  |              |              | <b>Pearson chi2 = 48.4011 Pr = 0.000</b>   |           |              |              |             |              |              |
| 0-23 months                                   | 37.1         | 31.6         | 32.4                                       | 32.9      | 30.1         | 40.1         | 29.7        | 35.1         | 2,936        |
| 24-47 months                                  | 41.2         | 42.2         | 44.2                                       | 40.9      | 39.9         | 38.4         | 44.9        | 38.6         | 3,718        |
| 47-59 months                                  | 21.6         | 26.2         | 23.4                                       | 26.2      | 29.9         | 21.5         | 25.4        | 26.3         | 2,299        |
| <b>Sex of child</b>                           |              |              | <b>Pearson chi2 = 17.5935 Pr = 0.014</b>   |           |              |              |             |              |              |
| male                                          | 55.7         | 54.3         | 56.4                                       | 52.7      | 50.6         | 53.3         | 50.5        | 49.7         | 4,618        |
| female                                        | 44.3         | 45.7         | 43.6                                       | 47.3      | 49.4         | 46.7         | 49.5        | 50.3         | 4,335        |
| <b>Health seeking factors</b>                 |              |              |                                            |           |              |              |             |              |              |
| <b>Place of delivery</b>                      |              |              | <b>Pearson chi2 = 1093.0922 Pr = 0.000</b> |           |              |              |             |              |              |
| Home delivery                                 | 4.1          | 24.1         | 63                                         | 38.7      | 25           | 16.1         | 49.6        | 17.8         | 2,927        |
| Institutional delivery                        | 95.9         | 75.9         | 37                                         | 61.3      | 75           | 83.9         | 50.4        | 82.2         | 5,989        |
| <b>Distance to Health Facility</b>            |              |              | <b>Pearson chi2 = 1100.00 Pr = 0.000</b>   |           |              |              |             |              |              |
| no problem                                    | 19.59        | 15.97        | 19.62                                      | 42.88     | 74.08        | 19.38        | 17.18       | 23.18        | 2,199        |
| some problem                                  | 39.18        | 53.09        | 43.06                                      | 21.89     | 8.06         | 34.3         | 41.99       | 37.76        | 3,418        |
| big problem                                   | 41.24        | 30.93        | 37.32                                      | 35.23     | 17.86        | 46.32        | 40.82       | 39.06        | 3,336        |
| <b>Transportation problem to medical help</b> |              |              | <b>Pearson chi2 = 1100.0000 Pr = 0.000</b> |           |              |              |             |              |              |
| no problem                                    | 14.43        | 16.25        | 21.02                                      | 46.8      | 74.43        | 23.06        | 18.84       | 24.79        | 2,338        |
| some problem                                  | 45.36        | 51.62        | 44.2                                       | 22.78     | 7.18         | 31.98        | 39.41       | 35.07        | 3,264        |
| big problem                                   | 40.21        | 32.13        | 34.78                                      | 30.43     | 18.39        | 44.96        | 41.75       | 40.14        | 3,351        |
| <b>Total</b>                                  | <b>17.81</b> | <b>23.36</b> | <b>27.93</b>                               | <b>18</b> | <b>23.94</b> | <b>28.56</b> | <b>41.6</b> | <b>30.42</b> | <b>8,953</b> |

**Table 2 Prevalence of wasting by background characteristics in children under five years among northeastern states, NFHS 5**

| States                            | Sikkim                                     | Arunachal Pradesh | Nagaland | Manipur | Mizoram | Tripura | Meghalaya | Assam | Sample size |
|-----------------------------------|--------------------------------------------|-------------------|----------|---------|---------|---------|-----------|-------|-------------|
|                                   | (%)                                        | (%)               | (%)      | (%)     | (%)     | (%)     | (%)       | (%)   | N           |
| <b>Maternal Factors</b>           |                                            |                   |          |         |         |         |           |       |             |
| <b>Mother' age</b>                | <b>Pearson chi2= 80.1722 Pr = 0.000</b>    |                   |          |         |         |         |           |       |             |
| 15-20                             | 4.55                                       | 5.56              | 2.38     | 3.69    | 3.21    | 19.16   | 7.89      | 8.4   | 316         |
| 21-24                             | 22.73                                      | 17.74             | 14.49    | 20.08   | 13.9    | 22.4    | 16.69     | 24.91 | 860         |
| 25-29                             | 31.82                                      | 34.95             | 40.62    | 30.74   | 36.9    | 29.22   | 29.29     | 36.23 | 1,441       |
| 30-49                             | 40.91                                      | 41.76             | 42.52    | 45.49   | 45.99   | 29.22   | 46.13     | 30.46 | 1,554       |
| <b>Mother' age at first birth</b> | <b>Pearson chi2 = 168.5566 Pr = 0.000</b>  |                   |          |         |         |         |           |       |             |
| less than 20                      | 29.5                                       | 41.4              | 32.5     | 32.4    | 39.6    | 57.8    | 53.3      | 54.2  | 2,012       |
| 21-24                             | 38.6                                       | 32.1              | 36.6     | 37.3    | 34.8    | 27.9    | 30.7      | 29.7  | 1,313       |
| 25-29                             | 27.3                                       | 19.4              | 21.1     | 19.7    | 18.2    | 11.4    | 11.4      | 12.6  | 621         |
| 30-49                             | 4.5                                        | 7.2               | 9.7      | 10.7    | 7.5     | 2.9     | 4.7       | 3.5   | 225         |
| <b>Birth order</b>                | <b>Pearson chi2 = 258.2923 Pr = 0.000</b>  |                   |          |         |         |         |           |       |             |
| Firstborn                         | 56.8                                       | 38.5              | 35.6     | 33.2    | 31.6    | 50.3    | 25.6      | 40.3  | 1,559       |
| 2nd order                         | 29.5                                       | 28                | 24.2     | 29.5    | 32.6    | 33.1    | 24.3      | 33.2  | 1,247       |
| 3rd order                         | 6.8                                        | 18.3              | 17.6     | 17.2    | 18.7    | 9.1     | 15.3      | 14.4  | 637         |
| higher order                      | 6.8                                        | 15.2              | 22.6     | 20.1    | 17.1    | 7.5     | 34.7      | 12.1  | 728         |
| <b>Body mass index</b>            | <b>Pearson chi2 = 261.0096 Pr = 0.000</b>  |                   |          |         |         |         |           |       |             |
| normal                            | 55.8                                       | 74.3              | 77.9     | 70.8    | 75.9    | 61.8    | 78.6      | 73.7  | 3,069       |
| underweight                       | 2.3                                        | 5.9               | 10.2     | 8.6     | 8       | 27.1    | 13.5      | 19.8  | 630         |
| obese                             | 41.9                                       | 19.7              | 11.9     | 20.6    | 16      | 11.1    | 7.9       | 6.5   | 457         |
| <b>Socio-economic factors</b>     |                                            |                   |          |         |         |         |           |       |             |
| <b>Religion</b>                   | <b>Pearson chi2 = 3600.0000 Pr = 0.000</b> |                   |          |         |         |         |           |       |             |
| Muslims                           | 4.55                                       | 3.41              | 0.24     | 7.79    | 0.00    | 13.31   | 2.28      | 42.91 | 848         |
| Hindu                             | 47.73                                      | 22.40             | 4.75     | 18.85   | 0.00    | 77.27   | 3.34      | 52.91 | 1,398       |
| Christians                        | 18.18                                      | 48.92             | 95.01    | 65.16   | 86.63   | 6.49    | 87.86     | 4.06  | 1,672       |
| Others                            | 29.55                                      | 25.27             | 0.00     | 8.20    | 13.37   | 2.92    | 6.53      | 0.11  | 253         |
| <b>Caste</b>                      | <b>Pearson chi2 = 1480.1871 Pr = 0.000</b> |                   |          |         |         |         |           |       |             |
| others                            | 47.6                                       | 12.2              | 0.7      | 26.7    | 3.2     | 30      | 2         | 57.9  | 841         |
| SC                                | 7.1                                        | 5.7               | 3.6      | 6.4     | 4.3     | 27.7    | 0.8       | 17.9  | 330         |
| ST                                | 45.2                                       | 82.1              | 95.6     | 66.9    | 92.5    | 42.3    | 97.2      | 24.2  | 2,153       |
| <b>Wealth index</b>               | <b>Pearson chi2 = 330.3617 Pr = 0.000</b>  |                   |          |         |         |         |           |       |             |
| poorest                           | 11.4                                       | 30.5              | 45.4     | 35.2    | 17.1    | 48.7    | 44        | 49.5  | 1,791       |
| poorer                            | 27.3                                       | 30.5              | 29.5     | 33.2    | 23.5    | 28.9    | 36        | 31.3  | 1,304       |
| middle                            | 31.8                                       | 22.4              | 13.3     | 20.9    | 30.5    | 14.9    | 14.3      | 12.7  | 665         |
| richer                            | 25                                         | 14                | 8.6      | 7.8     | 18.2    | 6.5     | 4.9       | 4.6   | 310         |
| richest                           | 4.5                                        | 2.7               | 3.3      | 2.9     | 10.7    | 1       | 0.9       | 1.9   | 101         |
| <b>Mother' education</b>          | <b>Pearson chi2 = 169.0455 Pr = 0.000</b>  |                   |          |         |         |         |           |       |             |
| no education                      | 9.1                                        | 24.2              | 11.2     | 7       | 11.2    | 12.3    | 19.3      | 19.4  | 729         |
| primary                           | 22.7                                       | 12.5              | 19.7     | 23      | 17.6    | 18.2    | 28.8      | 16.1  | 780         |
| secondary                         | 50                                         | 56.3              | 62       | 57.8    | 63.6    | 64.9    | 47.3      | 59.7  | 2,414       |
| higher                            | 18.2                                       | 7                 | 7.1      | 12.3    | 7.5     | 4.5     | 4.6       | 4.7   | 248         |

|                                               |              |              |                                           |             |             |             |              |              |              |
|-----------------------------------------------|--------------|--------------|-------------------------------------------|-------------|-------------|-------------|--------------|--------------|--------------|
| <b>Type of place of residence</b>             |              |              | <b>Pearson chi2 = 130.9955 Pr = 0.000</b> |             |             |             |              |              |              |
| urban                                         | 6.8          | 15.8         | 19                                        | 19.3        | 32.1        | 11.7        | 7.6          | 9.1          | 524          |
| rural                                         | 93.2         | 84.2         | 81                                        | 80.7        | 67.9        | 88.3        | 92.4         | 90.9         | 3,647        |
| <b>No media access at least once a week</b>   |              |              | <b>Pearson chi2 = 153.2732 Pr = 0.000</b> |             |             |             |              |              |              |
| No                                            | 56.8         | 40.9         | 27.6                                      | 36.5        | 61          | 39.9        | 40.8         | 26.5         | 1,427        |
| Yes                                           | 43.2         | 59.1         | 72.4                                      | 63.5        | 39          | 60.1        | 59.2         | 73.5         | 2,744        |
| <b>Child-related factors</b>                  |              |              |                                           |             |             |             |              |              |              |
| <b>Child's age in months</b>                  |              |              | <b>Pearson chi2 = 29.0594 Pr = 0.010</b>  |             |             |             |              |              |              |
| 0-23 months                                   | 40.9         | 34.2         | 39.4                                      | 38.1        | 39.6        | 36          | 45.7         | 38.7         | 1,632        |
| 24-47 months                                  | 43.2         | 46.1         | 42.8                                      | 45.5        | 34.8        | 45.8        | 36.7         | 42.6         | 1,761        |
| 47-59 months                                  | 15.9         | 19.7         | 17.8                                      | 16.4        | 25.7        | 18.2        | 17.6         | 18.6         | 778          |
| <b>Sex of child</b>                           |              |              | <b>Pearson chi2 = 10.7937 Pr = 0.148</b>  |             |             |             |              |              |              |
| male                                          | 61.4         | 55.7         | 54.2                                      | 52          | 50.3        | 47.4        | 50.1         | 54.1         | 2,210        |
| female                                        | 38.6         | 44.3         | 45.8                                      | 48          | 49.7        | 52.6        | 49.9         | 45.9         | 1,961        |
| <b>Health seeking factors</b>                 |              |              |                                           |             |             |             |              |              |              |
| <b>Place of delivery</b>                      |              |              | <b>Pearson chi2 = 491.0319 Pr = 0.000</b> |             |             |             |              |              |              |
| Home delivery                                 | 2.3          | 22.3         | 61.4                                      | 38.7        | 21.4        | 15.6        | 39           | 15.3         | 1,087        |
| Institutional delivery                        | 97.7         | 77.7         | 38.6                                      | 61.3        | 78.6        | 84.4        | 61           | 84.7         | 3,070        |
| <b>Distance to Health Facility</b>            |              |              | <b>Pearson chi2 = 436.3293 Pr = 0.000</b> |             |             |             |              |              |              |
| no problem                                    | 27.27        | 17.92        | 20.19                                     | 43.85       | 75.4        | 20.13       | 15.93        | 24.29        | 2,199        |
| some problem                                  | 18.18        | 52.15        | 45.37                                     | 22.54       | 5.88        | 33.44       | 46.59        | 34.74        | 3,418        |
| big problem                                   | 54.55        | 29.93        | 34.44                                     | 33.61       | 18.72       | 46.43       | 37.48        | 40.97        | 3,336        |
| <b>Transportation problem to medical help</b> |              |              | <b>Pearson chi2 = 465.1023 Pr = 0.000</b> |             |             |             |              |              |              |
| no problem                                    | 27.27        | 16.31        | 21.62                                     | 48.77       | 78          | 25.65       | 16.84        | 27.14        | 1,123        |
| some problem                                  | 31.82        | 54.48        | 45.13                                     | 22.13       | 6.42        | 28.57       | 44.16        | 32.63        | 1,524        |
| big problem                                   | 40.91        | 29.21        | 33.25                                     | 29.1        | 16.04       | 45.78       | 39           | 40.23        | 1,524        |
| <b>Total</b>                                  | <b>11.05</b> | <b>11.61</b> | <b>16.46</b>                              | <b>7.86</b> | <b>8.57</b> | <b>16.1</b> | <b>11.21</b> | <b>19.65</b> | <b>4,171</b> |

**Table 3 Prevalence of underweight by background characteristics in children under five years among northeastern states, NFHS 5**

| States                            | Sikkim<br>(%)                              | Arunachal Pradesh<br>(%) | Nagaland<br>(%) | Manipur<br>(%) | Mizoram<br>(%) | Tripura<br>(%) | Meghalaya<br>(%) | Assam<br>(%) | Sample size<br>N |
|-----------------------------------|--------------------------------------------|--------------------------|-----------------|----------------|----------------|----------------|------------------|--------------|------------------|
| <b>Maternal Factors</b>           |                                            |                          |                 |                |                |                |                  |              |                  |
| <b>Mother' age</b>                | <b>Pearson chi2 = 168.4950 Pr = 0.000</b>  |                          |                 |                |                |                |                  |              |                  |
| 15-20                             | 3.45                                       | 5.64                     | 2.19            | 5.01           | 2.6            | 16.54          | 4.55             | 8.78         | 563              |
| 21-24                             | 13.79                                      | 18.26                    | 14.84           | 13.78          | 13.87          | 25.96          | 16.22            | 25.32        | 1,681            |
| 25-29                             | 34.48                                      | 34.63                    | 35.33           | 33.61          | 31.79          | 30             | 32.39            | 35.75        | 2,832            |
| 30-49                             | 48.28                                      | 41.48                    | 47.64           | 47.6           | 51.73          | 27.5           | 46.85            | 30.15        | 3,214            |
| <b>Mother' age at first birth</b> | <b>Pearson chi2 = 366.9742 Pr = 0.000</b>  |                          |                 |                |                |                |                  |              |                  |
| less than 20                      | 41.4                                       | 44.4                     | 34.2            | 37.8           | 45.4           | 64.2           | 56.6             | 57.1         | 4,326            |
| 21-24                             | 34.5                                       | 34.8                     | 34.8            | 31.7           | 30.1           | 24.4           | 30.3             | 28.6         | 2,505            |
| 25-29                             | 19                                         | 15.2                     | 21.3            | 21.1           | 16.8           | 8.8            | 9.9              | 11.3         | 1,081            |
| 30-49                             | 5.2                                        | 5.6                      | 9.8             | 9.4            | 7.8            | 2.5            | 3.3              | 3            | 378              |
| <b>Birth order</b>                | <b>Pearson chi2 = 711.3702 Pr = 0.000</b>  |                          |                 |                |                |                |                  |              |                  |
| Firstborn                         | 46.6                                       | 36.1                     | 31.6            | 33.6           | 27.5           | 47.1           | 21.8             | 39.8         | 2,823            |
| 2nd order                         | 27.6                                       | 27.9                     | 26              | 27.8           | 28.9           | 32.5           | 21.9             | 33           | 2,378            |
| 3rd order                         | 13.8                                       | 17.3                     | 20              | 17.1           | 21.1           | 11.9           | 16.5             | 14.6         | 1,334            |
| higher order                      | 12.1                                       | 18.7                     | 22.3            | 21.5           | 22.5           | 8.5            | 39.7             | 12.6         | 1,755            |
| <b>Body mass index</b>            | <b>Pearson chi2 = 439.4449 Pr = 0.000</b>  |                          |                 |                |                |                |                  |              |                  |
| normal                            | 55.4                                       | 72.8                     | 78.7            | 71.1           | 76             | 61.3           | 76.3             | 68.9         | 5,941            |
| underweight                       | 0                                          | 7.7                      | 9.8             | 10.3           | 9.2            | 27.7           | 15.7             | 23.8         | 1,459            |
| obese                             | 44.6                                       | 19.5                     | 11.5            | 18.6           | 14.7           | 11             | 8.1              | 7.4          | 868              |
| <b>Socio-economic factors</b>     |                                            |                          |                 |                |                |                |                  |              |                  |
| <b>Religion</b>                   | <b>Pearson chi2 = 7300.00 Pr = 0.000</b>   |                          |                 |                |                |                |                  |              |                  |
| Muslims                           | 5.17                                       | 3.22                     | 0.58            | 13.15          | 0.29           | 15.77          | 1.96             | 45.52        | 1,735            |
| Hindu                             | 56.9                                       | 25.37                    | 2.3             | 21.71          | 0.58           | 74.81          | 2.74             | 50.76        | 2,484            |
| Christians                        | 10.34                                      | 43.89                    | 97.12           | 55.95          | 90.75          | 5.77           | 86.88            | 3.57         | 3,590            |
| Others                            | 27.59                                      | 27.52                    | 0               | 9.19           | 8.38           | 3.65           | 8.42             | 0.15         | 481              |
| <b>Caste</b>                      | <b>Pearson chi2 = 3263.7712 Pr = 0.000</b> |                          |                 |                |                |                |                  |              |                  |
| others                            | 44.6                                       | 16.5                     | 0.2             | 35.8           | 1.7            | 28.6           | 2.7              | 59.3         | 1,625            |
| SC                                | 7.1                                        | 7.3                      | 1.6             | 6.9            | 2.3            | 28.9           | 0.7              | 18           | 591              |
| ST                                | 48.2                                       | 76.1                     | 98.1            | 57.3           | 96             | 42.5           | 96.6             | 22.7         | 4,426            |
| <b>Wealth index</b>               | <b>Pearson chi2= 745.1593 Pr = 0.000</b>   |                          |                 |                |                |                |                  |              |                  |
| poorest                           | 6.9                                        | 33.8                     | 51.8            | 38.2           | 18.8           | 52.7           | 51.7             | 51.8         | 3,956            |
| poorer                            | 22.4                                       | 30.3                     | 26.9            | 37.2           | 24             | 28.8           | 32.7             | 32.6         | 2,605            |
| middle                            | 55.2                                       | 22.6                     | 13              | 15.4           | 30.3           | 14.2           | 12.8             | 10.9         | 1,179            |
| richer                            | 12.1                                       | 11.8                     | 6.7             | 6.3            | 19.4           | 3.7            | 2.6              | 3.7          | 445              |
| richest                           | 3.4                                        | 1.5                      | 1.6             | 2.9            | 7.5            | 0.6            | 0.2              | 1            | 105              |

|                                               |              |             |              |                                           |              |              |              |              |              |
|-----------------------------------------------|--------------|-------------|--------------|-------------------------------------------|--------------|--------------|--------------|--------------|--------------|
| <b>Mother' education</b>                      |              |             |              | <b>Pearson chi2= 375.4229 Pr = 0.000</b>  |              |              |              |              |              |
| No                                            |              |             |              |                                           |              |              |              |              |              |
| education                                     | 12.1         | 27.1        | 12.8         | 10.2                                      | 12.7         | 13.7         | 22.2         | 20.6         | 1,601        |
| primary                                       | 32.8         | 13.2        | 18.8         | 19.4                                      | 18.8         | 20.2         | 30.8         | 17.7         | 1,729        |
| secondary                                     | 43.1         | 54.2        | 63.2         | 60.5                                      | 64.7         | 63.7         | 43.9         | 58.5         | 4,625        |
| higher                                        | 12.1         | 5.5         | 5.3          | 9.8                                       | 3.8          | 2.5          | 3.1          | 3.2          | 335          |
| <b>Type of place of residence</b>             |              |             |              | <b>Pearson chi2 = 334.1147 Pr = 0.000</b> |              |              |              |              |              |
| urban                                         | 8.6          | 16.9        | 17.6         | 22.1                                      | 29.2         | 8.7          | 6.6          | 7.3          | 906          |
| rural                                         | 91.4         | 83.1        | 82.4         | 77.9                                      | 70.8         | 91.3         | 93.4         | 92.7         | 7,384        |
| <b>No media access at least once a week</b>   |              |             |              | <b>Pearson chi2= 315.7790 Pr = 0.000</b>  |              |              |              |              |              |
| No                                            | 60.3         | 38.1        | 23.9         | 41.1                                      | 64.5         | 36.5         | 30.8         | 25.7         | 2,590        |
| Yes                                           | 39.7         | 61.9        | 76.1         | 58.9                                      | 35.5         | 63.5         | 69.2         | 74.3         | 5,700        |
| <b>Child-related factors</b>                  |              |             |              |                                           |              |              |              |              |              |
| <b>Child's age in months</b>                  |              |             |              | <b>Pearson chi2 = 26.0946 Pr = 0.025</b>  |              |              |              |              |              |
| 0-23                                          |              |             |              |                                           |              |              |              |              |              |
| months                                        | 27.6         | 26.7        | 29           | 27.1                                      | 28.3         | 30           | 31.3         | 32.6         | 2,545        |
| 24-47                                         |              |             |              |                                           |              |              |              |              |              |
| months                                        | 51.7         | 49.9        | 48.8         | 49.1                                      | 42.8         | 46.3         | 46.3         | 44.3         | 3,823        |
| 47-59                                         |              |             |              |                                           |              |              |              |              |              |
| months                                        | 20.7         | 23.4        | 22.2         | 23.8                                      | 28.9         | 23.7         | 22.4         | 23.1         | 1,922        |
| <b>Sex of child</b>                           |              |             |              | <b>Pearson chi2 = 11.6945 Pr = 0.111</b>  |              |              |              |              |              |
| male                                          | 53.4         | 52.5        | 55.6         | 48.4                                      | 49.4         | 48.1         | 50.4         | 51.2         | 4,241        |
| female                                        | 46.6         | 47.5        | 44.4         | 51.6                                      | 50.6         | 51.9         | 49.6         | 48.8         | 4,049        |
| <b>Health seeking factors</b>                 |              |             |              |                                           |              |              |              |              |              |
| <b>Place of delivery</b>                      |              |             |              | <b>Pearson chi2= 1001.4515 Pr = 0.000</b> |              |              |              |              |              |
| Home                                          |              |             |              |                                           |              |              |              |              |              |
| delivery                                      | 6.9          | 25.4        | 61.9         | 36.3                                      | 28.3         | 19.3         | 47.2         | 16.8         | 2,565        |
| Institutional                                 |              |             |              |                                           |              |              |              |              |              |
| delivery                                      | 93.1         | 74.6        | 38.1         | 63.7                                      | 71.7         | 80.7         | 52.8         | 83.2         | 5,690        |
| <b>Distance to Health Facility</b>            |              |             |              | <b>Pearson chi2= 797.5302 Pr = 0.000</b>  |              |              |              |              |              |
| no problem                                    | 17.24        | 17.45       | 20.6         | 44.05                                     | 74.28        | 18.46        | 15.55        | 23.91        | 1,982        |
| some                                          |              |             |              |                                           |              |              |              |              |              |
| problem                                       | 39.66        | 51.95       | 43.73        | 20.04                                     | 6.36         | 34           | 44.63        | 35.81        | 3,146        |
| big                                           |              |             |              |                                           |              |              |              |              |              |
| problem                                       | 43.1         | 30.6        | 35.67        | 35.91                                     | 19.36        | 47.12        | 39.82        | 40.28        | 3,162        |
| <b>Transportation problem to medical help</b> |              |             |              | <b>Pearson chi2= 766.0092 Pr = 0.000</b>  |              |              |              |              |              |
| no problem                                    | 20.69        | 14.63       | 22.09        | 48.02                                     | 73.7         | 22.88        | 17.2         | 26.13        | 2,122        |
| some                                          |              |             |              |                                           |              |              |              |              |              |
| problem                                       | 37.93        | 51.28       | 43.96        | 19.83                                     | 5.2          | 32.31        | 41.84        | 33.8         | 3,005        |
| big                                           |              |             |              |                                           |              |              |              |              |              |
| problem                                       | 41.38        | 34.09       | 33.95        | 32.15                                     | 21.1         | 44.81        | 40.96        | 40.07        | 3,163        |
| <b>Total</b>                                  | <b>12.94</b> | <b>16.8</b> | <b>31.44</b> | <b>16.64</b>                              | <b>13.42</b> | <b>27.77</b> | <b>32.82</b> | <b>36.86</b> | <b>8,290</b> |

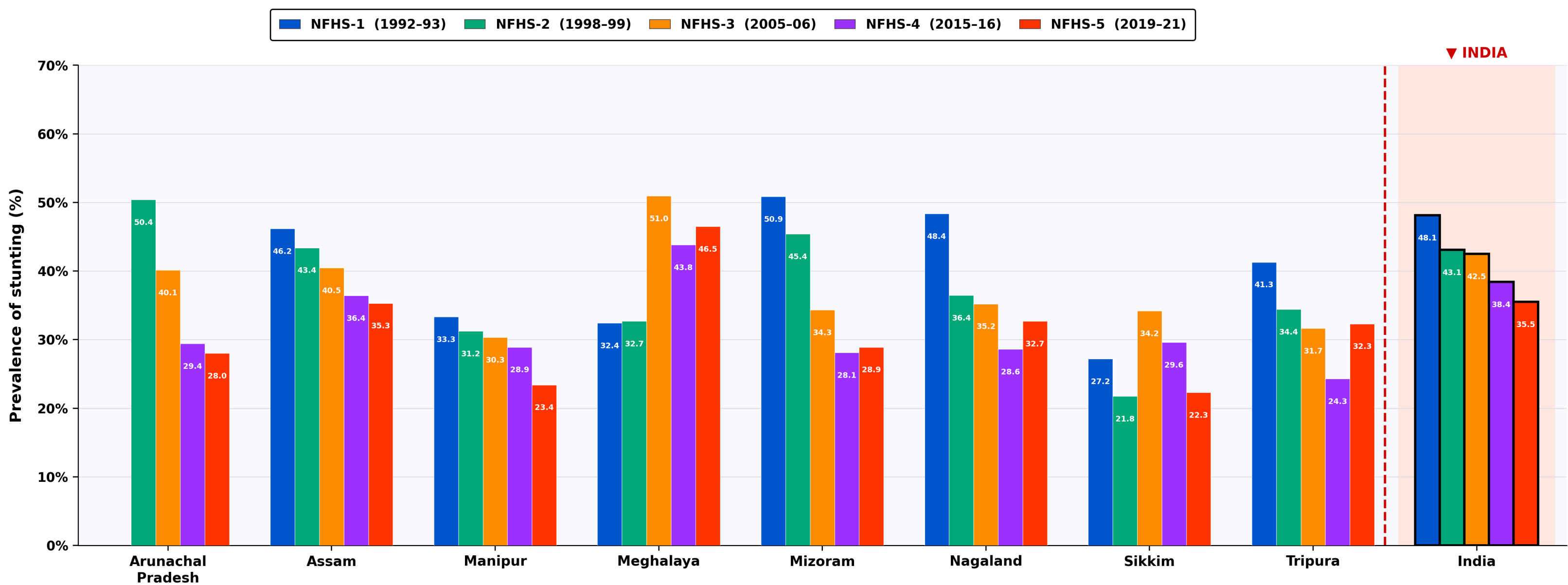
**Table 4: Multivariate logistic regression analysis of three anthropometric measures of undernutrition among north-eastern regions of India, 2019-21**

|                                             | Stunting |                | Wasting  |                | Underweight |                |
|---------------------------------------------|----------|----------------|----------|----------------|-------------|----------------|
|                                             | OR       | 95% CI         | OR       | 95% CI         | OR          | 95% CI         |
| <b>Maternal Factors</b>                     |          |                |          |                |             |                |
| <b>Mother's age</b>                         | 1        |                | 1        |                | 1           |                |
| 30-49                                       | 1.023    | [0.93 ,1.125]  | 0.969    | [0.855 ,1.098] | 1.054       | [0.953 ,1.165] |
| 21-24                                       | 0.982    | [0.914 ,1.055] | 0.982    | [0.893 ,1.079] | 1.015       | [0.942 ,1.095] |
| 25-29                                       |          |                |          |                |             |                |
| <b>Mother's age at first birth</b>          | 1        |                | 1        |                | 1           |                |
| less than 20                                |          |                |          |                |             |                |
| 21-24                                       | 0.948    | [0.887 ,1.013] | 1.099**  | [1.005 ,1.201] | 1.02        | [0.951 ,1.094] |
| 25-29                                       | 0.936    | [0.853 ,1.026] | 1.061    | [0.94 ,1.198]  | 0.976       | [0.885 ,1.076] |
| 30-49                                       | 0.853**  | [0.744 ,0.979] | 1.047    | [0.877 ,1.251] | 0.975       | [0.844 ,1.128] |
| <b>Birth order</b>                          | 1        |                | 1        |                | 1           |                |
| Firstborn                                   |          |                |          |                |             |                |
| 2nd order                                   | 1.021    | [0.949 ,1.098] | 1.009    | [0.919 ,1.109] | 1.057       | [0.98 ,1.141]  |
| 3rd order                                   | 1.115**  | [1.017 ,1.222] | 1.029    | [0.91 ,1.163]  | 1.2***      | [1.089 ,1.322] |
| Higher order                                | 1.216*** | [1.101 ,1.343] | 0.941    | [0.82 ,1.079]  | 1.21***     | [1.089 ,1.345] |
| <b>Body mass index</b>                      | 1        |                | 1        |                | 1           |                |
| Normal                                      |          |                |          |                |             |                |
| Underweight                                 | 1.377*** | [1.261 ,1.503] | 1.241*** | [1.11 ,1.387]  | 1.626***    | [1.489 ,1.775] |
| Obese                                       | 0.918**  | [0.846 ,0.996] | 0.729*** | [0.65 ,0.818]  | 0.775***    | [0.708 ,0.847] |
| <b>Socio-economic factors</b>               |          |                |          |                |             |                |
| <b>Religion</b>                             | 1        |                | 1        |                | 1           |                |
| Hindu                                       |          |                |          |                |             |                |
| Muslims                                     | 1.323*** | [1.124 ,1.556] | 1.157    | [0.946 ,1.415] | 1.376***    | [1.172 ,1.616] |
| Christians                                  | 1.081    | [0.959 ,1.218] | 1.136    | [0.973 ,1.327] | 0.996       | [0.878 ,1.131] |
| Others                                      | 1.069    | [0.932 ,1.226] | 0.854    | [0.707 ,1.031] | 0.936       | [0.806 ,1.087] |
| <b>Caste</b>                                | 1        |                | 1        |                | 1           |                |
| Others                                      |          |                |          |                |             |                |
| SC                                          | 1.092    | [0.97 ,1.229]  | 0.99     | [0.856 ,1.144] | 0.91        | [0.808 ,1.025] |
| ST                                          | 1.063    | [0.961 ,1.175] | 0.939    | [0.827 ,1.066] | 0.805***    | [0.726 ,0.892] |
| <b>Wealth index</b>                         | 1        |                | 1        |                | 1           |                |
| Poorest                                     |          |                |          |                |             |                |
| Poorer                                      | 0.859*** | [0.801 ,0.921] | 0.983    | [0.895 ,1.079] | 0.832***    | [0.774 ,0.895] |
| Middle                                      | 0.746*** | [0.68 ,0.82]   | 0.945    | [0.833 ,1.07]  | 0.762***    | [0.69 ,0.841]  |
| Richer                                      | 0.59***  | [0.518 ,0.672] | 0.926    | [0.781 ,1.097] | 0.602***    | [0.523 ,0.692] |
| Richest                                     | 0.467*** | [0.373 ,0.584] | 1.023    | [0.782 ,1.338] | 0.501***    | [0.392 ,0.641] |
| <b>Mother' education</b>                    | 1        |                | 1        |                | 1           |                |
| None                                        |          |                |          |                |             |                |
| Primary                                     | 1.002    | [0.913 ,1.099] | 1.057    | [0.931 ,1.199] | 1.01        | [0.917 ,1.113] |
| Secondary                                   | 0.86***  | [0.791 ,0.936] | 0.909    | [0.811 ,1.019] | 0.872***    | [0.799 ,0.953] |
| Higher                                      | 0.736*** | [0.633 ,0.857] | 0.833*   | [0.685 ,1.013] | 0.67***     | [0.569 ,0.79]  |
| <b>Type of place of residence</b>           | 1        |                | 1        |                | 1           |                |
| Urban                                       |          |                |          |                |             |                |
| Rural                                       | 0.926    | [0.845 ,1.015] | 1.016    | [0.9 ,1.147]   | 0.965       | [0.875 ,1.064] |
| <b>No media access at least once a week</b> | 1        |                | 1        |                | 1           |                |
| No                                          |          |                |          |                |             |                |
| Yes                                         | 1.084**  | [1.017 ,1.155] | 1.076*   | [0.988 ,1.172] | 1.146***    | [1.072 ,1.226] |
| <b>Child-related factors</b>                |          |                |          |                |             |                |
| <b>The child's age in months</b>            | 1        |                | 1        |                | 1           |                |
| 0-23 months                                 |          |                |          |                |             |                |
| 24-47 months                                | 1.188*** | [1.114 ,1.267] | 0.957    | [0.881 ,1.039] | 1.566***    | [1.463 ,1.675] |
| 47-59 months                                | 1.477*** | [1.371 ,1.591] | 0.733*** | [0.661 ,0.814] | 1.405***    | [1.297 ,1.523] |
| <b>Sex of child</b>                         | 1        |                | 1        |                | 1           |                |
| Male                                        |          |                |          |                |             |                |
| Female                                      | 0.916*** | [0.867 ,0.968] | 0.903*** | [0.838 ,0.972] | 0.965       | [0.91 ,1.022]  |
| <b>Health seeking factors</b>               |          |                |          |                |             |                |
| <b>Place of delivery</b>                    | 1        |                | 1        |                | 1           |                |
| Home delivery                               |          |                |          |                |             |                |
| Institutional delivery                      | 0.923**  | [0.861 ,0.99]  | 1.063    | [0.965 ,1.172] | 0.989       | [0.919 ,1.065] |
| <b>Distance to Health Facility</b>          |          |                |          |                |             |                |

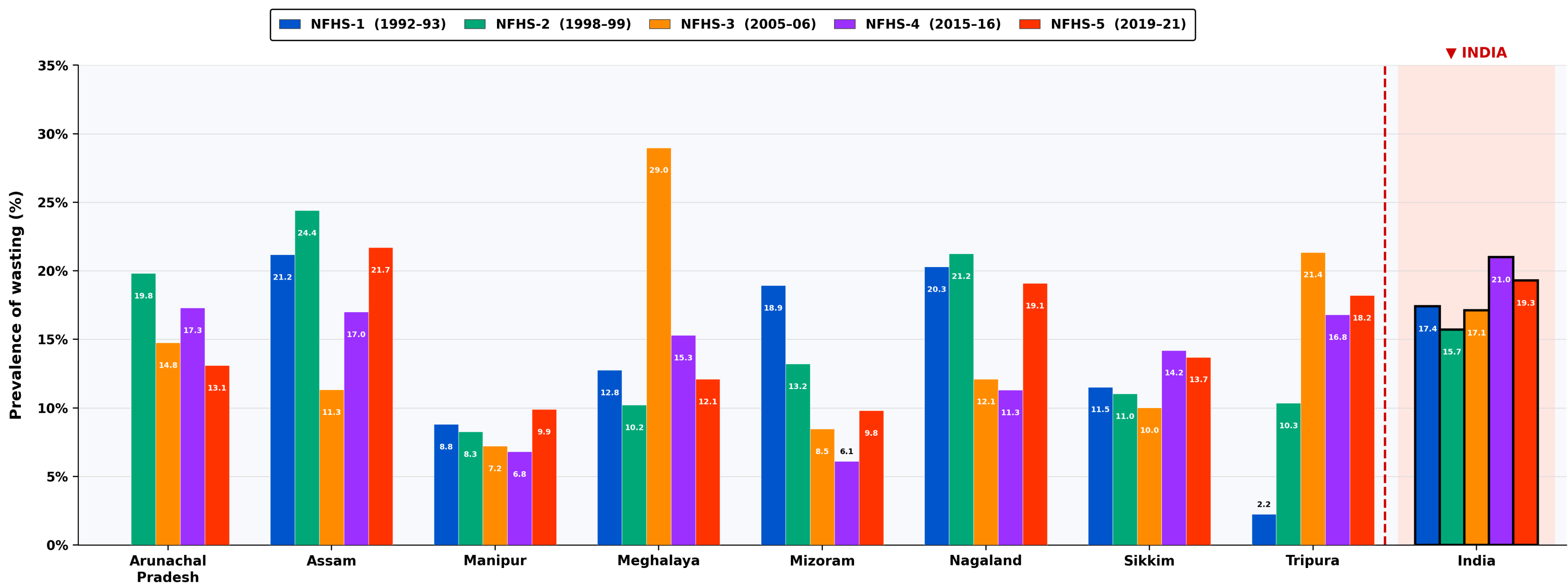
|                                                |          |                |          |                |          |                |
|------------------------------------------------|----------|----------------|----------|----------------|----------|----------------|
| <b>No problem</b>                              | 1        |                | 1        |                | 1        |                |
| <b>Some problem</b>                            | 0.957    | [0.846 ,1.082] | 0.955    | [0.813 ,1.123] | 0.957    | [0.842 ,1.087] |
| <b>Big problem</b>                             | 0.987    | [0.893 ,1.091] | 0.935    | [0.818 ,1.067] | 0.946    | [0.852 ,1.05]  |
| <b>Transportation problems to medical help</b> |          |                |          |                |          |                |
| <b>No problem</b>                              | 1        |                | 1        |                | 1        |                |
| <b>Some problem</b>                            | 1.06     | [0.938 ,1.197] | 1.188**  | [1.011 ,1.396] | 1.055    | [0.928 ,1.198] |
| <b>Big problem</b>                             | 1.069    | [0.969 ,1.18]  | 1.128*   | [0.99 ,1.287]  | 1.111**  | [1.003 ,1.232] |
| <b>Any north-eastern region</b>                |          |                |          |                |          |                |
| <b>Arunachal Pradesh</b>                       | 1        |                | 1        |                | 1        |                |
| <b>Nagaland</b>                                | 1.197    | [0.915 ,1.567] | 1.379*   | [0.962 ,1.976] | 2.626*** | [1.919 ,3.593] |
| <b>Manipur</b>                                 | 0.811    | [0.622 ,1.058] | 0.798    | [0.557 ,1.143] | 1.15     | [0.842 ,1.571] |
| <b>Mizoram</b>                                 | 1.366**  | [1.04 ,1.795]  | 0.838    | [0.575 ,1.219] | 1.373*   | [0.993 ,1.897] |
| <b>Tripura</b>                                 | 1.366**  | [1.038 ,1.797] | 1.715*** | [1.196 ,2.461] | 2.02***  | [1.471 ,2.776] |
| <b>Meghalaya</b>                               | 1.936*** | [1.496 ,2.505] | 0.954    | [0.672 ,1.353] | 2.443*** | [1.802 ,3.313] |
| <b>Assam</b>                                   | 1.436*** | [1.11 ,1.857]  | 1.798*** | [1.278,2.531]  | 2.511*** | [1.857 ,3.396] |
| <b>Constant</b>                                | 0.329*** | [0.24 ,0.451]  | 0.125*** | [0.082 ,0.191] | 0.18***  | [0.126 ,0.258] |

**Table 5: Concentration Index for three anthropometric indicators of undernutrition across north-eastern states of India.**

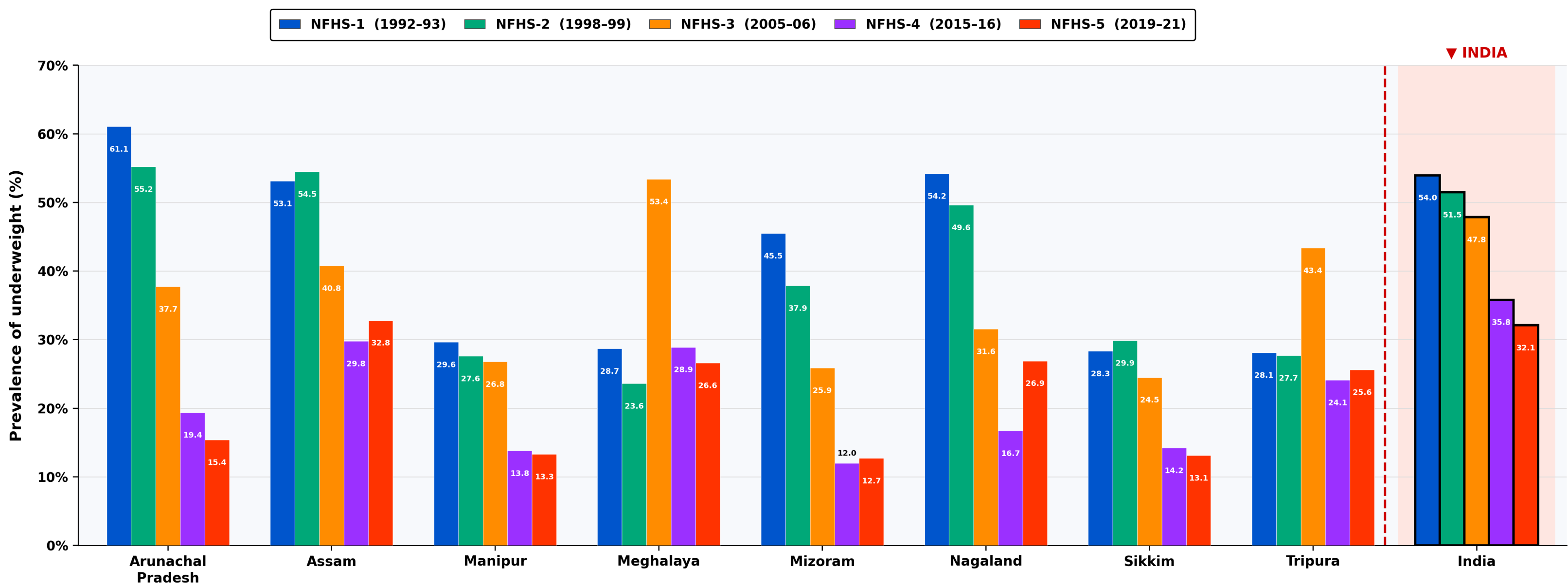
| North-eastern regions    | Stunting          |                                  | Wasting           |                                  | Underweight       |                                  |
|--------------------------|-------------------|----------------------------------|-------------------|----------------------------------|-------------------|----------------------------------|
|                          | Wealth<br>CI (SE) | Mother's<br>Education<br>CI (SE) | Wealth<br>CI (SE) | Mother's<br>Education<br>CI (SE) | Wealth<br>CI (SE) | Mother's<br>Education<br>CI (SE) |
| <b>Sikkim</b>            | -0.10(0.08)       | -0.11(0.07)                      | 0.13(0.15)        | 0.09(0.12)                       | -0.02(0.10)       | -0.15(0.07)                      |
| <b>Arunachal Pradesh</b> | -0.10(0.02)       | -0.09(0.02)                      | -0.04(0.03)       | -0.02(0.02)                      | -0.13(0.02)       | -0.08(0.25)                      |
| <b>Nagaland</b>          | -0.15(0.03)       | -0.09(0.02)                      | 0.06(0.04)        | -0.01(0.03)                      | -0.09(0.03)       | -0.14(0.03)                      |
| <b>Manipur</b>           | -0.22(0.03)       | -0.14(0.25)                      | -0.08(0.04)       | -0.09(0.04)                      | -0.21(0.03)       | -0.15(0.03)                      |
| <b>Mizoram</b>           | -0.09(0.04)       | -0.11(0.02)                      | -0.13(0.65)       | -0.04(0.05)                      | -0.20(0.05)       | -0.14(0.04)                      |
| <b>Tripura</b>           | -0.16(0.04)       | -0.14(0.02)                      | -0.12(0.04)       | -0.05(0.03)                      | -0.23(0.03)       | -0.14(0.03)                      |
| <b>Meghalaya</b>         | -0.14(0.02)       | -0.10(0.01)                      | 0.02(0.03)        | -0.01(0.03)                      | -0.11(0.02)       | -0.11(0.02)                      |
| <b>Assam</b>             | -0.15(0.02)       | 0.12(0.01)                       | -0.08(0.01)       | -0.05(0.01)                      | -0.16(0.01)       | -0.12(0.01)                      |



Source: National Family Health Survey (NFHS), Rounds 1-5, Government of India (1992-93 to 2019-21). NFHS-1 data unavailable for Arunachal Pradesh.



Source: National Family Health Survey (NFHS), Rounds 1-5, Government of India (1992-93 to 2019-21). NFHS-1 data unavailable for Arunachal Pradesh.



Source: National Family Health Survey (NFHS), Rounds 1-5, Government of India (1992-93 to 2019-21). NFHS-1 data unavailable for Arunachal Pradesh.

