Targeting Nutrition in Early Life: Evidence on ICDS and Minimum Dietary Diversity in India

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Despite sustained public investment in child nutrition, dietary diversity among young children in India remains inadequate. This study evaluates whether the Supplementary Nutrition Programme (SNP) under the Integrated Child Development Services (ICDS) improves Minimum Dietary Diversity (MDD) among children aged 6–23 months. Using NFHS-5 data covering 64,725 children, we estimate the association between the frequency of SNP receipt and MDD using logistic regression. Further, propensity score matching (PSM) is employed to address observable selection bias. Regular SNP supplementation (daily/weekly) significantly increases the likelihood of achieving MDD at the national level (OR 1.8; 95% CI 1.6, 2). However, interstate variation exists. In states with less diversified ICDS food menus (Bihar, Rajasthan, Chhattisgarh, Haryana), regular supplementation is positively associated with MDD (OR 1.5; 95% CI 1.2–1.8), but not in states with more diversified menus (Kerala, Telangana, Gujarat, Odisha). It significantly increases dietary diversity among rural and poorer households, with stronger effects also observed in Empowered Action Group (EAG) states (OR = 1.30; 95% CI: 1.13–1.48). ICDS supplementary nutrition improves dietary diversity among vulnerable child populations, especially in poorer and nutritionally disadvantaged regions, though broader nutritional gains remain limited.

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Dietary diversity serves as a key indicator of food consumption patterns, reflecting both household access to a variety of foods and the adequacy of nutrient intake. In this context, the World Health Organization's (WHO) indicator of Minimum Dietary Diversity (MDD) for children aged 6–23 months is widely used as a proxy for the micronutrient quality of a child's diet. Adequate dietary diversity is particularly important for child health, as insufficient intake of essential nutrients can adversely affect survival, physical growth, and cognitive development (UNICEF, 2019). Examining patterns of dietary diversity also helps identify specific food groups that are under-consumed in children's diets. Recent evidence suggests that children in India who do not meet MDD standards are less likely to consume fresh foods, including vitamin A-rich fruits and vegetables (Beckerman et al., 2020).

Malnutrition is a global health concern with diverse causes, including inadequate dietary patterns, socio-economic conditions, and health disparities. The literature has primarily focused on anthropometric measures (such as height-for-age, weight-for-age, or weight-for-height) to combat child malnutrition (Corsi et al.,2011; Maternal, L., 2013). However, dietary patterns have been overlooked even though a lack of a diversified diet is one of the leading causes of child malnutrition (UNICEF, 2020). While anthropometric measurements capture genetics, environment, and illness exposure (Perkins et al., 2016), they do not necessarily exhibit nutritional inadequacies. Estimating the MDD among children is also important to aid youngsters with nutritional deficiencies (Moursi et al., 2008), even in the absence of any anthropometric failure. For instance, 36% of children in India were estimated to be stunted in 2021, but 78% of children were unable to attain MDD (Fanzo et al., 2019). Furthermore, vitamin A deficiency is 30 percentage points more common than stunting among children under five (Black et al., 2013).

A child aged 6–23 months was considered to have achieved MDD if he or she consumed foods from at least four out of seven specified food groups, typically including fruits or vegetables, animal-source foods, and staple items (WHO, 2008; 2010). In 2017, the WHO–UNICEF Technical Expert Advisory Group on Nutrition Monitoring (TEAM) revised this indicator by adding breast milk as an eighth food group and increasing the threshold to five out of eight food groups (WHO, 2021). The Infant and Young Child Feeding (IYCF) guidelines similarly stress the importance of consuming foods from multiple food groups to ensure adequate nutrient intake among children aged 6–23 months. More broadly, regular consumption of a diverse range of foods is widely recognised as a useful proxy for dietary quality in early childhood (Mishra & Ray, 2009; Ruel et al., 2010).

In India, the Integrated Child Development Services (ICDS) scheme was introduced on October 2, 1975, as a national initiative to improve the health, nutrition, and development of young children and mothers. The ICDS targets vulnerable populations, particularly children under three years and pregnant or lactating women, providing a crucial window for nutritional support. Services include immunization, health check-ups, supplementary feeding, and nutrition education, along with preschool education for children aged three to six years. Under the Supplementary Nutrition Programme (SNP), Take-Home Rations (THR) are distributed to bridge the gap between actual intake and Recommended Dietary Allowances, aiming to improve nutritional status (Talati et al., 2016).

Previous research has found limited evidence that ICDS programs have a substantial causal impact on reducing chronic child malnutrition (Kumar et al., 2006; Bhutta et al., 2008; Onis et al., 2013; Dixit et al., 2018). Some recent studies observed a positive impact of the ICSD program on children's height (Kandpal, 2011; Jain, 2015). When infants are introduced to a wider variety of food in addition to breast milk, it has been associated with lower rates of stunted growth, being underweight, and experiencing wasting (Chandrasekhar et al., 2017; Meshram et al., 2019). Understanding whether the provision of food supplements in the program increases dietary diversity among children is crucial as it might later contribute to the reduction in stunting, wasting, and underweight.

This paper focuses on delineating the impact of services under the ICDs program on dietary diversity among children. The key contribution of this study lies in its detailed exploration of the links between children's MDD and the ICDS services, particularly the receipt and frequency of food supplementation from Anganwadi/ICDS centres , across different contexts—states with more versus less diversified ICDS food menus, poor versus rich households, rural versus urban areas, and Empowered Action Group (EAG) versus non-EAG states. We used the multivariable logistic regression to estimate the odds ratio (ORs) of ICDS services and other personal and socioeconomic characteristics on MDD of children aged 6-23 months. Further, the paper compares the MDD of children aged 6-23 months who received supplementary food from Anganwadi (Treatment group) with those who didn't receive any supplements (Control group). Investigating the effect of supplementary food on diet diversity is challenging because individuals self-select themselves to receive supplementary food. There is a possibility that those who receive supplementary food are more educated, more motivated, or more aware. To establish the causal relation between supplements taken and diet diversity the individuals receiving supplements must be randomly selected. Therefore, we used propensity score matching (PSM) to address potential endogeneity arising from self-selection, under the assumption that differences influencing both the likelihood of receiving treatment and the outcome can be accounted for by observable pre-treatment characteristics.

The following sections of this paper are structured as follows: Section 2 presents details about the data, sample size, and the key variables employed in the study. Section 3 delves into the statistical methodologies that have been applied in the analysis. Section 4 discusses the empirical results. Finally, Section 5, concludes and engage in a comprehensive discussion of the results.

Data

- **Study Population And Sample Size**

The study uses data from NFHS-5 (2019–21), a nationally representative survey covering all Indian states and union territories. It surveyed 7,24,115 women (15–49 years), providing information on 2,32,920 children under five. This analysis focuses on 64,725 children aged 6–23 months, consistent with WHO/UNICEF IYCF guidelines for assessing nutrient adequacy during the complementary feeding period (WHO, 2010).

- **Outcome – Food Consumption And Dietary Diversity**

In NFHS-5, mothers reported all foods consumed by their child in the previous 24 hours. Information on 16 food items was collected and aggregated into seven food groups following WHO IYCF guidelines (2008, 2010, 2021): (1) dairy products; (2) grains, roots and tubers; (3) vitamin A-rich fruits and vegetables; (4) other fruits and vegetables; (5) eggs; (6) flesh foods; and (7) legumes and nuts.

In 2017, WHO and UNICEF added an eighth group, breast milk, updating the MDD definition from consuming at least four of seven groups to at least five of eight groups (WHO, 2021). A dietary diversity score was created for each child, ranging from 0 to 8, where 0 indicates no consumption of any food item and 8 indicates consumption from all eight groups. Using this score, a binary variable for MDD was created, coded as 1 if a child consumed foods from five or more groups, and 0 if the score was four or less, indicating inadequate dietary diversity.

- **Primary Correlates**

To assess the impact of ICDS on MDD, the key explanatory variable captures whether a child received food supplements from an Anganwadi/ICDS centre. Mothers were asked how often the child received food in the past 12 months (not at all, almost daily, at least once a week, at least once a month, or less often). A binary variable was constructed, coded 1 if the child received food regularly (almost daily or at least once a week) and 0 if the child did not receive any food supplements.

- **Secondary Correlates**

The analysis controlled for a set of child, maternal, and household characteristics commonly associated with child dietary outcomes. These included child's sex, birth order, maternal education, maternal employment and dietary diversity, household wealth, access to mass media, religion, caste, and region of residence. Maternal dietary diversity was measured using a score based on consumption from multiple food groups, with a binary indicator created for adequate diversity following FAO guidelines (FAO, 2021; Rajpal et al., 2021). Household wealth was derived from a standard asset-based index and categorized into quintiles. Region and other sociodemographic controls were included to account for contextual variation in dietary practices.

Methodology

To estimate the effect of supplementary food from Anganwadi centres on children's dietary diversity, we first employed a logistic regression model controlling for key sociodemographic characteristics:

$$Y_{ids} = \alpha_0 + \alpha_1 F_{ids} + X'_{ids}\alpha_2 + \epsilon_{ids}$$

Where Y_{ids} is a binary variable and takes the value 1 if MDD exits for child i from district d and state s, else it's 0. The frequency of receiving food supplements (F_{ids}) is a categorical variable. It has five categories: not at all, almost daily, at least once a week, at least once a month, and less often. X vector includes all the explanatory variables children's gender, birth order, child current illness, household wealth, mother's education, mother's employment status, mother's diet diversity, mass media, religion, caste, urban, improved sanitation, improved drinking water and regions. Further, the model is enhanced by incorporating state fixed effects (S) and district fixed effects (D) in equation (1) to strengthen the robustness of the logistic regression results. Lastly, to compare outcomes between EAG and non-EAG states, we add an interaction term between F_{ids} and EAG states in Equation (1). In other specification, regional controls are excluded from X to avoid multicollinearity.

Estimating the causal effect of supplementary food on children's dietary diversity is challenging due to self-selection, as participation in Anganwadi services is not random. Mothers who access these services may differ in education, awareness, and practices, which can bias results. To address this, we use propensity score matching (PSM) to estimate the average treatment effect on the treated (ATET), comparing children who received supplements with those who did not. The matching is based on observed characteristics such as child, maternal, and household factors, assuming selection depends only on these variables. Robustness checks are also conducted across subsamples.

Results

Figure 1 shows the prevalence of MDD among children aged 6–23 months across frequency of supplementation food. The x-axis represents the prevalence of MDD, measured as the proportion of children meeting the MDD threshold, while the different bars on y-axis indicate program frequency of receiving supplementary food. Results show that breastfeeding children benefit most from regular supplementation, whereas non-breastfeeding children gain limited advantage, indicating that SNP alone may not be sufficient for this group. Over time, a modest increase in MDD prevalence is observed from NFHS-4 to NFHS-5 for all children, however, among non-breastfed children MDD prevalence has declined.

Figure 1: . Prevalence of MDD among children (6–23 months) by ICDS Food Supplementation and its Frequency, India, NFHS 4 & 5; S.F-Supplementary Food; Less- Less Often.

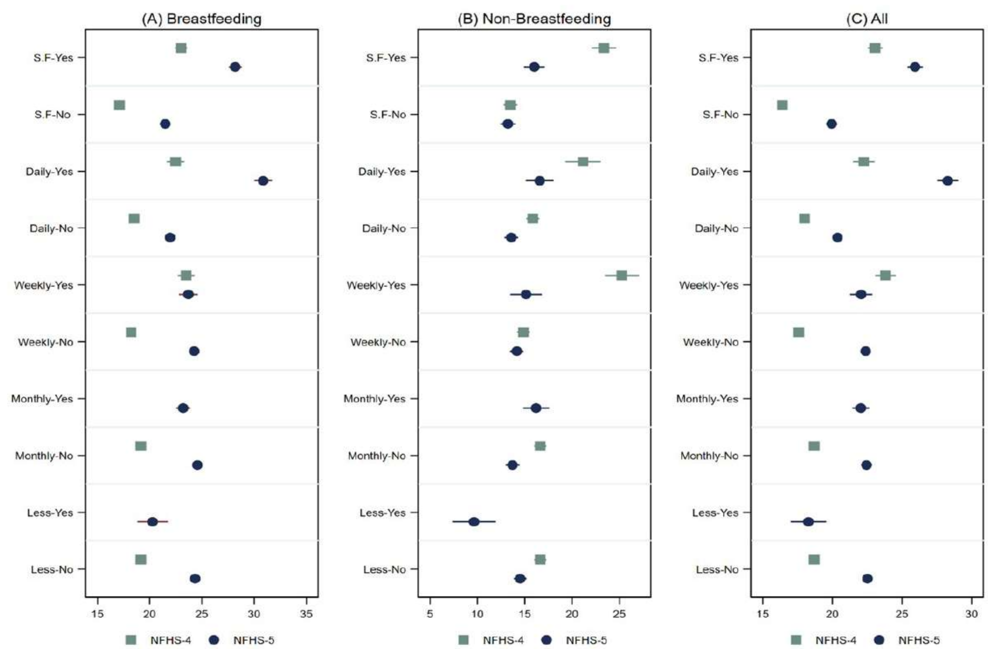

Table 1 presents summary statistics for children aged 6–23 months using NFHS-4 and NFHS-5. The share of children achieving MDD increased from 19% to 22%, while the proportion of breastfeeding children remained steady at 81%. Intake increased for most food groups, except grains, roots, and tubers (Group 2). ICDS services (supplementary nutrition, health check-ups, immunization, and early childhood care) aim to support child and maternal development. Between 2015–16 and 2019–21, children receiving any benefits rose from 51% to 77%, with supplementary nutrition coverage increasing from 34% to 71%. Although stunting, wasting, and underweight decreased, anaemia among children rose from 64% to 71%. Health check-ups and immunization improved, but early childhood care/

preschool participation fell sharply from 57% to 26%. Maternal characteristics show rising education levels, with more mothers attaining secondary or higher education, yet employment rates remained unchanged. Adequate maternal diet diversity increased from 48% to 53%, but anaemia also rose slightly from 56% to 60%.

Table 1. Descriptive Statistics for children aged 6-23 months (NFHS-5 and NFHS-4)

	NFHS 5 (2019-21) N=64,725		NFHS 4 (2015-16) N=74,132	
Variable	Mean	SD	Mean	SD
Infant & young child feeding				
Weaned (fed semisolid food in last 24 h)	0.24	0.43	0.21	0.41
Minimum dietary frequency[a]	0.32	0.46	0.31	0.46
Minimum dietary diversity	0.22	0.42	0.19	0.39
Breastfed (currently)	0.81	0.39	0.81	0.39
Consumed in last 24 h				
Dairy products	0.52	0.50	0.51	0.50
Grains, roots, and tubers	0.66	0.47	0.69	0.46
Vitamin A rich fruits and vegetables	0.41	0.49	0.39	0.49
Other fruits and vegetables	0.28	0.45	0.24	0.43
Eggs	0.17	0.38	0.14	0.35
Flesh foods	0.09	0.29	0.08	0.27
Legumes and nuts	0.17	0.38	0.13	0.34
ICDS services in past 12 months				
Received any benefits	0.77	0.42	0.51	0.50
Received food supplements	0.71	0.45	0.34	0.47
Never received food supplements	0.06	0.24	0.29	0.45
Received food supplements daily	0.25	0.43	0.16	0.37
Received food supp. At least once a week	0.15	0.36	0.18	0.38
Received food supp. At least once a month	0.27	0.44	NA	NA
Received food supp. Less often	0.04	0.20	NA	NA
Received health checkup regularly	0.51	0.50	0.28	0.45
Received immunization	0.65	0.48	0.31	0.46
Go to anganwadi for early childhood care	0.26	0.44	0.57	0.49
Child characteristics				
Female child	0.48	0.50	0.48	0.50
Birth order[b]	1.97	0.99	2.04	1.03
Nutrition outcomes[c]				
Stunting	0.32	0.47	0.33	0.47
Underweight	0.28	0.45	0.30	0.46
Wasting	0.19	0.39	0.22	0.41
Anaemic	0.71	0.45	0.64	0.48

	NFHS 5 (2019-21) N=64,725		NFHS 4 (2015-16) N=74,132	
Variable	Mean	SD	Mean	SD
Mother characteristics				
Mother not educated	0.19	0.39	0.27	0.45
Mothers completed primary education	0.11	0.31	0.14	0.34
Mothers completed secondary education	0.52	0.50	0.47	0.50
Mothers completed higher education	0.18	0.38	0.12	0.32
Mother anaemic	0.60	0.49	0.56	0.50
Mother's diet diversity[d]	0.53	0.50	0.48	0.50
Wealth index				
Lowest	0.24	0.43	0.24	0.43
Lower middle	0.21	0.41	0.22	0.41
Middle	0.20	0.40	0.20	0.40
Upper middle	0.19	0.39	0.19	0.39
Highest	0.16	0.37	0.15	0.36
Caste				
SC	0.23	0.42	0.22	0.41
ST	0.10	0.30	0.10	0.31
OBC	0.44	0.50	0.44	0.50
No caste	0.19	0.39	0.20	0.40
Religion				
Hindu	0.79	0.40	0.79	0.41
Muslim	0.16	0.37	0.16	0.37
Christian	0.02	0.14	0.02	0.14
others/no religione	0.02	0.15	0.03	0.16
Urban	0.27	0.44	0.28	0.45
Rural	0.73	0.44	0.72	0.45
Regions				
North Region	0.12	0.32	0.08	0.28
Northeast Region	0.04	0.19	0.13	0.33
West Region	0.13	0.33	0.01	0.12
East Region	0.27	0.44	0.27	0.44
Central Region	0.28	0.45	0.13	0.34
South Region	0.17	0.38	0.34	0.48

[a]Minimum meal frequency refers to two meals for breastfed infants aged 6–8 months, three meals for breastfed children aged 9–23 months, and four meals for non-breastfed children aged 6–23 months; [b]Birth order has 4 categories: 1, 2, 3 4+; [c]Stunting, wasting, and underweight are defined as height-for-age, weight-for-height, and weight-for-age Z-scores below -2 SD, respectively. Anaemia refers to haemoglobin levels below the WHO threshold for children; [d]Mothers were considered to have minimum dietary diversity if they are consuming food items daily or weekly from at least five of the nine food groups i.e., (Group 1) "milk/or curd"; (Group 2) "pulses or beans"; (Group 3) "dark green leafy vegetables"; (Group 4) "fruits"; (Group 5) "eggs"; (Group 6) "fish", (Group 7) "chicken or meat", (Group 8) "fried food", (Group 9) "aerated drinks"; eOthers include Sikh, Buddhist, Jain, Jewish, Zoroastrian; SD is Standard Deviation

Consistent with existing literature, ICDS, particularly SNP, has little effect on stunting, wasting, and underweight (Table A1, Supplementary Material S1). This study focuses on the association between children's MDD and ICDS food implementation programmes. Table 2 shows that children receiving food supplements daily or weekly have higher odds of achieving MDD compared to those who never receive them, with odds decreasing as frequency declines. Regular health check-ups are also positively linked to MDD.

Maternal education and diet diversity are positively associated with children's MDD (OR: 1.5, % CI: 1.48, 1.6). Maternal employment is linked to higher MDD (OR: 1.29, 95% CI: 1.24–1.34), and children who were recently ill show higher odds (OR: 1.40, 95% CI: 1.25–1.56). Households with mass media access (OR: 1.3, 95% CI: 1.18–1.44), improved sanitation (OR: 1.09, 95% CI: 1.04–1.15), and improved drinking water (OR: 1.13, 95% CI: 1.08–1.18) also have higher MDD. No significant rural–urban differences are observed nationally, and compared to the south, other regions have lower odds except the east. Findings remain consistent with state and district fixed effects (Table A2, S1).

Table 2. Adjusted Odds Ratios (OR) of MDD and ICDS Services, Children Aged 6–23 Months, India (NFHS-5)

	MDD-Child		**MDD-Child**		**MDD-Child**	
Correlates	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Received any benefits from ICDS						
No®						
Yes	1.22***	[1.14 1.30]				
Received food supplementation from ICDS						
No®						
Yes			1.33***	[1.24 1.43]		
Frequency of food supplementation from ICDS						
Never®					1.00	-
Daily Food Supplementation					1.78***	[1.59 1.98]
Weekly Food Supplementation					1.67***	[1.49 1.86]
Monthly Food Supplementation					1.55***	[1.39 1.72]
Less Often Food Supplementation					1.43***	[1.26 1.63]
Health Checkup	1.28***	[1.22 1.35]	1.20***	[1.14 1.26]	1.19***	[1.13 1.25]
Immunizations	0.86***	[0.81 0.91]	0.85***	[0.81 0.90]	0.86***	[0.82 0.92]
Early Childhood Care	1.00	[0.96 1.05]	0.99	[0.94 1.04]	0.96	[0.91 1.01]
Child Sex						
Male®						
Female	1.00	[0.96 1.04]	0.99	[0.95 1.03]	0.99	[0.95 1.03]

	MDD-Child		MDD-Child		MDD-Child	
Correlates	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Birth Order						
Birth Order-1®						
Birth Order-2	1.27***	[1.21 1.33]	1.26***	[1.20 1.32]	1.26***	[1.19 1.32]
Birth Order-3	1.12***	[1.05 1.19]	1.08*	[1.01 1.15]	1.08*	[1.01 1.15]
Birth Order-4	1.23***	[1.15 1.31]	1.22***	[1.13 1.32]	1.23***	[1.14 1.32]
Child Illness						
No®						
Yes	1.29***	[1.24 1.34]	1.28***	[1.23 1.34]	1.29***	[1.23 1.35]
Child Illness						
Weekly Food Supplementation					1.67***	[1.49 1.86]
Mother's Education						
No Education®						
Primary	1.09*	[1.02 1.17]	1.09*	[1.00 1.18]	1.08	[1.00 1.17]
Secondary education	1.17***	[1.11 1.24]	1.19***	[1.11 1.27]	1.18***	[1.11 1.26]
Higher education	1.27***	[1.17 1.37]	1.29***	[1.18 1.40]	1.28***	[1.18 1.40]
Mother's Currently Working						
No®						
Yes	1.40***	[1.25 1.56]	1.43***	[1.26 1.61]	1.42***	[1.26 1.61]
Mother's Dietary Diversity						
No®						
Yes	1.54***	[1.48 1.61]	1.52***	[1.45 1.59]	1.51***	[1.44 1.58]
Mother's Anemia Status						
No®						
Yes	1.01	[0.97 1.05]	1.00	[0.96 1.04]	1.00	[0.95 1.04]
Mass Media						
No®						
Yes	1.34***	[1.23 1.45]	1.32***	[1.20 1.45]	1.31***	[1.18 1.44]
Wealth Quintile						
Poorest®						
Poorer	1.00	[0.94 1.06]	1.02	[0.96 1.09]	1.02	[0.96 1.09]
Middle	1.07*	[1.00 1.14]	1.10**	[1.02 1.18]	1.10**	[1.02 1.18]
Richer	1.14***	[1.06 1.22]	1.18***	[1.09 1.28]	1.19***	[1.10 1.29]
Richest	1.23***	[1.13 1.34]	1.28***	[1.16 1.41]	1.30***	[1.18 1.43]
Social Category						
Schedule Castes®						
Schedule Tribes	1.18***	[1.11 1.25]	1.21***	[1.13 1.30]	1.21***	[1.13 1.29]
Other Backward Class	0.88***	[0.84 0.92]	0.89***	[0.85 0.94]	0.90***	[0.85 0.95]
Others	1.00	[0.94 1.06]	1.00	[0.93 1.07]	1.00	[0.93 1.07]

	MDD-Child		MDD-Child		MDD-Child	
Correlates	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Religion						
Hindu®						
Muslim	1.15***	[1.09 1.21]	1.14***	[1.07 1.22]	1.14***	[1.07 1.21]
Christian	1.49***	[1.37 1.63]	1.44***	[1.31 1.60]	1.42***	[1.29 1.58]
Others	1.26***	[1.14 1.39]	1.25***	[1.11 1.40]	1.23***	[1.10 1.39]
Improved Sanitation						
No®						
Yes	1.09***	[1.04 1.15]	1.09***	[1.04 1.15]	1.09**	[1.03 1.15]
Improved Drinking Water						
No®						
Yes	1.13***	[1.08 1.18]	1.11***	[1.06 1.17]	1.11***	[1.06 1.16]
Sector						
Rural®						
Urban	0.99	[0.94 1.04]	0.95	[0.90 1.02]	0.96	[0.90 1.02]
NFHS Regions						
South®						
North	0.87***	[0.81 0.94]	0.89**	[0.82 0.97]	0.90*	[0.83 0.98]
North-East	1.07	[0.99 1.16]	1.08	[0.98 1.19]	1.08	[0.98 1.19]
West	0.66***	[0.60 0.72]	0.66***	[0.60 0.72]	0.66***	[0.60 0.73]
East	1.19***	[1.11 1.27]	1.32***	[1.22 1.42]	1.36***	[1.26 1.47]
Central	0.66***	[0.62 0.71]	0.68***	[0.63 0.73]	0.68***	[0.64 0.74]
Observations	64,725		50,281		50,281	

OR- Adjusted Odds Ratios based on logistic regression; 95% CI – 95% Confidence interval. ® denotes the reference category for the correlates. *** p<0.01, ** p<0.05, * p<0.1

The ATET estimated using PSM indicates that children aged 6–23 months receiving any ICDS benefits are 5 percentage points (pp) more likely to meet MDD compared to non-beneficiaries (Table 3, column 1).

PSM reveal that children in the treatment group, who received food supplements regularly from ICDS, were 7 pp (column 2) more likely to attain MDD compared to those in the control group who never received food supplements from ICDS. Further, PSM was employed on distinct sub-samples, maintaining a consistent control group. However, the treatment group is different in each sub-sample. The first sub-sample encompassed children who received supplements almost daily (column 3), the second sub-sample comprised those who received supplements at least once a week (column 4) and the third sub-sample consisted of those who received supplements at least once a month (column 5). The results indicate that the ATET on MDD is highest among children who received supplements almost daily (7 pp), followed by those receiving supplements once a week (5.5 pp) and once a month (5.1 pp), compared to children who never received food supplements, indicating a positive relationship between supplement frequency and MDD.

Table 3. Propensity Score-based ATET of ICDS supplementary nutrition on MDD among children aged 6-23 months, India (NFHS-5)

MDD	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
	ATET	**ATET**	**ATET**	**ATET**	**ATET**
Any Benefits[a]	0.049*** (0.026)				
Food Supplementation – Regularly[b]		0.069*** (0.033)			
Food Supplementation – Daily			0.072*** (0.026)		
Food Supplementation – Weekly				0.055*** (0.028)	
Food Supplementation – Monthly					0.051*** (0.047)
Demographic & SES Controls[c]	Yes	Yes	Yes	Yes	Yes
Treated observations[d]	48,763	24,430	13,988	10,442	17,647
Observations	62,371	41,083	30,641	27,095	34,300

Standard errors in parentheses; * p < 0.05, ** p < 0.01, *** p < 0.001. a-Received any benefits from Anganwadi/ICDS centre in last 12 months (food supplements/health check-ups/immunization or early childhood education). b-Treatment - Children received food supplements regularly (daily or weekly); Control- Children never received food supplements. Control group is same for all the results. c-Demographic & SES (Socioeconomic) controls include children's sex, birth order, household wealth, mother's education, mother's employment status, mother's diet diversity, mass media, religion, caste, and regions.

Most of the covariates were in balance after the matching (Table A3, S1). Significant mean differences in observed characteristics prior to matching have either diminished or been eliminated after matching, indicating a higher degree of similarity between children in the control and treated groups when calculating ATET[3]. The results indicate that a higher frequency of receiving supplements from ICDS is associated with increased dietary diversity among children[4]. Further, a sensitivity analysis comparing children receiving regular ICDS supplements (daily or weekly) with a control group receiving supplements irregularly (monthly, less often, or never; Table A5, S1) shows that children receiving regular supplementation were 4% more likely to achieve MDD than those in the control group.

[3]Covariate matching is performed for all the subsamples considered in the PSM analysis.
[4]The results are consistent with state fixed effects (Table A4, S1)

Table 4 presents data regarding the food items distributed through Take Home Ration (THR) and Home Cooked Meal (HCM) in ten states (Bihar, Chhattisgarh, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Odisha, Rajasthan, and Telangana), offering insights into which states are offering a diverse range of food items as part of their ICDS program. MDD was defined as the consumption of food items from at least four out of the seven food groups if do not include breastfeeding as a category. Further, it demonstrated that among the ten states, Group 6 “flesh foods” is not provided under take home ration and hot cooked meal. On the other hand, Group 2 “grains, roots, and tubers” and Group 7 “legumes and nuts” are consistently covered under THR and HCM in all ten states. Bihar, Rajasthan, Chhattisgarh, and Haryana only cover these two food groups under SNP, suggesting a need for these states to diversify their food offerings to include at least two more food groups and ensure adequate dietary diversity. Karnataka and Madhya Pradesh covered at least three of the food groups but still fell short of

Table 4. Take Home Ration (THR) and Home Cooked Meals (HCM) food items in selected states, India

State	THR (6-35 months)	HCM (3-6 year)	Food groups covered under SNP
Bihar	Rice, dal, soybean	Rasiyav, khichri, halwa, pulao	2, 7
Chhattisgarh	Ragi, wheat, soybean, Bengal gram, groundnut, fortified oil	-	2, 7
Gujarat	Wheat besan, soybean flour, groundnut, fortified oil, milk	Wheat flour, pulses, rice, vegetables	1, 2, 4, 7
Haryana	Fortified wheat, oil, sugar, besan, peanut	Aloo-puri, parantha, meetha chawal, panjiri	2, 7
Kerala	Wheat, rice, soybean, Bengal gram, groundnut	Milk, banana, egg, seasonal fruits	1, 2, 3, 4, 5, 7
Karnataka	Nutrimix, ragi, rice, greengram, milk	Chitranna, rice kichadi, sprouted greengram	1, 2, 7
Madhya Pradesh	Wheat flour, soy flour, milk powder, moong dal, oil	Daliya mix, khichidi	1, 2, 7
Odisha	Wheat, Bengal gram, groundnut, milk powder	Ragi ladoo, sprouted moong, egg curry	1, 2, 3, 5, 7
Rajasthan	Wheat, Rice, chana dal	-	2, 7
Telangana	Egg, wheat, milk powder, Bengal gram, groundnut	Rice, dal, vegetables, egg	1, 2, 3, 5, 7

Food group numbers correspond to WHO IYCF classifications: 1 = Dairy; 2 = Grains/roots/tubers; 3 = Vitamin A-rich fruits and vegetables; 4 = Other fruits and vegetables; 5 = Eggs; 6 = Flesh foods; 7 = Legumes and nuts. Sources: Compiled from state ICDS portals and NITI Aayog (2022) provided in the reference.

qualifying for providing a diversified meal under SNP. States that provided food items covering four food groups and thus offered a diversified diet under SNP were Kerala, Telangana, Odisha, and Gujarat.

Table 5: Adjusted Odds Ratios (OR) of MDD and ICDS services, Children Aged 6–23 Months, Diversified and Less Diversified States, India (NFHS-5)

	Diversified States				**Less Diversified States**			
	(1)		(2)		(3)		(4)	
	MDD-OR	**95% CI**	**MDD-OR**	**95% CI**	**MDD-OR**	**95% CI**	**MDD-OR**	**95% CI**
Food Supplementation								
No®								
Regularly	1.42	[0.94 2.16]			1.49***	[1.23 1.80]		
Frequency								
Never®			1	[1 1]			1	[1 1]
Daily			1.42	[0.94 2.14]			1.46***	[1.20 1.76]
Weekly			1.64*	[1.07 2.51]			1.45***	[1.19 1.75]
Monthly			2.26***	[1.50 3.40]			1.29**	[1.08 1.55]
Less Often			2.44***	[1.44 4.15]			1.20	[0.92 1.58]
Health Checkup	1.04	[0.84 1.29]	1.08	[0.93 1.24]	1.23*	[1.05 1.44]	1.28***	[1.14 1.44]
Immunizations	1.08	[0.83 1.41]	0.94	[0.79 1.12]	0.96	[0.74 1.23]	0.87	[0.72 1.05]
Early Childhood Care	0.99	[0.84 1.16]	0.97	[0.86 1.08]	1.06	[0.92 1.20]	1.02	[0.91 1.14]
Controls	YES		YES		YES		YES	
Observations	3826		7160		6470		10597	

All definitions, controls excluding regions, and specifications are the same as in Table 3.

Table 5 presents the association between ICDS services and MDD across states with more and less diversified ICDS food menus. In less diversified states, regular food supplementation is positively and significantly associated with MDD (OR:1.49, 95% CI: 1.2-1.8), with consistent effects across daily, weekly, and monthly receipt. In contrast, in more diversified states, the association is weaker and mostly insignificant, except for monthly (OR: 2.26, 95%CI: 1.5-3.4) and less frequent receipt.

Further, the PSM results support these findings. Regular (daily or weekly) food supplementation under SNP is not statistically significant in diversified states (Table 6), but shows a significant effect in less diversified states (Table 7). Interestingly, monthly supplementation has a larger impact on MDD in diversified states (12 percentage points) compared to less diversified states (3 percentage points).

Table 6: Propensity Score-based ATET of ICDS supplementary nutrition on MDD among children (6-23 months), Diversified States, India (NFHS-5)

MDD	(1) ATET	(2) ATET	(3) ATET	(4) ATET	(5) ATET
Any Benefits[a]	0.073** (0.026)				
Food Supplementation – Regularly[b]		0.03 (0.033)			
Food Supplementation – Daily			0.045* (0.026)		
Food Supplementation – Weekly				0.037 (0.028)	
Food Supplementation – Monthly					0.122*** (0.047)
Demographic & SES Controls[c]	Yes	Yes	Yes	Yes	Yes
Treated observations[d]	6,968	3,535	2,575	960	3,118
Observations	7,900	4,634	3,674	2,059	4,217

All definitions, controls, and specifications are the same as in Table 3.

Table 7: Propensity Score-based ATET of ICDS supplementary nutrition on MDD among children (6-23 months), Less Diversified States, India (NFHS-5)

MDD	(1) ATET	(2) ATET	(3) ATET	(4) ATET	(5) ATET
Any Benefits[a]	0.038** (0.011)				
Food Supplementation – Regularly[b]		0.039** (0.010)			
Food Supplementation – Daily			0.057*** (0.014)		
Food Supplementation – Weekly				0.049* (0.02)	
Food Supplementation – Monthly					0.034** (0.011)
Demographic & SES Controls[c]	Yes	Yes	Yes	Yes	Yes
Treated observations[d]	10,341	4,777	2,396	2,381	3,437
Observations	13,726	9,687	7,306	7,291	8,347

All definitions, controls, and specifications are the same as in Table 3.

Further, among poor households, all forms of ICDS food supplementation, daily (OR: 2.10, 95%CI: 1.82–2.42), weekly (OR: 1.89, 95%CI: 1.64–2.19), and monthly (OR: 1.64, 95%CI: 1.43–1.89) show a strong and statistically significant positive association with MDD (Table 8). For rich households, the association remains significant but with smaller magnitudes: daily (OR: 1.28, 95%CI: 1.06–1.55), weekly (OR: 1.30, 95%CI: 1.07–1.57), and monthly (OR: 1.40, 95%CI: 1.16–1.67)

Table 8. Adjusted Odds Ratios (OR) of MDD and frequency of food supplementation, Children Aged 6–23 Months, Poor and Rich Households, India (NFHS-5)

	Poor Households		Rich Households	
	MDD-OR	**95% CI**	**MDD-OR**	**95% CI**
ICDS Food Supplementation Frequency				
Never®				
Daily	2.10***	[1.82 2.42]	1.28**	[1.06 1.55]
Weekly	1.89***	[1.64 2.19]	1.30**	[1.07 1.57]
Monthly	1.64***	[1.43 1.89]	1.40***	[1.16 1.67]
Less Often	1.50***	[1.27 1.77]	1.46**	[1.15 1.84]
Health Checkup	1.23***	[1.16 1.31]	1.12*	[1.02 1.23]
Immunizations	0.91**	[0.84 0.97]	0.83***	[0.75 0.92]
Early Childhood Care	0.96	[0.90 1.02]	0.95	[0.87 1.04]
Controls	YES		YES	
Observations	34037		13788	

All definitions, controls, and specifications are the same as in Table 2.

Further, in Table 9, the PSM estimates suggest that the impact of regular supplementation from ICDS on MDD is evident for poor households, while there is no significant effect for rich households. Similar results were found across both less and more diversified states, with no significant effect of SNP observed among rich households (Table A7, S1).

Table 9. Propensity Score-based ATET of ICDS supplementary nutrition on MDD among children (6-23 months) in poor and rich households, India (NFHS-5)

	Poor Households	Rich Households
MDD-Child	**ATET**	**ATET**
ICDS Food Supplementation – Regularly[a]	0.039** (0.010)	0.039** (0.010)
Demographic & SES Controls b	Yes	Yes
Treated Observations (No.)	17,376	7,054
Observations (No.)	32,584	13,023

All definitions, controls, and specifications are the same as in Table 3.

Next, we examine the association separately for rural and urban areas (Table A8, A9 and A10, S1). As expected, food supplementation and its frequency increase the likelihood of MDD in rural areas, while no significant impact is observed in urban areas. Further, we checked rural households by wealth in Table 10. ICDS food supplementation showed a strong positive association with MDD among poor rural households, with daily supplementation more than doubling the odds of achieving MDD (OR: 2.2; 95% CI: 1.9-2.6). Among rich rural households, some association with ICDS services was observed, but the effect of food supplementation on MDD was smaller[5].

Table 10. Adjusted Odds Ratios (OR) of MDD and frequency of food supplementation, Children Aged 6–23 Months, Poor and Rich Households of Rural Region, India (NFHS-5)

	Poor Households		Rich Households	
	MDD-OR	**95% CI**	**MDD-OR**	**95% CI**
Supplementation Frequency				
Never®	1	[1 1]	1	[1 1]
Daily	2.22***	[1.91 2.57]	1.35*	[1.04 1.76]
Weekly	2.00***	[1.72 2.33]	1.46*	[1.12 1.90]
Monthly	1.73***	[1.50 2.00]	1.49**	[1.16 1.93]
Less Often	1.57***	[1.33 1.86]	1.52*	[1.10 2.09]
Health Checkup	1.24***	[1.16 1.32]	1.10	[0.98 1.24]
Immunizations	0.90*	[0.84 0.98]	0.84*	[0.73 0.96]
Early Childhood Care	0.95	[0.89 1.01]	0.95	[0.84 1.07]
Controls	YES		YES	
Observations	32678		8936	

. All definitions, controls, and specifications are the same as in Table 2.

Lastly, from a policy perspective, we compare the effects across EAG and non-EAG states in Table 11. The results show that children in EAG states have about 40% lower odds of achieving MDD compared to non-EAG states. Receiving any ICDS benefits is associated with higher dietary diversity (OR: 1.13, 95%CI: 1.05–1.21), and the interaction term indicates that this effect is significantly larger in EAG states (OR: 1.23, 95%CI: 1.11–1.35). Food supplementation, on average, does not have a statistically significant effect on dietary diversity in non EAG states (OR: 1.08, 95%CI: 0.97–1.19). However, the interaction with EAG states is positive and significant (OR: 1.30, 95% CI: 1.13–1.48), indicating that supplementation is effective specifically in EAG states. Similarly, the frequency of supplementation does not show a significant effect on average in non EAG states, but becomes important in EAG states.

Table 11. Adjusted Odds Ratios (OR) of MDD and ICDS services, Children Aged 6–23 Months, EAG versus Non EAG states using interaction term, India (NFHS-5)

MDD-chid	**(1)**		**(2)**		**(3)**	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Variables						
EAG state						
No®						
Yes	0.60***	[0.54 0.65]	0.59***	[0.52 0.67]	0.51***	[0.42 0.63]
Received any benefits						
No®						
Yes	1.13**	[1.05 1.21]				
Received any benefits *						
EAG	1.23***	[1.11 1.35]				
Received food supplementation from ICDS						
No®						
Yes			1.08	[0.97 1.19]		
Received food supp. from ICDS * EAG			1.30***	[1.13 1.48]		
Frequency of Food Supplementation						
Never®						
Daily					1.14	[0.96 1.36]
Weekly					1.15	[0.96 1.38]
Monthly					1.11	[0.93 1.32]
Less Often					1.08	[0.88 1.32]
Daily * EAG					1.57***	[1.26 1.96]
Weekly * EAG					1.38**	[1.10 1.73]
Monthly * EAG					1.50***	[1.20 1.86]
Less Often *EAG					1.33*	[1.02 1.72]
Health Checkup	1.20***	[1.15 1.26]	1.14***	[1.08 1.19]	1.13***	[1.08 1.19]
Immunizations	0.87***	[0.82 0.92]	0.87***	[0.83 0.93]	0.88***	[0.83 0.93]
Early Childhood Care	1.00	[0.96 1.05]	1.00	[0.96 1.05]	0.99	[0.94 1.04]
Controls	YES		YES		YES	
Observations	64,725	50,281	50,281			

All definitions, controls excluding regions and specifications are the same as in Table2.

Discussion

This study provides encouraging evidence on the association between the SNP under ICDS and MDD among children aged 6–23 months in India. First, dietary diversity has improved between NFHS-4 and NFHS-5, particularly in the consumption of vitamin A-rich fruits and vegetables (Group 3), other fruits and vegetables (Group 4), eggs (Group 5), and legumes and nuts (Group 7). Second, more regular receipt of supplementary nutrition is associated with better MDD outcomes, suggesting that the regularity of programme contact matters. It is important to note that frequency of receipt reflects engagement with Anganwadi services and does not directly measure whether the child consumed the supplement.

Maternal and household characteristics play a central role in shaping children's diets. The positive association between maternal education and children's MDD is consistent with Bhati et al. (2022), who show that higher years of schooling among mothers increase the likelihood of achieving MDD. Similarly, the strong link between maternal and child diet diversity supports the evidence from Amugsi et al. (2015) that improvements in mothers' diets translate into better child feeding practices. Children of currently working mothers have significantly higher odds of achieving MDD. Descriptive patterns show that casually or self-employed mothers have higher ICDS utilisation, followed by unemployed and then salaried mothers (Table A13, S1), while MDD is highest among children of salaried mothers. This indicates that ICDS is reaching more vulnerable groups, while better dietary outcomes remain concentrated among relatively better-off households. Economic status remains a strong determinant, with wealthier households exhibiting higher MDD. Access to mass media is positively associated with MDD, reinforcing findings by Bhati et al. (2022) on the role of information and awareness in shaping feeding behaviour. Regional differences persist, with southern and eastern states showing better dietary outcomes than northern and western regions, where diets are more cereal-based, consistent with earlier evidence on geographical disparities in child nutrition (Jain et al., 2022).

At the same time, weak associations with stunting, wasting, and underweight suggest that although SNP may improve dietary diversity, it is insufficient to address broader nutritional and micronutrient deficits, as reflected in the persistently high burden of anaemia.

The state-level heterogeneity in effects offers important insights into how the SNP operates in different contexts. In states with already diversified SNP menus (Kerala, Telangana, Gujarat, and Odisha) regular (daily or weekly) supplementation shows no significant association with MDD, whereas monthly receipt, likely in the form of Take-Home Rations (THR), remains positively associated. A plausible explanation lies in both behavioural and implementation factors. These states start from a higher baseline MDD (0.28 versus 0.18 in less diversified states), suggesting a possible ceiling effect that limits the marginal gains from more frequent supplementation. In practice, THR in some states is typically distributed on a monthly and relatively predictable basis, and better-educated mothers may be more likely to use these rations consistently at home, spreading them over time and integrating them into children's daily diets. For children aged 6–23 months, an age group for whom THR is more relevant, thus regular and reliable household use of monthly rations may therefore matter more than nominal frequency of contact with centres. Moreover, non-beneficiary children in these states are more likely to come from better-off households with higher maternal education and better maternal diet diversity (Table A6, S1), implying that home diets are already relatively adequate and reducing the observable marginal impact of ICDS on MDD.

In contrast, in less diversified states such as Bihar, Rajasthan, Chhattisgarh, and Haryana, regular supplementation is strongly associated with improvements in MDD, reflecting the critical role of SNP where baseline nutrition is weaker. These states often exclude items such as eggs or milk from SNP menus due to social or logistical constraints, which may limit overall diet quality. Expanding the diversity of SNP offerings could enhance programme effectiveness in these regions.

The distributional analysis indicates that the gains from regular supplementation are concentrated among poorer households, both in less and more diversified states, and particularly in rural areas, with minimal impact on wealthier households. This highlights that the marginal benefits of ICDS are greatest for disadvantaged populations. Lastly, EAG states are examined separately due to their higher undernutrition and lower dietary diversity. Our findings show that the effect of food supplementation on MDD is stronger in these states, highlighting that ICDS effectively reaches nutritionally vulnerable populations where the need is greatest.

Conclusion

This study highlights the nuanced role of ICDS, particularly supplementary nutrition (SNP), in shaping children's (6-23 months) dietary diversity in India. The findings show that ICDS is effectively targeted towards disadvantaged regions, with stronger impacts of food supplementation on MDD observed in EAG states where baseline dietary diversity is low; the frequency of supplementation also matters more in these contexts. At the same time, programme effectiveness varies across states, those with more diversified SNP menus show smaller marginal gains, while less diversified states benefit more from regular supplementation, indicating that impact depends on the existing food environment. Further, the study finds that the impact of regular (daily or weekly) food supplementation on MDD is stronger in rural areas and among poorer households, with particularly pronounced effects among the rural poor, while limited or no significant effects are observed among richer and urban households. However, the limited effects on anthropometric outcomes and persistent anaemia suggest that improvements in dietary diversity alone are not sufficient. Overall, future progress will require context-specific programme design, with greater focus on improving the quality, diversity, and reliability of food provision, along with stronger implementation to translate dietary gains into broader nutritional outcomes.

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