

# Identifying Factors Associated with the Level of Child Malnutrition in India: Observations from the Comprehensive National Nutrition Survey

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## Research Article

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# Identifying factors associated with the level of child malnutrition in India: Observations from the Comprehensive National Nutrition Survey

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## Abstract

**Background:** Malnutrition is a complex phenomenon that has become a universal problem inhibiting human development. India is home of disproportionate height and weight of children including anemia are sign of malnutrition. This study aimed to examine child malnutrition by considering three parameters—stunting (short), underweight (thin), and/or anaemia—among children aged 1–9 years.

**Methods:** This study used nationally representative data from the Comprehensive National Nutrition Survey (CNNS). The analytic sample was restricted to 25,885 children aged 1–9 years for whom data on height, weight, and haemoglobin level was available. This analytic sample was not significantly different from the total sample of 69,413. Based on World Health Organisation's (WHO) cut-off for child growth standards, child malnutrition is defined as 'severe' if a child has suffered all 3 parameters—stunting, underweight, and anaemia, 'mild/moderate' if a child has suffered 1 or 2 parameters and 'none' if a child has not suffered from any of the 3 parameters. Univariate and bivariate analysis were used for descriptive associations and marginal effects probabilities were calculated using the ordinal logit regression model to identify the correlates of severe malnutrition.

**Results:** Nine percent of children aged 1-9 years were severely malnourished in the country. The prevalence of malnutrition declined considerably with increasing age of children—13% in children aged 1–4 years to 6% in children aged 5–9 years. Severe malnutrition was significantly higher among higher birth order children, children born to illiterate mothers, children belonging to Scheduled Tribes and poor families, children living in rural areas, and the eastern region of the

country. Zinc deficiency was found more (22%, 95% CI:18.2–26.0) among severely malnourished children as compared to normal children (16%, 95% CI:13.9–17.3).

**Conclusions:** Malnutrition is widely prevalent in children belonging to illiterate mothers, Scheduled Tribes, poor families, rural areas, and eastern region of the country. Frontline workers should identify such vulnerable children through regular monitoring of height, weight, and haemoglobin testing in their coverage areas.

**Keyword:** Malnutrition, stunting, underweight, anaemia, micronutrient deficiency, India

## **Background**

Malnutrition is a complex phenomenon that has become a universal problem inhibiting human development. Its impact can be seen in most developing countries, where children and adults are vulnerable to malnutrition because of inadequate food intake, sanitation, social inequality, diseases, maternal factors, gender and inequitable distribution of food within the household [1,2,3]. Disproportionate height and weight of children are indicative of malnutrition. Stunted and underweight children indicate a lack of proper nutritional intake and inadequate care after childbirth. Further, anaemia is a common problem among children and is found more in undernourished children, especially in infants and children who are stunted and underweight [4,5,6]. Malnutrition and anaemia adversely affect a child's health, cognitive capacity, school performance and productivity in adulthood [7-10]. One of the targets to achieve the Sustainable Development Goal 2 (SDG-2) is to end all forms of malnutrition by the end of the next decade. India is home to 46.6 million stunted children out of 150.8 million stunted children all over the world [11].

The high levels of undernutrition in children and women pose a major challenge for child survival and development [11] in South Asia and Sub-Saharan Africa. In India, the prevalence of stunting, underweight and anaemia among children has declined in the last decade but remains high in some areas. Anaemia in children is caused due to a deficiency in iron and insufficiency of other essential minerals and vitamins in the body. More than half of India's children are anaemic (58%), indicating inadequate hemoglobin levels in the blood [12]. Marked differences in socioeconomic determinants and in caring practices for children by favouring male children are documented well in the South Asian region [13-15]. One of the major causes of malnutrition in

India is economic inequality. In India, poverty, mother's literacy, ethnicity and place of residence significantly impact child malnutrition [12].

The Integrated Child Development Services (ICDS) is a government programme that was launched in 1975 [16] in accordance with the National Policy for Children in India [17]. Over the years, it has grown into one of the largest integrated family and community welfare schemes in the world [18]. ICDS continues to be India's flagship programme to tackle undernutrition and is one of the key programmes under *POSHAN* Abhiyan.. *POSHAN* Abhiyan was launched in 2017–18 to reduce anaemia, stunting, low birth weight, and under-nutrition [19]. The *POSHAN* Abhiyan is aimed at reducing the prevalence of stunting, undernutrition, anaemia and low birth weight by 2%, 2%, 3% and 2% per annum, respectively [20]. Specifically, it strives to reduce stunting at an annual rate of 2%, i.e. from 38.4% to 25% under Mission 25 by 2022.

The National Nutrition Strategy (NNS), launched in 2017 by Niti Aayog, the government think tank, is committed to ensuring that every child, adolescent girl and woman attains an optimal nutritional status, especially those from the most vulnerable communities. The monitorable outcomes of NNS are to reduce undernutrition (3 percentage points per annum) and anaemia among children (by one-third) by 2022, keeping the National Family Health Survey 2015-16 as baseline [4]. In line with NNS, the present study focused on stunting, underweight and anaemia among children and its association with multiple micronutrient deficiencies in India.

## **METHODS**

### ***Data***

This study used nationally representative data from the first-ever Comprehensive National Nutrition Survey (CNNS) in India. The CNNS is a cross-sectional household survey that collects a wide range of data on biological sample assessment and multiple anthropometric measures in all 30 states of India. The CNNS was conducted under the leadership of the Ministry of Health and Family welfare, Government of India in collaboration with UNICEF and the Population Council. The detailed anthropometric measurements were collected from over 100,000 children and adolescents and biological samples (blood, urine and stool) from over 50,000 children and adolescents from 2,035 primary sampling units (PSUs) across the country. The CNNS adopted a multi-stage sampling design with probability proportional to population size (PPS) after geographical stratification in rural and urban areas. The biological samples were collected and analysed by Super Religare Laboratories (SRL) Ltd. Further details about sampling procedures and data collection for CNNS can be found elsewhere [21].

### ***Study sample***

This study used nationally representative data from the Comprehensive National Nutrition Survey (CNNS) in India, in which 1,06,446 children and adolescents aged 0–19 years (73,817 in 0–9 years) were anthropometrically assessed. Biological samples were also collected from nearly half of these participants (51,006 in the age group of 1–19 years and 34,829 in 1–9 years). This analysis was restricted to 25,885 children aged 1–9 years for whom data on height, weight and haemoglobin level were available. This analytic sample was not significantly different from the total CNNS sample. Table A, shown in the appendix, provides the comparison of the analytic

sample with the total sample by sociodemographic variables. However, the sample further reduced for analysis when the association of malnutrition with micronutrient deficiency was examined. Around 20% of biological samples could not be analysed due to various reasons such as sample haemolysed because of transportation delay, quantity was not sufficient, test were not performed, invalid results, etc.). Figure A, shown in the appendix, provides details of each of the micronutrient valid cases for analysis).

### *Anthropometric and micronutrient indicators*

In this paper, analyses were limited to parameters related to undernutrition and anaemia. Box 1 provides details on equipment used or analytical method and reference to cut-off taken to mark undernutrition/deficiency.

<b>Box 1.</b> List of anthropometric and micronutrient indicators			
Indicators	Equipment used/Analytical method in lab	Cut-off	Reference
Stunting Underweight	SECA stadiometer SECA electronic weighing scale	Below -2 standard deviations using WHO AnthroPlus software	WHO standard
Anaemia	Haemoglobin concentration in venous whole blood sample analysed by cyanmethaemoglobin method using automated haematology counter	Hb<11.0 g/dl for children aged 12–59 months and Hb<11.5 g/dl for children aged 5–11 years considered as anaemia. Hb levels for all age groups adjusted for altitude	WHO standard
Vitamin D deficiency	Antibody competitive immunoassay using direct chemiluminescence (Siemens Centaur)	Serum 25(OH)D concentration <12 ng/mL (30 nmol/L)	Institute of Medicine (IOM) standard, 2011
Vitamin A deficiency*	HPLC reversed-phase chromatography	Serum retinol concentration <20 µg/dL	
Zinc deficiency	Flame Atomic Absorption spectrometry with D2 correction	Serum zinc concentration <65 µg/dl	International Zinc Nutrition Consultative Group, 2012
*All the cases with C-creative protein > 5 mg/L were excluded from the analysis.			

### *Outcome variable*

In the present paper, three parameters—stunting (short), underweight (thin) and anaemia among children aged 1–9 years were considered to understand child malnutrition. As per the WHO child growth standards [22], the three indicators are defined as:

1. Stunting: Children with height-for-age Z-score below -2 standard deviations (-2SD) from the median of the reference population are considered short for their age (stunted) and are chronically malnourished.
2. Underweight: The weight-for-age is a composite index of height-for-age and weight-for-height. It takes into account both acute and chronic malnutrition. Children whose weight-for-age is below -2SD from the median of the reference population are classified as underweight.
3. Anaemia: Children aged 12–59 months with Hb < 11.0 g/dl and children aged 5–11 years with Hb < 11.5 g/dl are considered as anaemic. Appropriate adjustments in these cut-off points were made for children living at altitudes above 1000 meters as these children require more haemoglobin in their blood.

The outcome variable of child malnutrition is operationally defined and categorised into the following three categories:

- Category 1 (severe): children stunted, underweight and anaemic (H/A: Z-score < -2SD and W/A: Z-score < -2SD and Hb < 11.0 g/dl)
- Category 2 (mild/moderate): children stunted or underweight or anaemic (H/A: Z-score < -2SD or W/A: Z-score < -2SD or Hb < 11.0 g/dl)

- Category 3 (normal): not stunted, not underweight and not anaemic (H/A: Z-score  $\geq$  -2SD and W/A: Z-score  $\geq$  -2SD and Hb  $\geq$  11.0 g/dl)

### ***Explanatory variables***

This study considered 11 explanatory variables based on literature review. Box 2 shows each of these explanatory variables and the categories used for this analysis.

<b>Box 2. List of Explanatory Variables and The Categories Used for this Study</b>		
	Name of the Variable	Categories
1.	Age of the child	1–4 years, 5–9 years
2.	Sex of the child	Male, Female
3.	Birth order of the child	1, 2, 3, 4+
4.	Preceding birth interval	Less than 2 years, 2–3 years, 3 years or more, No live birth before index child
5.	Mother's age at index childbirth	Under 20 years, 20–24 years, 25–29 years, 30 or more years
6.	Mother's schooling	No schooling, 1–7 years complete, 8–9 years complete, 10–11 years complete, 12 or more years complete
7.	Mother exposed to any media at least once a week	Yes, no
8.	Caste/tribe of the household	Scheduled Caste, Scheduled Tribe, Other Backward Class, Other (general caste)
9.	Wealth quintile	Poorest, Poor, Middle, Rich, Richest
10.	Place of residence	Rural, Urban
11.	Geographic region	North, Central, East, Northeast, West, South

### ***Statistical analysis***

In view of the complexity of the survey design, sampling weights were used and accounted for stratification and clustering in the sample design to estimate the proportion and 95% confidence intervals (CIs) for child malnutrition outcomes. The association of child malnutrition outcomes with socioeconomic and demographic characteristics and micronutrient deficiency (vitamin A, vitamin D and Zinc deficiency) indicators were verified using Pearson's  $\chi^2$  test and 95% CIs. The marginal effects probabilities with corresponding 95% CIs were calculated using the ordinal logit regression model to identify correlates of severe malnutrition. To account for the complex

sampling design, appropriate sampling weights were applied to maximise the representativeness of the sample of the intended population. The ‘svy’ command in Stata software version 15.1 (StataCorp LP, College Station, USA) was used to consider this effect. The WHO AnthroPlus software was utilised to calculate Z-scores (SD scores) for height-for-age and weight-for-age which expresses the anthropometric value below or above the reference mean or median value [23,24]. The unweighted number of cases were shown in each table as a base against each estimate.

## Results

The prevalence of stunting, underweight and anaemia was 28% (95% CI 26.6–29.4), 36% (95% CI 34.2–37.3) and 31% (95% CI 29.1–32.1), respectively (Figure 1). Nearly 1 of ten children were severely malnourished in the country (9%: 95% CI 8.0–9.6). Half of the children (48%: 95% CI 46.8–49.7) were mild/moderately malnourished and the remaining (43%: 95% CI 41.5–44.6) were normal (neither stunted nor underweight nor anaemic).

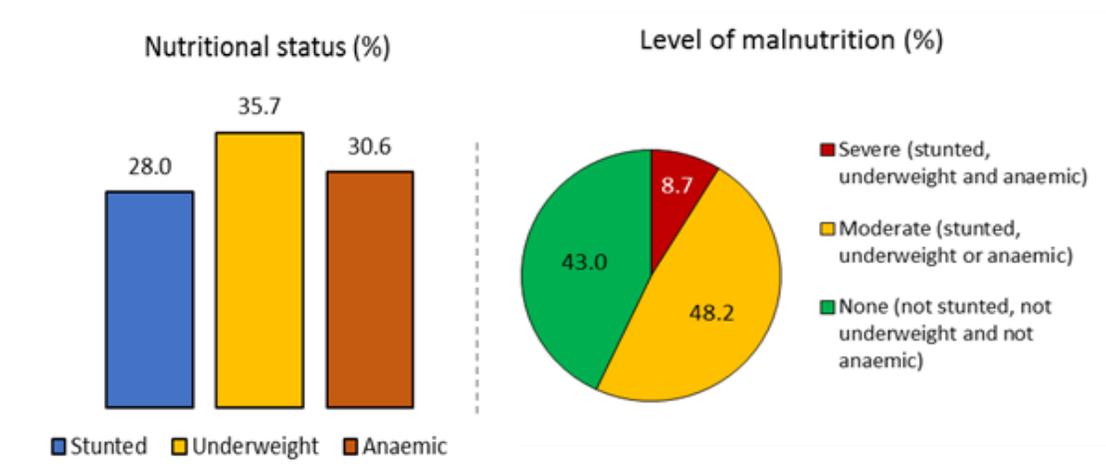
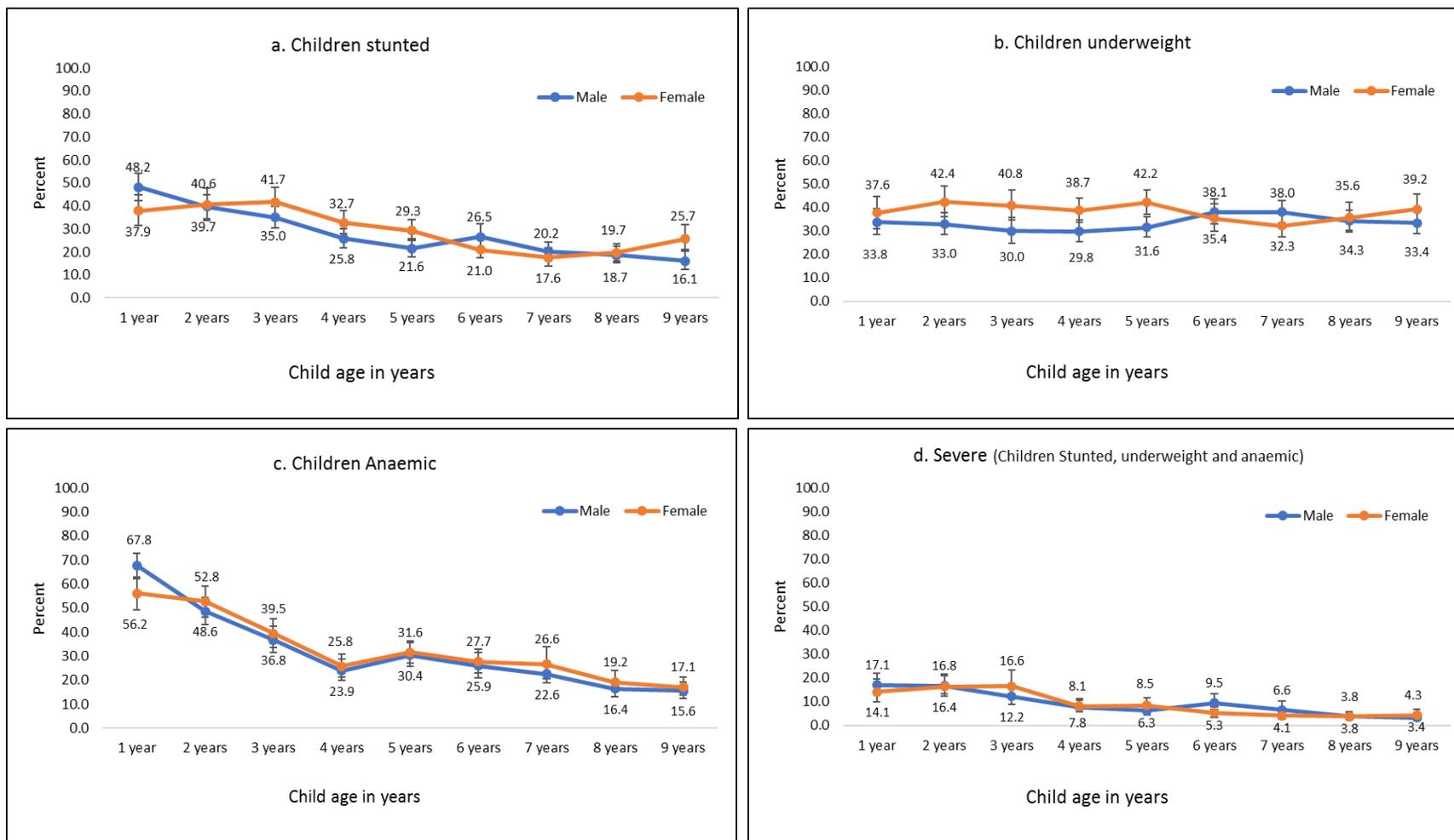


Figure 1: Nutritional outcome and level of malnutrition among children aged 1-9 years

Figure 2 shows how stunting decreased with an increase in the age of male children—from 48% (95% CI 42.2–54.3) at age 1 to 16% (95% CI 12.3–21.0) at age 9. A larger number of female children were underweight (38%: 95% CI 35.9–40.3) as compared to male children (34%: 95% CI 31.7–35.3) at age 1 (Figure 2b). The prevalence of anaemia among children was higher at a younger age, and declined sharply with an increase in age. Over two-thirds of male children (68%: 95% CI 62.3–72.9) were anaemic at age 1, while 16% (95% CI 12.5–19.3) were anaemic at age 9 (Figure 2c). A similar decline in prevalence of anaemia was observed among female children. Younger children were more severely malnourished as compared to older children—16% (95% CI 12.6–19.3) at age 1 vs 4% (95% CI 2.8–5.2) at age 9 (Figure 2d).

Table 1 shows how the prevalence of severe malnutrition was higher among children aged 1–4 years (13%: 95% CI 11.4–14.6) as compared to 6% (95% CI 4.9–6.3) in older children. A higher proportion of children whose mothers had no schooling were significantly severely malnourished (12%: 95% CI 10.6–13.5) as compared to children whose mothers had 12 or more years of schooling (3%: 95% CI 2.3–4.6). A higher proportion of children in poor households were severely malnourished as compared to children from rich households—(poor 15%: 95% CI 12.9–17.3) vs (rich 4%: 95% CI 3.0–4.6). Children living in the eastern region of the country were more severely malnourished (12%: 95%CI 10.3–13.2) as compared to children living in other regions.



**Figure 2:** Level of malnutrition (stunting, underweight, anaemia) among children by their age in years and gender, India

**Table 1:** Percentage of children aged 1–9 years who are malnourished (stunted, underweight, anaemic) by background characteristics, India, 2016-18

Background characteristics	Level of malnutrition			p-value*
	Severe % (95% CI)	Mild/moderate % (95% CI)	None % (95% CI)	
Age of the child				
1–4 years	12.9 (11.4 to 14.6)	51.2 (49.2 to 53.2)	35.8 (33.9 to 37.8)	<0.001
5–9 years	5.5 (4.9 to 6.3)	45.9 (43.9 to 48.0)	48.5 (46.5 to 50.6)	
Sex of the child				
Male	8.9 (7.9 to 10.0)	45.8 (44.1 to 47.5)	45.3 (43.5 to 47.1)	<0.720
Female	8.6 (7.4 to 9.8)	50.7 (48.6 to 52.9)	40.7 (38.6 to 42.8)	
Preceding birth interval				
Less than 2 years	9.3 (7.3 to 11.8)	52.4 (48.3 to 56.4)	38.3 (34.3 to 42.5)	<0.001
2–3 years	11.0 (9.3 to 13.0)	49.3 (46.1 to 52.5)	39.7 (36.6 to 42.9)	
3 years or more	8.7 (7.3 to 10.2)	47.8 (45.5 to 50.1)	43.5 (41.1 to 46.0)	
No live birth before index child	7.3 (6.3 to 8.4)	46.5 (44.5 to 48.5)	46.2 (44.1 to 48.3)	
Mother's age at index childbirth				
Under 20 years	9.0 (7.5 to 10.7)	51.4 (48.9 to 53.9)	39.7 (37.3 to 42.1)	<0.001
20–24 years	8.3 (7.3 to 9.5)	49.2 (47.2 to 51.3)	42.4 (40.4 to 44.5)	
25–29 years	9.9 (8.3 to 11.7)	44.8 (42.3 to 47.4)	45.3 (42.3 to 48.3)	
30 or more years	8.0 (6.1 to 10.4)	45.3 (41.6 to 49.1)	46.7 (42.9 to 50.5)	
Mother's schooling				
No schooling	12.0 (10.6 to 13.5)	50.2 (47.8 to 52.6)	37.8 (35.3 to 40.3)	<0.001
1–7 years complete	9.3 (7.8 to 11.0)	50.4 (47.5 to 53.3)	40.3 (37.4 to 43.3)	
8–9 years complete	8.2 (6.5 to 10.2)	50.0 (47.2 to 52.9)	41.8 (38.8 to 44.8)	
10–11 years complete	4.6 (3.6 to 5.8)	45.4 (41.8 to 49.1)	50.0 (46.4 to 53.6)	
12 or more years complete	3.2 (2.3 to 4.6)	40.5 (37.9 to 43.2)	56.3 (53.5 to 58.9)	
Mother exposed to any media <sup>1</sup>				
No	11.7 (10.3 to 13.3)	52.6 (49.6 to 55.5)	35.7 (32.9 to 38.6)	<0.001
Yes	6.9 (6.1 to 7.8)	45.6 (44.1 to 47.1)	47.4 (45.9 to 49.0)	
Caste/tribe of the household				
Scheduled Caste	9.6 (8.1 to 11.3)	50.1 (46.8 to 53.4)	40.3 (37.2 to 43.6)	<0.001
Scheduled Tribe	15.2 (12.5 to 18.3)	55.1 (52.2 to 57.9)	29.7 (26.7 to 33.0)	
Other Backward Class	8.1 (7.1 to 9.2)	46.6 (44.6 to 48.7)	45.3 (43.1 to 47.5)	
Other (general caste)	5.5 (4.0 to 7.4)	44.3 (41.8 to 46.9)	50.2 (47.0 to 53.4)	
Wealth quintile				
Poorest	14.9 (12.9 to 17.3)	51.5 (47.7 to 55.3)	33.6 (29.8 to 37.5)	<0.001
Poor	11.2 (9.2 to 13.6)	52.4 (49.2 to 55.6)	36.4 (32.6 to 40.3)	
Middle	8.5 (7.0 to 10.2)	51.3 (48.5 to 54.1)	40.2 (37.4 to 43.1)	
Rich	6.4 (4.9 to 8.2)	47.1 (44.7 to 49.6)	46.5 (43.8 to 49.2)	
Richest	3.7 (3.0 to 4.6)	38.8 (36.2 to 41.4)	57.5 (55.0 to 60.0)	
Place of residence				
Rural	9.3 (8.4 to 10.3)	49.8 (48.1 to 51.6)	40.9 (39.0 to 42.7)	<0.001
Urban	7.1 (5.8 to 8.7)	43.4 (41.0 to 45.8)	49.6 (46.9 to 52.2)	
Geographic region <sup>2</sup>				
North	5.9 (4.8 to 7.4)	41.8 (39.3 to 44.4)	52.2 (49.9 to 54.6)	<0.001
Central	8.7 (6.7 to 11.2)	47.8 (44.2 to 51.3)	43.6 (39.5 to 47.7)	
East	11.7 (10.3 to 13.2)	51.4 (48.4 to 54.3)	36.9 (34.2 to 39.8)	
Northeast	5.9 (4.4 to 7.8)	56.2 (51.0 to 61.4)	37.8 (33.0 to 43.0)	
West	9.2 (7.6 to 11.1)	50.3 (47.7 to 52.8)	40.5 (37.9 to 43.2)	
South	6.5 (5.2 to 7.9)	45.3 (42.6 to 48.0)	48.3 (45.4 to 51.1)	
Total	8.7 (8.0 to 9.6)	48.2 (46.8 to 49.7)	43.0 (41.5 to 44.6)	

Total includes 343 cases of 'do not know' category of 'age of mother at index child birth' which are not shown separately. \*Pearson's  $\chi^2$  test

<sup>1</sup>Reading newspaper, listening to radio or watching television at least once a week

<sup>2</sup>Geographic region: North (Jammu & Kashmir, Haryana, Rajasthan, Punjab, Delhi, Uttarakhand, Himachal Pradesh), Central (Uttar Pradesh, Madhya Pradesh, Chhattisgarh), East (Bihar, Odisha, Jharkhand, West Bengal), Northeast (Assam, Arunachal Pradesh, Manipur, Nagaland, Meghalaya, Mizoram, Sikkim, Tripura) West (Maharashtra, Gujarat, Goa) and South (Karnataka, Tamil Nadu, Kerala, Andhra Pradesh, Telangana).

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### *Socioeconomic determinants*

The results of the multivariate ordered logit model confirmed the bivariate analyses (Table 2).

After controlling the potential confounders in the model, the covariates that highly correlated with severe malnutrition among children were age and gender of the child, birth interval, mother's age at index childbirth, mother's schooling years, caste/tribe of household, wealth quintile and geographic regions (all  $P < 0.005$ ). For children aged 5–9 years, the probability of being severely malnourished was 5 percentage points (95% CI: -6.3 – -4.4) lower than children aged 1–4 years. Female children were more likely to become severely malnourished (one percentage point higher: 95% CI 0.3 to 1.8) than male children. Among children of mothers who had given birth at age 30 or more, the probability of being severely malnourished was 3 percentage points (95% CI: -4.5 – -1.8) lower than children of mothers who had given birth at age below 20. Among children of mothers with 12+ years of schooling, the probability of being severely malnourished was 4 percentage points (95% CI: -4.8 – -2.3) lower than children of mothers with no schooling. The probability of being severely malnourished was 3 percentage points (95% CI: 1.2 – 4.8) higher among Scheduled Tribe children than Scheduled Caste children. Likewise, the probability of severe malnutrition among children was 4 percentage points (95% CI: -5.9 – -2.1) lower among women in richest quintile than those belonging to the poorest quintile. Notably, severe malnutrition among children of the western region was 3 percentage points (95% CI: 1.5–3.6) higher than children in the northern region of the country.

**Table 2:** Ordered logit model of level of malnutrition (stunting, underweight, anaemia) among children aged 1–9 years, by selected characteristics, India, 2016-18

Covariates	Marginal effects					
	Severe		Mild/moderate		None	
	% (95% CI)	p-value	% (95% CI)	p-value	% (95% CI)	p-value
Age of the child						
1–4 years	Ref.		Ref.		Ref.	
5–9 years	-5.4 (-6.3 to -4.4)	0.000	-11.8 (-13.5 to -10.1)	0.000	17.2 (14.7 to 19.6)	0.000
Sex of the child						
Male	Ref.		Ref.		Ref.	
Female	1.0 (0.3 to 1.8)	0.004	2.5 (0.8 to 4.3)	0.004	-3.6 (-6.0 to -1.1)	0.004
Preceding birth interval						
Less than 2 years	Ref.		Ref.		Ref.	
2–3 years	-0.1 (-1.6 to 1.3)	0.853	-0.3 (-3.3 to 2.7)	0.852	0.4 (-4.1 to 4.9)	0.852
3 years or more	-0.8 (-2.4 to 0.7)	0.283	-1.8 (-5.0 to 1.4)	0.270	2.6 (-2.1 to 7.4)	0.274
No live birth before index child	-1.9 (-3.1 to -0.6)	0.003	-4.5 (-7.2 to -1.8)	0.001	6.4 (2.5 to 10.3)	0.001
Mother's age at index childbirth						
Under 20 years	Ref.		Ref.		Ref.	
20–24 years	-1.2 (-2.2 to -0.2)	0.018	-2.5 (-4.5 to -0.5)	0.014	3.8 (0.7 to 6.8)	0.015
25–29 years	-2.1 (-3.5 to -0.7)	0.003	-4.7 (-7.9 to -1.6)	0.004	6.8 (2.3 to 11.3)	0.003
30 or more years	-3.1 (-4.5 to -1.8)	0.000	-7.9 (-11.4 to -4.5)	0.000	11.1 (6.4 to 15.8)	0.000
Mother's schooling						
No schooling	Ref.		Ref.		Ref.	
1–7 years complete	-0.5 (-1.7 to 0.8)	0.460	-1.0 (-3.6 to 1.6)	0.462	1.4 (-2.4 to 5.3)	0.461
8–9 years complete	-0.9 (-2.2 to 0.3)	0.155	-1.9 (-4.6 to 0.8)	0.167	2.8 (-1.1 to 6.8)	0.163
10–11 years complete	-2.5 (-3.8 to -1.3)	0.000	-6.3 (-9.7 to -3.0)	0.000	8.9 (4.3 to 13.4)	0.000
12 or more years complete	-3.5 (-4.8 to -2.3)	0.000	-10.0 (-13.7 to -6.3)	0.000	13.5 (8.6 to 18.4)	0.000
Mother exposed to any media <sup>1</sup>						
No	Ref.		Ref.		Ref.	
Yes	-1.0 (-2.1 to 0.1)	0.088	-2.3 (-5.0 to 0.3)	0.085	3.3 (-0.5 to 7.1)	0.085
Caste/tribe of the household						
Scheduled Caste	Ref.		Ref.		Ref.	
Scheduled Tribe	3.0 (1.2 to 4.8)	0.001	4.8 (2.2 to 7.4)	0.000	-7.8 (-12.1 to -3.5)	0.000
Other Backward Class	-1.1 (-2.2 to 0.0)	0.041	-2.7 (-5.1 to -0.2)	0.037	3.8 (0.2 to 7.3)	0.038
Other (general caste)	-1.9 (-3.1 to -0.6)	0.004	-4.8 (-8.3 to -1.3)	0.007	6.7 (1.9 to 11.4)	0.006
Wealth quintile						
Poorest	Ref.		Ref.		Ref.	
Poor	-1.1 (-3.0 to 0.7)	0.240	-2.0 (-5.5 to 1.4)	0.246	3.1 (-2.1 to 8.4)	0.243
Middle	-1.6 (-3.2 to 0.1)	0.064	-3.0 (-5.9 to 0.0)	0.048	4.5 (0.0 to 9.1)	0.052
Rich	-2.5 (-4.3 to -0.7)	0.006	-5.3 (-8.8 to -1.8)	0.003	7.8 (2.5 to 13.0)	0.004
Richest	-4.0 (-5.9 to -2.1)	0.000	-10.0 (-14.2 to -5.8)	0.000	14.0 (8.0 to 20.1)	0.000
Place of residence						
Rural	Ref.		Ref.		Ref.	
Urban	0.6 (-0.4 to 1.7)	0.229	1.6 (-0.9 to 4.0)	0.219	-2.2 (-5.7 to 1.3)	0.222
Geographic region						
North	Ref.		Ref.		Ref.	

Central	0.5 (-0.8 to 1.9)	0.421	1.6 (-2.1 to 5.2)	0.406	-2.1 (-7.1 to 2.9)	0.410
East	2.3 (1.2 to 3.3)	0.000	5.6 (2.9 to 8.2)	0.000	-7.8 (-11.4 to -4.2)	0.000
Northeast	1.5 (-0.2 to 3.2)	0.088	4.0 (-0.2 to 8.1)	0.062	-5.5 (-11.4 to 0.4)	0.068
West	2.5 (1.5 to 3.6)	0.000	6.0 (3.5 to 8.6)	0.000	-8.6 (-12.1 to -5.0)	0.000
South	0.2 (-0.7 to 1.2)	0.633	0.7 (-2.1 to 3.5)	0.634	-0.9 (-4.6 to 2.8)	0.633

Notes: All three unweighted samples n = 1558; Any one unweighted sample n = 11135; None unweighted samples n = 13192.

Ref: Reference category; CI: confidence interval.

<sup>1,2</sup>Refere to Table 1.

### *Association of malnutrition with micronutrient deficiency*

After controlling the potential confounders in the regression model (Table 3), it was found that out of the total number of children who were severely malnourished, 22% (95% CI: 18.2–26.0) had higher zinc deficiency as compared to normal children (16%, 95% CI: 13.9–17.3). No significant difference was observed in zinc deficiency by gender among severely malnourished children. Among severely malnourished children, vitamin D and vitamin A deficiencies were observed in an increasing trend in female and older children as compared to male and younger children. The marginal effect of level of malnutrition among children aged 1–9 years on key explanatory variables using the ordered logit model is shown in Figure 3. The probability of zinc deficiency was 1 and 4 percentage points higher among severely and mild/moderately malnourished children, respectively, as compared to children with no zinc deficiency. vitamin D, vitamin A and zinc deficiencies were found more in severely malnourished children compared to other children.

**Table 3:** Association of multiple micronutrient deficiencies among children according to level of malnutrition, India, 2016-18

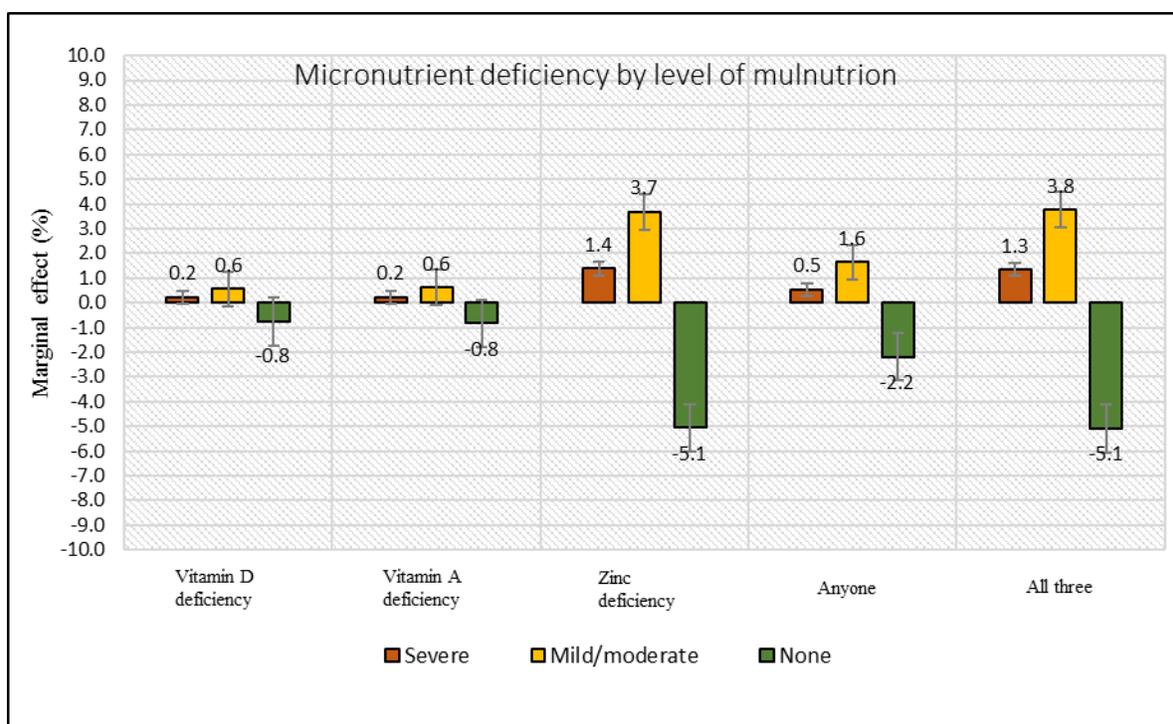
Level of malnutrition	Level of malnutrition			n (un-weighted)	
	Severe	Mild/moderate	None		
	Adj propn <sup>1</sup> . (95% CI)	Adj propn <sup>1</sup> . (95% CI)	Adj propn <sup>1</sup> . (95% CI)		
Vitamin D deficiency					
Gender	Male	16.3 (12.0 to 20.7)	12.9 (10.9 to 14.9)	13.9 (12.2 to 15.5)	11,654
	Female	18.1 (13.5 to 22.6)	14.3 (12.5 to 16.1)	15.3 (13.4 to 17.3)	10,108
Age	1–4 years	14.6 (10.6 to 18.7)	11.5 (9.4 to 13.6)	12.4 (10.6 to 14.2)	9,320
	5–9 years	19.2 (14.4 to 24.1)	15.3 (13.4 to 17.2)	16.4 (14.5 to 18.3)	12,442
	Total	17.2 (12.9 to 21.4)	13.6 (11.9 to 15.3)	14.6 (13.1 to 16.0)	21,762
Vitamin A deficiency					

Gender	Male	18.4 (14.1 to 22.7)	18.9 (16.6 to 21.2)	17.6 (15.2 to 20.1)	8,494
	Female	19.7 (15.0 to 24.5)	20.3 (17.4 to 23.2)	19.0 (15.4 to 22.6)	7,308
Age	1–4 years	16.9 (12.6 to 21.1)	17.3 (15.1 to 19.6)	16.2 (13.4 to 19.0)	6,528
	5–9 years	20.7 (16.0 to 25.5)	21.3 (18.3 to 24.3)	19.9 (16.6 to 23.2)	9,274
	Total	19.0 (14.7 to 23.3)	19.6 (17.3 to 21.8)	18.3 (15.6 to 21.0)	15,802
Zinc deficiency					
Gender	Male	22.0 (18.0 to 26.0)	17.2 (15.4 to 18.9)	15.5 (13.6 to 17.4)	10,856
	Female	22.3 (18.0 to 26.5)	17.4 (15.6 to 19.2)	15.7 (13.7 to 17.7)	9,341
Age	1–4 years	23.2 (19.0 to 27.4)	18.2 (15.9 to 20.4)	16.4 (13.8 to 19.1)	8,663
	5–9 years	21.4 (17.1 to 25.6)	16.6 (14.9 to 18.3)	15.0 (13.4 to 16.6)	11,534
	Total	22.1 (18.2 to 26.0)	17.3 (15.8 to 18.7)	15.6 (13.9 to 17.3)	20,197

Note: Out of 25,885 sample children, 16% of vitamin A, 39% of vitamin D and 22% of zinc samples could not be analysed because of various reasons (samples hemolyzed because of transportation delay, quantity was not sufficient, test not performed, invalid results, etc.).

<sup>1</sup>Adjusted proportion calculated from logistic regression model controlled for sex of child, age of child, preceding birth interval, mother's age at index childbirth, mother's education, mother exposed to any media at least once a week, place of residence, social group (caste/tribe), wealth quintile and geographic regions of India.

CI: Confidence Interval.



**Figure 3:** Marginal effect (with 95% CI) of level of malnutrition (stunting, underweight, anaemia) among children aged 1–9 years on key explanatory variables using ordered logit model. The modal adjusted for age and sex of the child, birth order, previous birth interval, mother's age at index child birth, mother's schooling, mother's exposure to any mass media (reading newspaper, listening to radio or watching television at least once a week), caste/tribe of household, wealth index, place of residence and geographic regions of India.

## Discussion

It was found that one out of ten children aged 1-9 years (13% in children aged 1–4 years and 6% in children aged 5–9 years) were severely malnourished and nearly half (48%) were mild/moderately malnourished in the country. There was no significant difference based on the gender of children. Altogether, six out of 10 children aged 1–9 years suffered from any of the three parameters associated with malnutrition (stunting, underweight or anaemia) in the country, indicating more care needs to be provided for younger age children in the future. The findings pointed out that children aged 1–4 years were more vulnerable to malnourishment as compared to older children. However, the prevalence of malnutrition declined with an increase in age of children but the rate remained the same between male and female children.

The findings of this study are important and were aimed at measuring the level of child malnutrition and its socioeconomic and demographic determinants in the child population of India. A study by Swaminathan et. al., revealed that in India 70% of children died before they completed their 5<sup>th</sup> birthday because of several underlying factors including malnutrition [25]. This study found that mother's education, mother's exposure to any mass media and wealth played an important role in minimising malnutrition among children in the country. However, measuring child malnutrition is complex as several factors are associated with it. According to CNNS, over one-third (35%) of children under the age of 5 were stunted, 33% were underweight and 17% were wasted. Among children aged 5–9 years, 22% were stunted and 10% were underweight. These findings along with the NFHS-4 findings point to the alarming, though gradually improving, situation of child nutrition in India. However, compared to the NFHS-4 data that showed malnutrition levels at 38%, the CNNS data showed a drop by 3% over the last

one and a half years. Anaemia in young children is a serious concern because it can result in increased morbidity from infectious diseases and impaired cognitive development. Based on NFHS-4 and CNNS data, it is evident that anaemia continues to remain high among children [12, 21]. Stunting, underweight and anaemia among children are somewhat associated with poverty, dietary restrictions, lack of awareness about consequences and poor hygiene practice in the household [26-30].

The ICDS is one of Government of India's flagship programmes for early childhood care and development of children. It provides pre-school non-formal education and aims to break the vicious cycle of malnutrition, deformity, low learning ability and mortality [31,32]. The national-level surveys revealed that more than half of the children received at least one service from ICDS, but only less than 10% received a comprehensive package of benefits (daily food, monthly health checkups, regular visit for early childhood care and monthly weight measurement) [12, 21,33]. Although, a significant decrease in malnutrition can be observed among children of poor families attending *Anganwadi* centers, thereby minimising the inequality between poor and rich households in the country [32]. In recent years, the Indian government has launched other similar initiatives. The *Poshan Abhiyaan* is one such initiative aimed at battling malnutrition among children and mothers [19].

Although India has achieved considerable success in ending poverty in recent decades, malnutrition still affects a large segment of the population [12]. Hence, reducing the prevalence of stunting among children by 2% per annum, from 38.4% (NFHS 2015–16) to 25% by 2022 under Mission 25, is an over-ambitious target [20]. In India, there are varied forms of child

malnutrition by socioeconomic status. The findings of this study clearly showed an increased prevalence of severe malnutrition among children with an unfavourable socioeconomic status, such as higher proportion of children born to illiterate mothers, children belonging to Scheduled Tribes and poor families and children living in rural areas and the eastern region of the country. Similar findings have also been highlighted in many other studies worldwide [34-38].

Malnutrition is found in many forms such as wasting, stunting, underweight, inadequate vitamins or minerals, overweight, obesity and diet-related nonclinical diseases [39, 40]. One of the key principles of WHO is to ensure that actions are employed in such a way that addressing one form of malnutrition should not increase the risk of other forms [41]. According to Dr. Francesco Branca, WHO Director of Nutrition for Health and Development and Anna Lartey, Director of Nutrition Division, FAO, “The purpose of the UN Decade of Action on Nutrition—from 2016 to 2025—is to inject new energy into efforts to improve people’s nutrition worldwide. We should strengthen our health systems so that everybody has access to essential nutrition services. We should ensure that women are educated and that schools offer nutritious food to all children to fulfill the SDG-2 goal” [42, 43].

This study analysed cross-sectional data, due to which a causal relationship between contextual factors and reduced likelihood of severity of malnutrition could not be established. The level of child malnutrition must be read with caution as it is operationally defined with the inclusion of three indicators – anaemia along with stunting and underweight. Nevertheless, it is believed that this study’s results are consistent for the following reasons. First, the CNNS is a nationally representative survey covering all the states of India, in terms of both the sample size and the

surveyed components (behavioral, anthropometry and biological). Second, in general, data was analysed using appropriate statistical methods and the findings corroborate similar studies. Third, the analytical sample for this study was not significantly different from the total sample of CNNS in context of all the selected background characteristics. However, the association of child malnutrition with different micronutrient deficiency could not be examined in detail because of the small analytic sample.

## **Conclusions**

Almost one out of ten children in aged 1-9 years were suffering from severe malnutrition (more younger children than older) and nearly half were mild/moderately malnourished in the country, where boys and girls were not significantly different. Severe malnutrition was significantly higher among higher birth interval children, children born to illiterate mothers, children belonging to Scheduled Tribes and poor families and children living in rural areas and the eastern region of the country. Children who were severely malnourished had more zinc deficiencies as compared to children with no zinc deficiencies. Targeted strategies are required to guide and monitor frontline workers to identify at-risk and affected children through regular monitoring of height, weight and haemoglobin testing in their coverage areas.

## **List of abbreviations**

CNNS: Comprehensive National Nutrition Survey (CNNS); SDG: Sustainable Development Goal; ICDS: Integrated Child Development Services; NNS: National Nutrition Strategy; NFHS: National Family Health Survey; PSU: primary sampling unit; PPS: probability proportional to

population size; CI: Confidence Interval; SRL: Super Religare Laboratories; PGIMER: Post Graduate Institute for Medical Education and Research; FAO: Food and Agriculture Organization;

## **Declarations**

### ***Ethics approval and consent to participants***

The CNNS received ethical clearance from the Ethical Review Board of the Post Graduate Institute for Medical Education and Research (PGIMER). The survey personnel obtained informed consent from each respondent before the survey interviews and anthropometry and biological sample collections.

### ***Consent for publication***

Not applicable.

### ***Availability of data and materials***

The CNNS data is not in the public domain, but it is headed by principal investigator, Dr. Rajib Acharya (co-author of this manuscript). Data can be obtained by writing him an email for research purposes with reasonable request

### ***Competing interests***

None of the authors listed on this manuscript reported any conflict of interest. The opinions expressed are those of the authors do not necessarily reflect the views of their affiliate institutions.

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### ***Authors' contributions***

NK, RA and PA conceptualised and designed the paper. NK analysed the data and wrote the first draft. AP and SA reviewed data presented in tables and figures. SR, RA, PA, RJ, AP, and AS reviewed the paper. All authors read the manuscript, made substantial contributions to the revision and approved the final manuscript.

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Not applicable

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# Figures

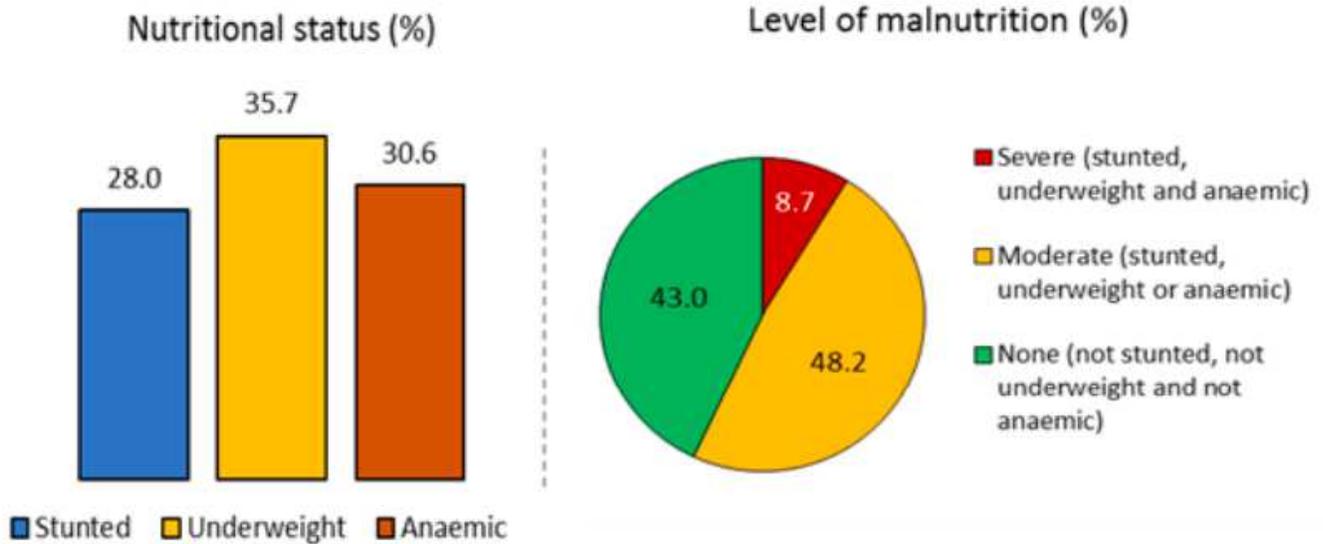


Figure 1

Please see the Manuscript PDF file for the complete figure caption

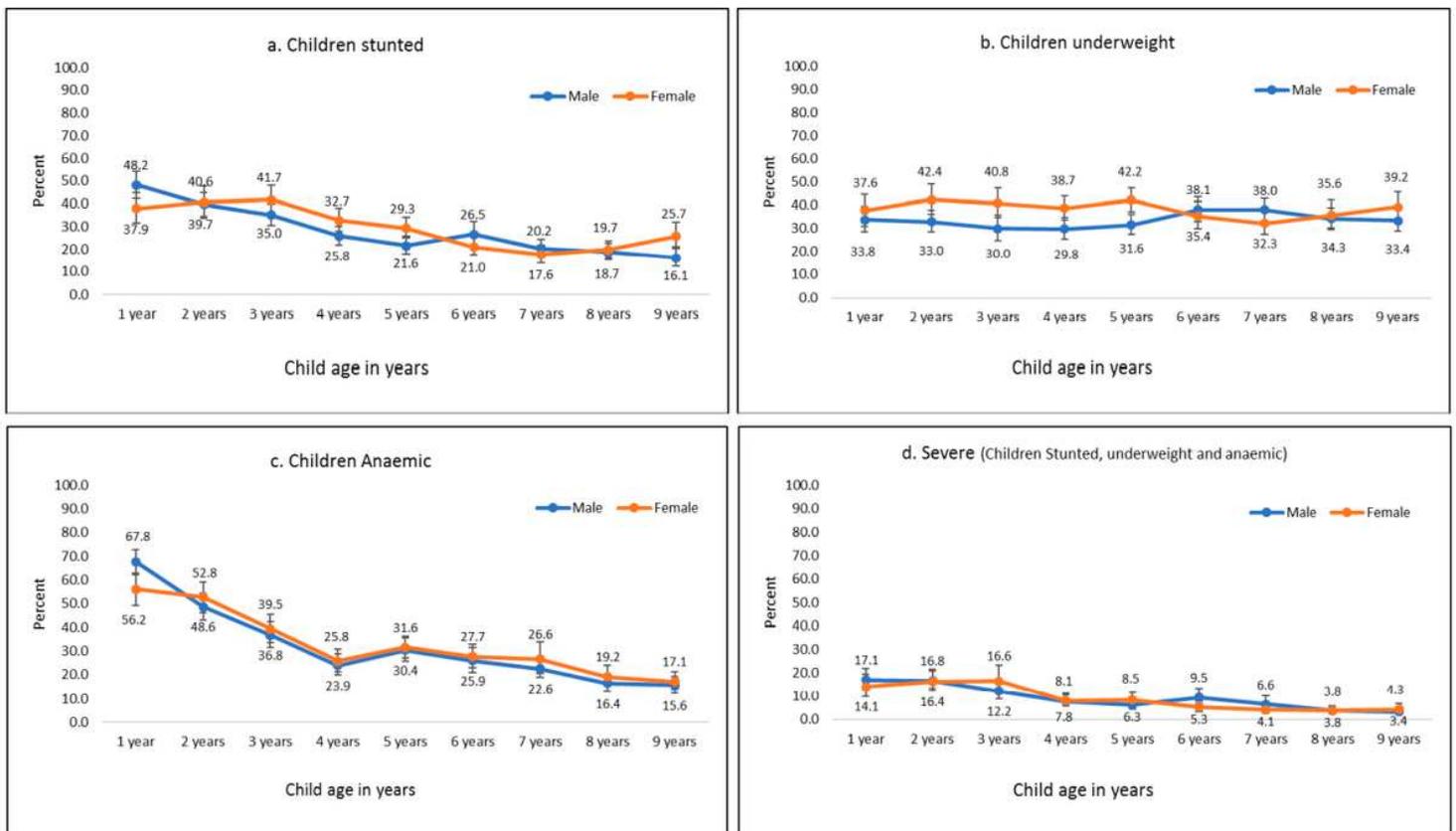


Figure 2

Level of malnutrition (stunting, underweight, anaemia) among children by their age in years and gender, India

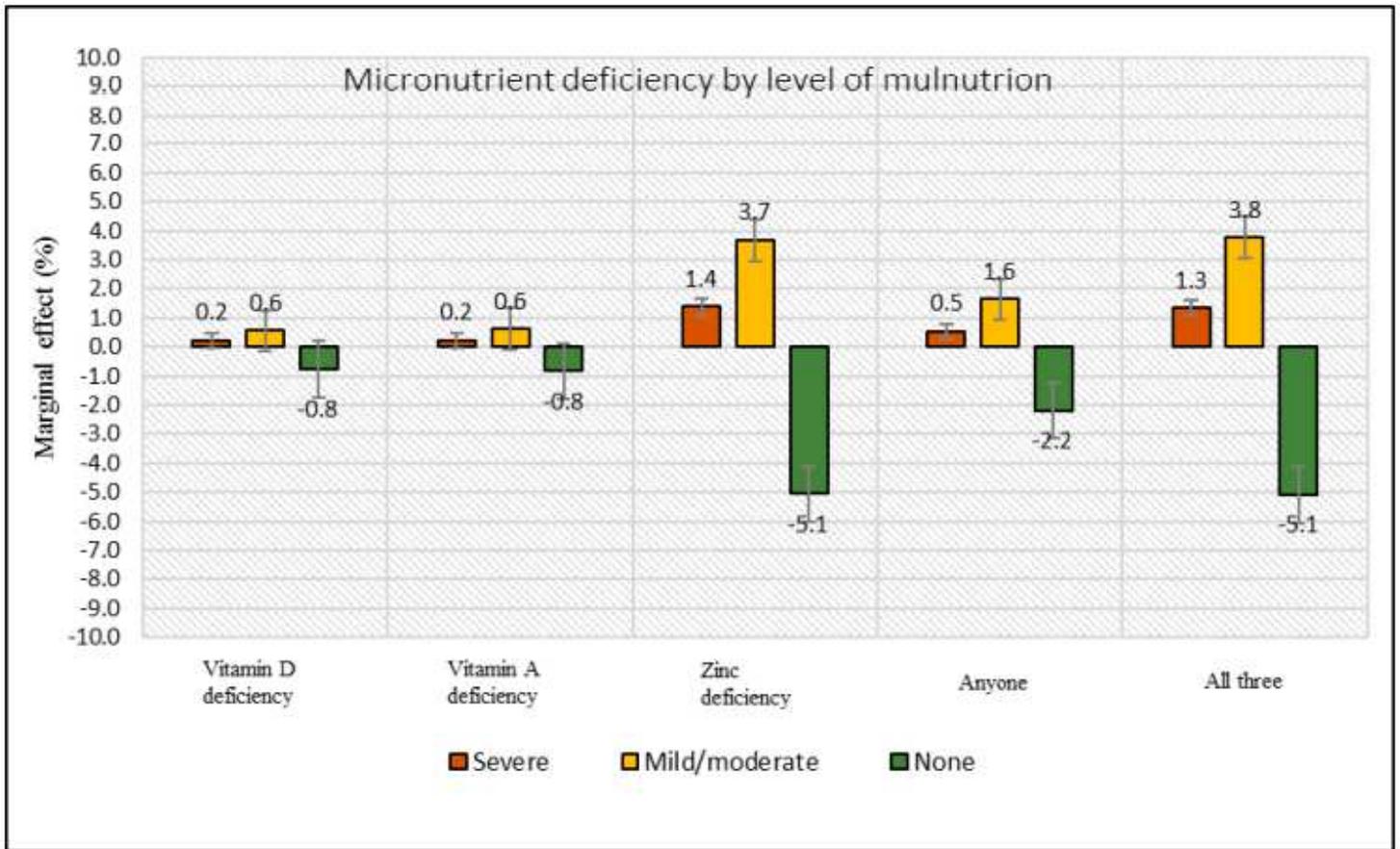


Figure 3

Marginal effect (with 95% CI) of level of malnutrition (stunting, underweight, anaemia) among children aged 1–9 years on key explanatory variables using ordered logit model. The model adjusted for age and sex of the child, birth order, previous birth interval, mother's age at index child birth, mother's schooling, mother's exposure to any mass media (reading newspaper, listening to radio or watching television at least once a week), caste/tribe of household, wealth index, place of residence and geographic regions of India.

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