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ORIGINAL PAPER

Malnutrition among children in India: exploring the contribution of the integrated child development service scheme

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Abstract
In India, the current nutritional transition illustrates a noteworthy decline in the incidence of undernutrition among children under the age of 5 over the past decade. Decline in under-nutrition may be attributed to the various nutrition interventions. Nevertheless, the provision of nutrition supplementation under Integrated Child Development Services (ICDS) is hypothesized to contribute significantly. This study examines the factors influencing the decrease in undernutrition among children and assesses the contribution of ICDS based on data from the two rounds of the National Family Health Surveys conducted during 2005–2016. The results indicate a noteworthy reduction in the level of stunting and underweight among children. This decline was found to be positively associated with maternal nutrition, while it was negatively associated with utilization of ICDS. Decomposition results portray wealth index, caste and religion as the factors, significantly reducing undernutrition. Propensity Score Matching (PSM) portrays a substantial reduction in the estimated prevalence of stunting among those using ICDS (40%), which would have been 47% otherwise. After matching 7% difference exist in the prevalence of stunting among children using the ICDS in comparison to those who were not using the ICDS. Results indicate that the ICDS in its present form contributes to a considerable reduction in undernutrition among children, despite of selectivity bias in registration with Anganwadi centres. Therefore, the service provisions under ICDS need to be strengthening to break the detrimental cycle of undernutrition through intensification of counseling by prioritized home visits of anganwadi workers and reaching to the critical age-groups including pregnant women and lactating mothers.

Keywords Malnutrition · Children · ICDS · NFHS · India

Abbreviations

ICDS	Integrated child development services
PSM	Propensity score matching
MDG	Millennium development goals

Extended author information available on the last page of the article

SDG	Sustainable development goals
MAA	Mothers' absolute affection
RMNCH + A	Reproductive, maternal, newborn child plus adolescent health
AWCs	Anganwadi centres
AWWs	Anganwadi workers
THR	Taking home rations
NFHS	National family health survey
PSUs	Primary sampling units
CEBs	Census enumeration blocks

Background

Over the years, there has been a rising concern among health planners and program managers in most developing countries, including India, to effectively trim down the burden of malnutrition as part of ensuring the health and wellbeing of people. The weigh down of nutrition in any country adversely affects the health and wellbeing of all age group people, but children are at higher risk due to an adverse impact on their cognitive development affecting their entire lifecycle (Unicef and World Health Organization 2014). Ensuring healthy nutritional status in early ages is crucial as it plays a vital role in their overall growth and development. Reduction in chronic malnutrition among young children stood as a key goal within the of the primary objectives of Millennium Development Goals (MDG). However, 162 million young children below age five were still suffering from chronic malnutrition by the end of the MDGs (Unicef and World Health Organization 2014). In 2018, approximately 149 million under the age of five years children worldwide experienced stunting, while 49 million were classified as wasted. Around half of all stunted children lived in developing and less developed countries of Asia and Africa (World Health Organization 2019). In the Sustainable Development Goals (SDGs), nutrition has been considered as an essential domain to achieve other goals. For that reason, the SDGs-2 enforces to eradicate hunger, assuring food security, and increase the nutritional status of children by 2030 (Verburg 2015).

India is home to around 40% of the world's undernourished children (Mitra et al. 2007). The problem of malnutrition in India is more acute and severe in comparisons to most of the countries of sub-Saharan Africa, despite an impressive economic growth and agricultural production in the last decade (Deaton and Drèze 2009). It is worthwhile to mention that food insecurity may not be a key catalyst for malnourishment in India. Malnourishment may occur even in households with no food insecurity: many children from food secure environments belonging to non-poor households are malnourished. This may be due to inappropriate infant and young child feeding and child care practices, lack of baby friendly hospital initiatives, poor access to health services, lack of continuum of care, no or partial immunization and recurrent infections (Singh et al. 1998). It is not food production that is the limiting factor in many of the countries where malnutrition is prevalent. Investing in malnutrition lowers poverty, boosts economic growth, and yields large returns (Shekar et al. 2006). Socio-economic inequality significantly affects stunting in developing countries like Ecuador, Bangladesh, and Ghana (Milman et al. 2005; Poel et al. 2008; Novignon et al. 2015a; Nwosu and Ataguba 2020; Kumar and Paswan 2021). Existing literature suggest that the alleviating poverty and bolstering health infrastructure will contribute significantly to enhancing child health conditions, particularly addressing malnutrition (Larrea and Kawachi 2005; Novignon et al. 2015b). However, the causal link between child malnourishment and socio-economic inequality is not explicit. Child malnourishment is often identified as a cause of repeated morbidity (Yohannes et al. 2017; Dipasquale et al. 2020; Govender et al. 2021; Tette et al. 2015). It constitutes a major mechanism through which education and productivity are degraded resulting in the socio-economic inequality and spread of intergenerational poverty (Economic Commission for Latin America and the Caribbean (ECLAC) et al. 2006). In the context of India, child malnutrition disproportionately affects the economically disadvantaged. Child malnutrition is a prevalent consequence of poverty, particularly in economically disadvantaged states, exacerbating the scourge of malnutrition in India (Kanjilal et al. 2010).

Building upon the research findings mentioned earlier and recent evidence, it is increasingly clear that undernutrition results from a complex interplay involving insufficient dietary intake, absorption issues, inadequate prevention and management of diseases/infections, and various underlying determinants (Saunders and Smith 2010; Norman et al. 2021). In response, the Government of India has implemented a range of nutrition-sensitive and nutrition-specific interventions. Accordingly, an enormous number of the programmes have been undertaken to improve the children nutritional status, which includes a De-worming programme for children, early breastfeeding initiation under MAA (Mothers' Absolute Affection) national breastfeeding programme, supplementation of Iron-Folic Acid tablets (IFA), National Food Security Mission and Poshan Abhiyan for holistic nourishment. Also, there has been the provision of nutrition supplement under integrated child development Services (ICDS) scheme, Mid-day Meal (MDM), Targeted Public Distribution System (TPDS). The Government of India also started, Janani Suraksha Yojana, Matritva Sahyog Yojana, National Health Mission- including Reproductive, Maternal, Newborn Child plus Adolescent Health (RMNCH + A) and Swachh Bharat including Sanitation and the National Rural Drinking Water Programme, which target to eradicate the problem of under nutrition directly and indirectly. Among these programs, ICDS is a pioneering initiative aimed at breaking the cycle of undernutrition through a lifecycle approach, targeting crucial age groups. Initiated by the Government of India in 1975, the scheme is designed to enhance the children health and nutrition, pregnant women, and lactating mothers. Children up to six years old are eligible for ICDS services, which include supplementary nutrition, health check-ups, growth monitoring, and immunization. Additionally, pregnant and lactating mothers benefit from intensified counselling on nutritional and health information for both mothers and children.

It was the first time in 2005–06 after the NFHS-3 resulted were announced, the issue of malnutrition among children in India enticed the focused attention of programme managers and policymakers when it was announced that the prevalence of malnutrition in India was one of the highest in the world. The NFHS-3 results highlighted that nearly half of the children under age five (48%) were stunted, and 43%

were underweight (IIPS and ICF 2007). Also, it was highlighted that the ICDS programme in India covered only 110 out of 160 million children age up to six years. Based on these two sets of information, the consensus was that the ICDS scheme had not significantly contributed to an improvement in the nutritional status of children. Some of the reasons behind the lagging success of ICDS scheme were an inability to provide hot cooked food, irregularity and malpractices in the distribution of food for infants, which were primarily because of the irregular functioning of Anganwadi Centres (AWCs). Another reason was the selectivity in the list of beneficiaries, as the majority of the children registered under ICDS scheme were from the lowest socio-economic strata and hence more vulnerable to get protein, minerals, and vitamin-rich supplements. Consequently, the ICDS scheme underwent restructuring, incorporating care counselling with prioritized home visits by Anganwadi workers (AWW), and implementing decentralized monitoring to address day-to-day operational challenges more meticulously. As 2015–16 NFHS-4 results present a substantial decline in the prevalence of stunting as well as underweight among children. It is hypothesized that the vertical interventions for improving the functioning of the ICDS scheme and nutrition awareness to mothers might have been one of the contributory factors behind the improvement in malnutrition among children. It is against this backdrop; the study aims to analyse the factors affecting a reduction in the level of malnutrition among children and the contribution of ICDS scheme in addressing malnutrition among under-five children in the last one decade.

Data and methods

This paper relies on data derived from two rounds of the National Family Health Survey, specifically NFHS-3 (2005–06) and NFHS-4 (2015–16). NFHS's primary aim is to furnish vital information on health and family welfare, encompassing emerging issues like nutritional status of children under the age of five at national, state, and district levels. Consequently, NFHS-4 (2015–16) data serves as a benchmark to assess the country's progress in diverse health indicators over time. Altogether, NFHS-4 encompassed 601,509 households, surveyed 699,686 women and 103,525 men, sampled from 28,583 Primary Sampling Units (PSUs) comprising villages in rural areas and Census Enumeration Blocks (CEBs) in urban areas, spanning across 640 districts in India (IIPS and ICF 2017). This study's conclusions draw from a comprehensive dataset comprising 246,482 children aged below five years. The biomarker covered measurements of height, weight and haemoglobin levels for children; measurements of weight, height, blood pressure, hemoglobin levels, and level of random blood glucose for women aged 15–49 years and men aged 15–54 years. Anthropometric data collection involved measuring the height and weight of children aged 0–59 months, women aged 15–49 years, and, in a subset of households, men aged 15–54 years (IIPS and ICF 2017).

The Seca 874 digital scale was used to measure the weight of children. The height of children aged 24–59 months, was measured by Seca 213 stadiometer. The Seca stadiometer, also known as an infantometer, was employed to measure the recumbent length of children aged two years or younger, specifically those less than 85 cm in height. The national report of NFHS-4 contains information on the designs, tools, and protocols used in the program (IIPS and ICF 2017), and all the relevant information is accessible in the public domain on http://rchiips.org/NFHS/districtfactsheet_NFHS-4.shtml.

Statistical methods used in the analysis

Bivariate and multivariate regression analyses were applied appropriately to comprehend the level and changes in the nutritional status of children under the age of five. A binary logistic regression model was employed to assess the adjusted impacts of different predictors on stunting, wasting, and underweight. The estimation of the Logistic Regression Model commonly relies on the maximum likelihood function. Concerning the outcome variable, the logistic model is generally expressed as follows:

$$\text{Login P} = \ln(\text{P}/1-\text{P}) = \text{b0} + \text{b1x1} + \text{b2x2} + \text{b3x3} + \ldots\ldots + \text{bixi} + \text{e},$$

Here, b1, b2, b3, and bi denote the coefficients for each predictor variable incorporated in the model, with e representing the error term. The expression ln (P/1-P) signifies the natural logarithm of the odds of the outcome.

Fairlie decomposition

To assess the varying contributions of different factors to stunting, wasting, and underweight in children aged 0–59 months, we utilize a decomposition technique developed by Fairlie (2005). This approach helps break down the differences in malnutrition prevalence between the periods of 2005–06 (NFHS-3) and 2015–16 (NFHS-4). In the estimation process, we initially derive the logit model to estimate the prevalence of malnutrition among children aged 0–59 months., where i is the ith children and t = (m, n) represent the years, m is for 2005–06 and n is for 2015–16. The estimated probability that children in year t have malnutrition prevalence:

$$\text{Yit} = \Phi\text{Xit}\,\beta\text{t},\ \text{t} = \text{m},\ \text{n} \tag{1}$$

where βt is the logit estimate of the parameter vector and Φ is the standard logistic cumulative distribution function. The unbiased average predictor for those malnourished in the year t is given by the estimated β for two periods as

$$\text{Y} = 1/\,\text{Nt. Nti} = 1\Phi\,\text{Xit}\,\beta\text{t},\ \text{t} = \text{m},\ \text{n}. \tag{2}$$

where Nt is the number of children in Yeart's. As per Even and Macpherson (1990), assuming individual characteristics remain consistent between the 2005–06 and 2015–16 samples, the average estimated probability is:

$$\text{Y}_0 = 1/\,\text{Nt. Nti} = 1\Phi\text{Xit}\,\beta\text{t}\,. \tag{3}$$

Based on Fairlie's approach (Fairlie 1999), a decomposition of the logistic equation Y = Z X, β is given as:

$$\mathrm{Y^m} - \mathrm{Y^n} = \underset{i=1}{N^m} \frac{ZX_i^m \beta^m}{N^m} - \underset{i=1}{N^n} \frac{ZX_i^n \beta^n}{N^n} + \underset{i=1}{N^n} \frac{ZX_i^n \beta^m}{N^n} - \underset{i=1}{N^n} \frac{ZX_i^n \beta^n}{N^n} \quad (4)$$

where $\mathrm{Y^m}$ is the mean malnutrition prevalence in 2005–06 and $\mathrm{Y^n}$ is mean malnutrition prevalence in 2015–16 and Nt is the sample size for year t, (t = m, n). The superscripts ‘m’ and ‘n’ denote the values of covariates and estimates corresponding to the 2005–06 and 2015–16 samples, respectively. For the decomposition process, we define Yt as the average probability of the binary outcome of interest for the year ‘t,’ and Z as the cumulative distribution functions from the logistic distribution (Fairlie 2005, 2004).

$$\frac{1}{N^n} \underset{i=1}{N^n} Z\alpha^* + X_{1i}^m \beta_1^* + X_{2i}^m \beta_2^* - Z\alpha^* + X_{1i}^r \beta_1^* + X_{2i}^m \beta_2^*$$

Propensity score matching (PSM)

To assess the role of ICDS in mitigating malnutrition prevalence among children, we employed propensity score matching, utilizing nearest neighborhood and counterfactual methods. A counterfactual model is estimated for computing the average treatment effect (i.e., an estimated effect of using ICDS services on malnutrition). Counterfactual is the potential outcome that we would have been obtained in case the children under age five, who are currently not using ICDS, would have been using the ICDS services. Utilizing the counterfactual model, we estimate the Average Treatment Effect on Treated (ATT) as:

$$\mathrm{ATT} = \mathrm{E}\,(\mathrm{Y1}/\mathrm{D} = 1) - \mathrm{E}\,(\mathrm{Y0}/\mathrm{D} = 1)$$

where E (Y1/D = 1) gives the prevalence of malnutrition among under-five children using ICDS services, and E (Y0/D = 1) is the expected outcome if under five children not using ICDS would have been using ICDS services. Similarly, the Average Treatment Effect on the Untreated (ATU) is defined mathematically as:

$$\mathrm{ATU} = \mathrm{E}\,(\mathrm{Y1}/\mathrm{D} = 0) - \mathrm{E}\,(\mathrm{Y0}/\mathrm{D} = 0)$$

where E(Y1/D = 0) is the expected outcome if under five children not using ICDS would have been using ICDS services and E(Y0/D = 0) is the outcome for those not using ICDS services. The Average Treatment Effect (ATE) is the difference between the expected malnutrition prevalence among children under-five in India who used ICDS services and not used ICDS services in the 12 months before the survey.

$$\mathrm{ATE} = \mathrm{E}\,(\mathrm{Y}|\mathrm{D} = 1) - \mathrm{E}\,(\mathrm{Y}|\mathrm{D} = 0) = \Delta$$

We can write $\Delta = \mathrm{ATT} + \mathrm{E}\,(\mathrm{Y0}|\mathrm{D} = 1) + \mathrm{E}\,(\mathrm{Y0}\,|\mathrm{D} = 0)$.

The other important issues in PSM are “common support,” “balancing property,” and “quality of matching”. The balancing property assesses whether the matching procedure effectively balances the distribution of pertinent covariates. The matching quality evaluates whether there is adequate overlap in the distribution of propensity scores between the two groups of covariates (Fairlie 2005, 2004). More comprehensive understanding about the PSM method employed in this study can be found in the paper entitled "The central role of the propensity score in observational studies for causal effects" by Rosenbaum and Rubin (Rosenbaum and Rubin 1983).

Patient and public involvement statement: not applicable

Since the study is based on secondary data that is available in public domain on DHS website. Hence, the patient consent for publication is not applicable.

Results

Levels, trend and inequalities in nutritional status of children below age five

Malnutrition inequalities among children in any community are driven by a large number of proximate determinants operating at different levels. These determents vary by demographic and socio-economic characteristics of women and children and hence are expected to produce malnutrition differentials across various contexts and environments in which children are growing up. Table 1 gives an account of malnutrition among children of India, which shows a decline of 9% points in stunting (48% to 39%), and 7% points in underweight (43% to 36%), reflecting at the combined effect of chronic as well as acute effect of malnutrition among children below age five during 2005–06 to 2015–16. However, trends in wasting show a stagnant situation over the last decade, which remain around 21% with an increase of 1% points. Prevalence of stunting was higher among older children in both round of the survey, however, the level of stunting has been reduced more than 10% points in among all age groups except of 0–5 months. Mother's nutritional status is a vital predictor for child nutrition. As among all the children of the underweight mothers, around 54% were stunted in NFHS-3, and it reduced up to the level of 46% in NFHS-4. Moreover, about 47% of children of those mothers who are having normal BMI were stunted during NFHS-3, and this proportion was 38% in NFHS-4. Additionally, among all the children of overweight and obese mothers, 32% were found stunted in NFHS-3 and which was reduced up to the prevalence of 27% in NFHS-4.

Early initiation of breastfeeding is very crucial for childhood nutritional status, 37% of children found stunted among those who started breastfeeding within one hour after the birth in NFHS-4 decline from 44% in NFHS-3. However, 40% in NFHS-4 were stunted who initiated breastfeeding after one hour of the birth decline from 50% in NFHS-3. Schedule caste and tribe (SC/ST) children were more likely to be malnourished than other caste. The difference in the prevalence of stunting between the children of SC/ST and others is almost unchanged, which was around 12% points during both the rounds of the survey. Similarly, the level of underweight is high among older children in both the rounds of the survey; however, the gap in proportion of underweight between different age groups has reduced. Results also illustrate that children of low BMI mothers have more risk to be underweight, where 48% children of these mothers were underweight and 35% children of mother with

Table 1 Malnutrition among children under 5 years in India, by selected background characteristics, from NFHS-3 (2005–06) to NFHS-4 (2015–16)

Background characteristics		Stunting		Wasting		Underweight	
		2005–06	2015–16	2005–06	2015–16	2005–06	2015–16
Sex of child	Male	48.3	39.2	20.6	22.1	42.4	36.5
	Female	48.3	38.1	19.3	20.3	43.4	35.7
Age of child in month	0–5	20.4	20.1	30.6	32.2	29.6	26.7
	6–11	28.7	23.2	29.3	27.8	36.0	29.2
	12–23	52.8	43.0	22.9	21.2	43.5	35.4
	24–35	56.2	43.0	17.0	19.2	45.2	38.0
	36 and above	52.8	42.0	15.7	18.0	45.8	39.1
Weight at birth	Low (less than 2.5 kg)	47.4	44.3	23.3	27.4	46.5	46.6
	Average and above	33.5	33.8	15.5	20.0	27.6	33.9
Mother's education	No education	57.5	51.1	23.0	23.0	52.3	47.2
	Primary	48.9	43.8	19.9	21.5	42.8	40.4
	Secondary	38.3	33.1	16.6	20.8	32.5	31.4
	Higher	19.6	21.1	13.3	18.2	15.9	19.2
Father's education	No education	58.4	51.5	23.4	23.0	53.0	47.6
	Primary	53.5	43.5	21.7	23.0	48.5	41.2
	Secondary	45.0	35.9	18.7	20.2	39.1	33.2
	Higher	26.7	23.9	13.9	19.4	22.0	22.6
BMI of mother	Underweight	53.8	46.1	25.4	27.0	52.3	48.2
	Normal	46.5	38.4	17.5	20.6	38.9	34.5
	Overweight/obese	31.6	27.3	9.6	14.3	20.3	22.0
Initiation of breast feeding	Within 1 h	43.7	37.3	18.0	21.7	37.1	35.4
	After 1 h	49.7	39.7	20.7	21.0	44.7	36.7
Birth order	1–2	43.6	35.3	18.4	20.8	37.7	33.3
	3–4	51.8	44.6	21.2	22.1	47.1	41.2
	5 or more	59.4	53.5	24.0	22.6	54.4	48.5
Mother's age at birth of child	12–19	53.6	41.5	19.3	20.7	46.2	38.7
	20–24	46.8	38.6	19.6	21.4	40.6	36.3
	25–29	45.9	37.0	20.3	20.8	41.8	34.2
	> =30	50.6	40.2	21.8	21.9	47.1	37.5
C-section delivery	No	50.1	41.1	20.5	21.9	44.5	38.5
	Yes	28.6	27.2	15.0	18.0	24.6	24.5
Place of residence	Urban	40.1	31.3	17.0	20.2	33.2	29.6
	Rural	51.0	41.5	21.0	21.7	46.0	38.6
Religion	Hindu	48.2	38.8	20.5	21.7	43.6	36.7
	Muslim	50.5	40.1	18.9	19.5	42.1	35.3
	Christian	39.3	30.2	16.1	19.0	30.6	27.5
	Other	42.3	33.2	18.4	20.7	34.5	31.5

Table 1 (continued)

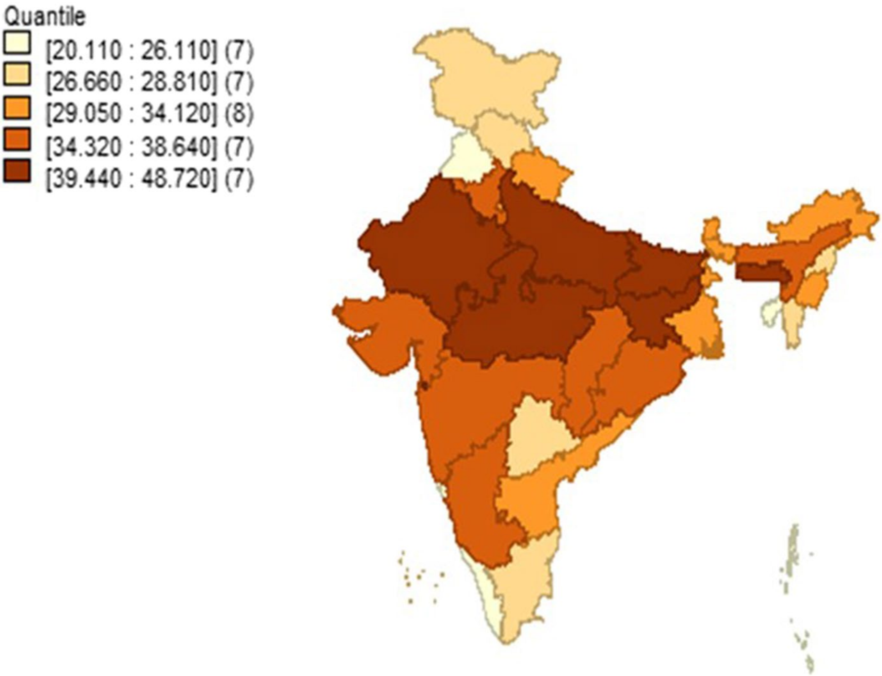
Background characteristics		Stunting		Wasting		Underweight	
		2005–06	2015–16	2005–06	2015–16	2005–06	2015–16
Caste	Scheduled castes	54.2	43.1	21.1	21.5	48.1	39.6
	Scheduled tribes	54.4	44.2	28.1	27.3	55.2	45.4
	Other backward class	49.1	39.0	20.3	20.8	43.6	36.0
	Other	40.8	31.2	16.6	19.4	34.1	29.2
Wealth quintiles	Poorest	60.2	51.8	25.3	24.4	57.1	49.0
	Poor	54.7	43.8	22.5	22.0	49.7	40.3
	Middle	49.0	36.8	19.1	20.3	41.9	33.7
	Richer	41.0	29.5	16.7	19.5	34.1	27.7
	Richest	25.8	22.5	12.8	18.1	19.9	20.4
ICDS	No	–	37.2	–	20.1	–	34.0
	Yes	–	39.7	–	22.1	–	37.6
Total		48.3	38.7	20.1	21.2	42.5	36.1

normal BMI and 22% children of overweight & obese mothers were underweight during 2015–16. Caste wise distribution of underweight indicates that ST (45%) and SC children (40%) were more venerable to be underweight as compared to OBC (36%) and other caste (29%). Furthermore, the proportion of underweight children was high among the households of lower socio-economic strata. Around 49% of children from the poorest households were underweight followed by those among poor household (34%), which was very far from the national average whereas only 20% of children of richest and 28% of the rich household were underweight.

Children who did not use the facilities of the ICDS, 37% of them were found to be stunted on the other hand 40% of children were stunted among those who received services from the ICDS scheme during 2015–16. This portrays the situation of selectivity bias among children using ICDS services in India (Dixit et al. 2018). In most of the Indian villages, the location of Anganwadi Centers is situated in the areas where people from lower socio-economic strata reside (Kumar and Pal 2010). That is why any unadjusted prevalence in malnutrition may not reveal a true situation. Similar situation can be seen in case of wasting, 20% of all the children who did not receive any services, and 22% of children who avail ICDS services from Anganwadi centers were wasted. Additionally, a higher proportion of children were underweight (38%) among those who received ICDS services, in comparison to those who did not receive service through ICDS (34%).

Spatial distribution of malnutrition

The level of malnutrition is not uniform across the country. It is evident from the state wise quintile map that there is a larger concentration of stunting in seven States (Map 1), where 39% to 49% of children were stunted during NFHS-4. Most of

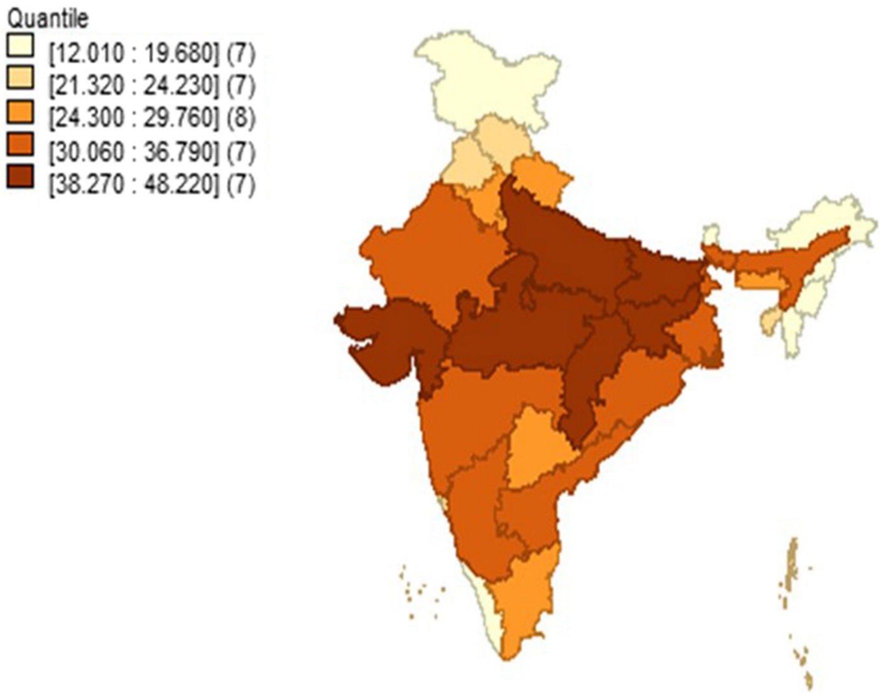


Map 1 State wise distribution of stunting among 0–59 month children in India, 2015–16

these States belong to the northern part of the country i.e., Uttar Pradesh, Madhya Pradesh, Bihar, Rajasthan, Jharkhand, and Meghalaya falls under this high prevalence States. In the Seven States namely, Haryana, Assam, Gujarat, Maharashtra, Chhattisgarh, Odisha and Karnataka, 34% to 39% of children were suffering stunting. Whereas, in seven States like Kerala, Punjab, Tripura and other prevalence of stunting was 20% to 26%, which was lowest in 2015–16. Similarly, it is evident from Map 2 that the underweight prevalence was much higher in seven States, where 38% to 48% of children were underweight i.e., Uttar Pradesh, Madhya Pradesh, Bihar, Chhattisgarh, Jharkhand, and Gujarat. In seven States, the prevalence of underweight was ranging from 30 to 36% in NFHS-4. These states were Rajasthan, West Bengal, Assam, Odisha, Maharashtra, Karnataka, and Andhra Pradesh. Moreover, Kerala, Goa, Jammu and Kashmir, Sikkim, Arunachala Pradesh, Nagaland, Manipur, and Mizoram come under those seven States where the prevalence of underweight was lowest in the country (12% to 20%).

Contribution of selected socioeconomic and demographic factors in reducing malnutrition

Results of observed changes in economic inequalities in malnutrition and its decomposition are presented in Table 2. Results portray how different factors contributed to the observed changes in prevalence of stunting, wasting and underweight from



Map 2 State wise distribution of underweight among 0–59 month children in India, 2015–16

NFHS-3 to NFHS-4 by using Fairlie (2005) non-linear decomposition technique (Fairlie 2005). By employing a decomposition approach, we can distinguish changes in malnutrition prevalence attributed to changing coefficients and changing sample characteristics. Moreover, it enables the identification of each variable's contribution to the overall change resulting from observable characteristics. Table 2 illustrates the individual contribution of each explanatory variable to the observed reduction in the prevalence of stunting, wasting, and underweight from 2005–06 to 2015–16. The base year is 2005–06 and the comparison year is 2015–16. Estimates indicate that the total predicted gap for stunting (differences in expected probabilities of stunting) is -0.552. Total observable characteristics reduce the gap by approximately 26%. Consequently, the observed disparity in stunting over this period is entirely elucidated by differences in coefficients or behavioral responses rather than variations in observable characteristics. Thus, the principal cause of the observed decline in stunting between 2005–06 and 2015–16 in India lies in the functional relationship between stunting and the explanatory variables, rather than a shift in the values of the sampled individuals' characteristics.

Similarly, the average estimated probability of wasting is 0.186 in 2005–06 and 0.207 in 2015–16. The difference in expected probabilities of wasting is 0.021. The explanatory variables increase the gap by 47%. Further, the average estimated probability of underweight is 0.379 in 2005–06 and 0.349 in 2015–16. The difference in expected probabilities of underweight is -0.030. This difference is explained by

Table 2 Summary table of decomposition of differences in the prevalence of stunting, wasting and underweight from NFHS-3 (2005–06) to NFHS-4 (2015–16)

	Stunting		Wasting		Underweight	
Stunting in 2015–16	0.38534		0.20728		0.34865	
Stunting in 2005–06	0.4405		0.18645		0.37885	
Difference	0.05516		0.02083		− 0.0302	
Predictors	Coefficient	% contributions	Coefficient	% contributions	Coefficient	% contributions
Details of total explanations						
Sex of child	− 0.00008	0.15	− 0.00004	− 0.02	− 0.00006	0.21
Age of child	− 0.0012	2.17	0.00087	0.47	− 0.00063	2.08
Birth weight	− 0.00565	10.24	− 0.00328	− 1.76	− 0.00819	27.13
Mother's education	− 0.00814	14.76	− 0.00217	− 1.17	− 0.00874	28.94
BMI of mother	− 0.00732	13.28	− 0.0079	− 4.24	− 0.01459	48.3
Initiation of breastfeed	− 0.00118	2.14	0.00033	0.18	− 0.00156	5.17
Birth order	− 0.00513	9.3	0.0002	0.1	− 0.00439	14.55
Mother's age at birth of child	− 0.00207	3.76	0.00022	0.12	− 0.00181	6
C-section	− 0.00068	1.24	− 0.00075	− 0.4	− 0.00114	3.78
Residence	− 0.00171	3.1	− 0.00328	− 1.76	− 0.00507	16.79
Religion	0.00051	− 0.92	0.00101	0.54	0.00192	− 6.35
Caste	0.00217	− 3.93	0.00123	0.66	0.00235	− 7.8
Wealth index	0.01587	− 28.78	0.0042	2.25	0.01448	− 47.94
Total explained	− 0.01208	26.48	− 0.00937	− 47.06	− 0.02743	90.84

the independent variable is 91% of particular interest is the contribution of each explanatory variable to the disparity in stunting, wasting and underweight between 2005–06 and 2015–16. Wealth Index, caste and religion are significantly contributing in reducing the gap in stunting between 2005–06 and 2015–16 by 28.8%, 3.9% and 0.9%, respectively. The high inequality in stunting is exacerbated by sex of the child, child age, birth weight, mother's education, mother's BMI, initiation of breastfeeding, birth order, mother's age at birth, birth by C-section and by type of residence. Of these maternal education increase the gap in stunting maximum by 15% followed by BMI of the mother (13.3%), birth weight (10.2%), birth order (9.3%) and father's education (4.6%) between 2005–06 and 2015–16.

Similarly, wealth index (2.25%), caste (0.66%), religion (0.54%), age of the child (0.47%), initiation of breastfeeding (0.18%), age of mother at birth (0.12%) and birth order (0.10%), are significantly increases the gap in wasting between 2005–06 and 2015–16. Whereas, sex of the child (0.02%), birth weight (1.76%), mother's education (1.17%), BMI of mother (4.24%), birth by C-section deliveries (0.40%) and residence (1.76%) are significantly reduces the gap in wasting between NFHS-3 (2005–06) to NFHS-4 (2015–16). Further, religion, caste and wealth index are significantly negatively contributed to reduces the gap in underweight between 2005–06 to 2015–16 by 6%, 8%, and 48%, respectively. The high inequalities in the prevalence of underweight is exacerbated by BMI of mother (48.3%), mother's education (28.9%), birth weight (27.1%), place of residence (16.8%), birth order (14.6%), initiation of breastfeeding (5.2%), mother's age at birth (5.2%), birth by C-section deliveries (3.8%), age of the child (2.1%) and the sex of the child (0.21%). These factors are positively contributing to increase the gap in underweight between 2005–06 to 2015–16 in India.

Contribution of the ICDS scheme in reducing malnutrition among children

Propensity score matching (PSM) serves as a valuable statistical tool for analyzing the impact of treatment variables in cross-sectional data when randomized control trials are unavailable. The findings in this section intend to assess the impact of ICDS on reducing malnutrition among children. This is achieved by comparing two groups: children who utilized ICDS services in the past 12 months and those who did not use any ICDS services. This comparison assumes that the under-five children using the ICDS scheme are randomly distributed in the population, and the selection process is independent of the prevalence of malnutrition. Nevertheless, in multistage large-scale surveys with diverse layers of objectives, the assignment of subjects to treatment and control groups is not random. Those in the treatment group may systematically differ from those in the control group. The prevalence of malnutrition among individuals registered under the ICDS scheme may be notably influenced by a large number of behavioral and biological characteristics considered in the earlier analysis of levels, trends, and inequalities in malnutrition. In such situations, the estimated effects of employing the ICDS scheme on the prevalence of malnutrition may be prone to bias due to numerous confounding factors. Therefore, PSM emerges as the optimal solution for obtaining an unbiased estimate of the treatment's contribution to the outcome variable. This is achieved by comparing the outcomes of individuals exposed (using the ICDS scheme) and unexposed (not using the ICDS scheme) who share similar observed characteristics. Based on the existing research on factors affecting malnutrition among children below age five, some predictors relating to socio-economic, demographic and maternal characteristics were included in the matching process.

This approach was adopted to enhance the likelihood of the PSM assumptions holding true by including a comprehensive set of predictors in the matching process. The model includes variables that impact both the utilization of the ICDS scheme and malnutrition but are not influenced by the prevalence of malnutrition. The results are presented in Table 3. As per the estimates for the unmatched sample, it is apparent that children who received ICDS services had a higher likelihood of being stunted (40%) in comparison to those who did not avail any services from the ICDS scheme in the 12 months preceding the survey (37%). After using the PSM with the counterfactual approach, there is a significant reduction in the estimated prevalence of malnutrition among children as the average treatment effect among those who were treated i.e., ATT = 40%, which would have been 47%, if they would not have been using the ICDS scheme. Results also indicate that children who had received ICDS services, stunting among treated children were 8% less than that of the unmatched control group. Further, ATU value shows that children who had not received any ICDS services; if they had received services, the prevalence of stunting would have decreased 37% to 30% points. The ATE shows the difference in the prevalence of stunting among children using the ICDS scheme and not using the

Table 3 Matching estimates shows the impact of receiving ICDS services on the nutritional status of children under-5 years in India, 2015–16

ICDS participation vs No Participation	Treated	Controls	Difference	S.E	T-stat
Stunting					
Unmatched	0.40	0.37	0.03	0.002	12.97
ATT	0.40	0.47	– 0.08	0.089	– 0.85
ATU	0.37	0.30	– 0.07		
ATE			– 0.07		
Wasting					
Unmatched	0.22	0.19	0.03	0.002	14.61
ATT	0.22	0.22	0.00	0.075	– 0.06
ATU	0.19	0.39	0.20		
ATE			0.08		
Underweight					
Unmatched	0.37	0.32	0.04	0.00	20.78
ATT	0.37	0.36	0.01	0.09	0.09
ATU	0.32	0.35	0.02		
ATE			0.01		

ATT average treatment effect on treated, *ATU* average treatment effect on untreated, *ATE* average treatment effect

ICDS scheme after matching using nearest neighborhood method, which is 7%. Similarly, for wasting, the unmatched sample estimate shows that children who received ICDS services were relatively more likely to suffer from wasting compared to those who did not receive ICDS services. ATT value in treated and control group was the same (0.22), which means that no improvement takes place in wasting among children because of ICDS participation. A similar finding has also been noticed in case of underweight, where unmatched sample estimate indicates that the children who went for ICDS services were more likely to be underweight (37%) compared to those children who did not go for ICDS (32%). The difference in ATT value for treated (0.37) and control (0.36) is only 1%. The ATE for wasting and underweight, which reveal the difference in the prevalence of wasting and underweight among children using ICDS scheme and not using ICDS scheme after matching are 8% and 1%, respectively. These findings indicate a substantial contribution of ICDS scheme in reducing stunting among children, but there is no evidence of ICDS contribution in addressing underweight and wasting. The result of wasting, however, is hard to explain.

Discussion

This study employs various analytical methods strategically arranged to address key questions concerning the levels, trends, and economic inequalities in malnutrition among children under the age of five, as well as to assess the impact of the ICDS scheme on reducing malnutrition in India. The findings portray a considerable decline in malnutrition among children in India. Reduction in stunting among low birth weight children is higher in comparison to those having normal birth weight, which has almost been unchanged over the last decade. Children of mothers having lower BMI are more likely to be stunted and underweight, though the prevalence has declined from 54 to 46% for stunting and 52% to 48% for underweight over 2005–06 to 2015–16. Reduction in stunting and underweight is higher among those children who initiated breastfeeding after an hour in comparison to those reported to have started breastfeeding within one hour; however, the prevalence of underweight and stunting is low among children who started breastfeeding within an hour.

Moreover, the findings from both rounds of NFHS indicated a heightened susceptibility to stunting and underweight among children of higher birth orders. This parallels results observed in studies conducted in other countries, where birth order demonstrated a strong association with stunting and had a comparatively lesser impact on wasting (Horton 1988). The other studies from developing countries including India has also argued that the birth order is one of the significant predictors of child malnutrition (Singh et al. 1998; Marston and Cleland 2003; Ukwuani and Suchindran 2003; Shapiro-Mendoza et al. 2004). Many scholars have endeavored to establish the pathways through which the birth order of children influences their nutritional status (Boerma and Bicego 1992; Rahman 2016; Sanchez-Escobedo et al. 2020). One of the key intervening factor emerged had been maternal nutrition from the results. The nutritional status of children is closely linked to maternal nutrition, with children born to mothers with low BMI demonstrating a higher likelihood of malnutrition. These results align with other studies in which researchers have examined the progression of malnutrition among children under the age of three in India, drawing upon data from diverse cross-sectional surveys (Singh et al. 1998). A study by Gwatkin et al. (2000), also highlighted that nutrition status of children were associated with mother's nutrition and their education (Gwatkin 2000). Further, in a study of Bolivia Forst et al., (2005) found that maternal characteristics including maternal nutrition affect stunting more than wasting among their children (Gwatkin 2000; Frost et al. 2005). These findings suggest that the level of female educational attainment in India is still not notably impressive. Integrating MIYCN counselling into maternal and child health care services, as well as any nutrition-specific intervention, is crucial. This ensures that even women with lower levels of education receive intensified counselling on effectively maintaining their nutritional status, particularly during pregnancy and lactation. Addressing both the challenges of low birth weight in infants and maternal malnutrition can be achieved through well-designed interventions focused on maternal care, health, and nutrition. This includes enhanced supplementary nutritional support during pregnancy and lactation through the ICDS scheme, improved antenatal care featuring IFA supplementation, promotion of adequately iodized salt consumption, and mitigation of severe anaemia.

Reduction in underweight among rural children is much more pronounced compared to urban. Caste wise trends show that maximum reduction in underweight took place among SC/ST children, which is around 10% points. These reductions in malnutrition over the last decade can be attributed to ongoing programmes and services to address malnutrition among children and their mothers, which have been primarily revolving around the ICDS scheme. Results of the spatial distribution of malnutrition show that higher prevalence of stunting was found in Uttar Pradesh, Bihar, Madhya Pradesh, Rajasthan, Jharkhand, Meghalaya, and Dadra & Nagar Haveli. Additionally, high prevalence states for underweight were Uttar Pradesh, Bihar, Madhya Pradesh, Jharkhand, Chhattisgarh and Gujarat, and Dadra & Nagar Haveli. These findings are consistent with the observations of the National Nutrition Mission, Government of India (2017), where the same states have also been identified as priority states for the implementation of Poshan Abhiyan. It is a comprehensive nutrition initiative designed to foster synergy and connect various schemes, working collectively towards the shared objective of alleviating malnutrition in India. The program aims to achieve a 2% reduction in both stunting and underweight, a 3% decrease in anaemia among young children, women, and adolescent girls, and a 2% reduction in the prevalence of low birth weight annually (PIB_ release _ National Nutrition Mission.pdf. n.d.).

Fairlie decomposition analysis shows that religion, caste and economic status of the household significantly reduce the gap in stunting over the last one decade. Highest inequality in stunting is exacerbated by the sex of the child, age, birth weight, birth order, mother's BMI, and their educational attainment. Results on the contribution of ICDS scheme in the reduction of malnutrition in India portray a positive impact on stunting, where children who were getting ICDS service would have been more stunted if they would not have received the services. Further, children who are not going for the services, if they will receive the services, the level of stunting will be further reduce.

Conclusion and recommendation

The study concludes that despite of selectivity bias in the registration of children with Aanganwadi centers, the ICDS scheme in its present form contributes in 7% reduction in stunting among below age five children in India. That is why, implementation of the Poshan Abhiyan in India can be more effective by adopting innovative approaches to enhance the coverage and efficiency of the ICDS scheme in the country, preferably through robust convergence mechanisms and by striving at promoting synergy between all the nutrition programmes and services being implemented by different ministries of Government of India. Service provisions under the ICDS scheme need to be reorganized to break the vicious cycle of undernutrition and intensification of counseling by prioritized home visits by AWWs to reach the critical age groups including pregnant women and lactating mothers. Another strategy to enhance the effectiveness of the ICDS scheme may be reforming the provision of Taking Home Rations (THR) with the flexibility to states in adopting differential approaches.

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Data availability The data utilized in this paper has been sourced from the National Family Health Survey, with the International Institute for Population Sciences serving as the nodal agency. Publicly available data from NFHS-4 and NFHS-3 has been employed.

Declarations

Conflict of interest All the authors have declared that they have no competing interest in this paper.

Ethical approval The data utilized in this study was obtained from two rounds of NFHS (3 and 4) in India, and respondents were requested to sign a proper consent form before data collection. The survey received approval from the relevant Institutional Review Board of IIPS prior to data collection.

Consent for publication During the interviews, respondents were explicitly informed that the collected data would be exclusively used for research purposes, potentially for studies or publications. Additionally, the first author served as the main coordinator for data collection, obtaining consent from both himself and all co-authors for publication.

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