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Nutrient adequacy, dietary pattern, and diet quality among rural school-going children aged 7-9 years: A nutritional surveillance study

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Abstract
Background: Inadequate nutrient intake and poor diet quality among rural school aged children are key contributors to undernutrition and micronutrient deficiencies.
Objective: To assess the nutrient adequacy, food group consumption and to evaluate the overall diet quality using a standardised scoring index among school children aged 7-9 years.
Methods: Three non-consecutive-days, 24-hour dietary recall method was used to collect food intake data from 200 children (100 boys and 100 girls). Actual intakes were compared with ICMR 2020 recommendations. Nutrient Adequacy Ratio (NAR), Average Average Overall Ratio (AOR) and Mean Adequacy Ratio (MAR) were calculated for food groups only.
Results: Mean NAR was 0.66 for boys and 0.59 for girls. Deficient intakes were observed in milk, green leafy vegetables (GLVs), and fruits. Only meat/fish/eggs met recommended levels. The Mean Adequacy Ratio (MAR) was 0.72 for boys and 0.67 for girls, indicating moderate dietary adequacy. These value suggest that boys met 72% and girls 67% of their recommended intake across major food groups, with deficits noted especially in fruits, milk, and green leafy vegetables.
Conclusion: The dietary intake of children aged 7-9 years is inadequate, particularly in micronutrient-dense food groups, which may contribute to long-term nutritional deficits. Immediate intervention through school meals and nutrition education to the parents/ guardians is recommended.

Keywords: Rural children, food groups, AOR, NAR, nutrients

1. Introduction
Nutrition in early childhood plays a vital role in physical growth, cognitive development, and immunity. In India, studies show that children aged 7-9 years often do not meet dietary recommendations due to socioeconomic and cultural factors. This study assesses the food intake adequacy among school-going children based on established Indian dietary standards. Khan *et al*. (2020) [6] found widespread protein-energy malnutrition in rural children, with limited intake of milk and vegetables. Patel & Singh (2021) [9] noted a 45% inadequacy in dairy product intake among children aged 6-10. Rao *et al*. (2021) observed that mid-day meals cover less than 50% of micronutrient requirements. Das & Mishra (2023) [4] showed gender bias in household food distribution among rural children. Mehta *et al*. (2023) [8] demonstrated a positive correlation between dietary diversity and academic performance in primary school children. Tripathi *et al*. (2024) [13] stressed the urgent need to revise school meal menus to include more micronutrient-rich foods. Gupta *et al*. (2020) [5] reported a high prevalence of iron and vitamin A deficiency in rural school children in Northern India and emphasized inadequate dietary diversity as a key factor. Ramakrishnan *et al*. (2021) [10] found that dietary intake in urban slums was energy-sufficient but lacked essential micronutrients, particularly zinc and folate. Saxena & Singh (2021) [11] conducted a diet quality analysis among tribal children and reported poor nutrient density and a high burden of anaemia and stunting. Das & Roy (2022) [3] linked low fruit and vegetable intake with vitamin C and A deficiency among children in the Eastern Indian region. Kumar *et al*. (2022) [7] highlighted that despite adequate calorie intake, micronutrient consumption remained below RDA in most school- going children in Bihar and Jharkhand. Sharma *et al*. (2023) associated poor diet diversity scores with low serum ferritin and retinol levels in children aged 6-10 years. Bora *et al*. (2023) [1] examined the relationship between food insecurity and micronutrient status in Northeast India and found that food-insecure households had children with significantly lower hemoglobin and vitamin A levels. Chatterjee & Mandal (2024) [2] assessed Mid-Day Meal contribution and concluded that while it covered calorie needs, it was insufficient in meeting the micronutrient requirements of iron and zinc.

Research Methodology

Study Design: Cross-sectional surveillance study.

- **Study Area:** Three blocks of rural area in Simdega district, Jharkhand.
- **Sample Size:** Cochran's formula was used for calculating sample size. The minimum required sample size was found to be approximately 196. To account for potential non-response, the sample size was rounded to 200 children, equally divided into 100 boys and 100 girls were included in the study. [The required sample size was calculated using the Cochran's formula: no = Required sample size; Confidence level= 95% (Z=1.96); Estimated Prevalence= 0.5 (50%); Margin of Error=7% (d=0.07)]
- **Sampling Technique:** A stratified random sampling technique was employed to ensure equal representation of boys and girls (100 each) aged 7-9 years.

Tools and Techniques

- 24-hour Dietary Recall Method (3 non-consecutive days) used to assess the food consumption of the children. Parents/guardians were interviewed to improve accuracy.
- **Food Frequency Questionnaire (FFQ):** The food items were grouped into 9 categories based on similarity of nutrient profiles. These categories were (1) cereals, including rice, bread, chapati (2) Pulses (3) green leafy vegetables (4) Other vegetables (5) fruits (6) milk (7) fats & oils (8) meat, fish & egg (9) Sugar & jaggery.
- **Data Analysis:** SPSS software for descriptive statistics, chi-square test, and associations between intake and deficiency.
- **Inclusion Factor:** Children whose parents or guardians gave informed consent for participation.
- **Exclusion Factor:** Children with chronic illnesses taking therapeutic diets or unwilling to participate.

Results and Discussion

Table 1: Demographic and Socioeconomic Characteristics of the Study Population (Age 7-9 years, N = 200)

Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	100	50
	Female	100	50
Family Income (₹/month)	< 5,000	40	20.0
	5,001 - 10,000	80	40.0
	10,001 - 15,000	50	25.0
	>15,000	30	15.0
Mother's Education	Illiterate	66	33.0
	Primary	34	17.0
	Middle	27	13.5
	Matriculation	30	15.0
	Above Matriculation	43	21.5
Type of Family	Nuclear	120	60.0
	Joint	80	40.0
Religion	Hindu	140	70.0
	Christian	60	30.0
Caste	Scheduled Tribe (ST)	69	34.5
	Scheduled Caste (SC)	90	45.0
	Other Backward Class (OBC)	33	16.5
	General	8	4.0
Father's Occupation	Daily Wage Labourer	80	40.0
	Driver	12	6.0
	Farmer	47	23.5
	Semiskilled	30	15.0
	City Area	17	8.5
	No Work	14	7.0
Mother's Occupation	Homemaker	124	62.0
	Agriculture	44	22.0
	Daily Wage Labourer	32	16.0

The table 1 presents the demographic characteristics of the 200 children participated in the study. The gender distribution showed an equal proportion, with 100 males (50%) and 100 females (50%), reflecting a balanced representation.

- **Family Income:** Most of the families had a monthly income of ₹5,001-10,000 (40%), followed by ₹10,001-15,000 (25%), less than ₹5,000 (20%), and
- above ₹15,000 (15%). This indicates a predominantly low-income population, suggesting limited access to resources.
- **Parental Education:** Parental education was low among the respondents in which 33% of parents were illiterate, 17% had completed primary education, 13.5% had middle
- school education, 15% had completed matriculation, and only 21.5% had education above matriculation.
- **Type of Family and Religion:** Most children belonged to nuclear families (60%) compared to joint families (40%). A majority practiced Hinduism (80%), followed by Christianity (20%).
- **Caste Distribution:** Scheduled Caste (SC) children formed the largest group (45%), followed by Scheduled Tribe (ST) (34.5%), Other Backward Classes (OBC) (16.5%), and General category (4%).
- **Father's Occupation:** Daily wage labour was the most

common occupation among fathers (40%), followed by farming (23.5%), semi-skilled jobs (15%), drivers (6%), city area jobs (8.5%), and those without employment (7%).

- **Mother's Occupation:** A significant majority of mothers were homemakers (62%), while others were engaged in agriculture (22%) and daily wage labour (16%).

Discussion

The demographic data highlights critical socio-economic constraints affecting the study population. The equal gender distribution strengthens the reliability of gender-based analyses. However, the high percentage of families falling below or near the poverty line underscores a prevalent economic vulnerability that may influence children's dietary intake, nutritional status, and access to health services. The low levels of parental education, particularly among mothers, are a matter of concern. Studies have consistently shown a strong correlation between maternal education and child nutritional status (UNICEF, 2022). The fact that 33% of the parents were illiterate indicates the need for community-based educational interventions. The occupational profile reveals a high dependency on daily wage labour, particularly among fathers, suggesting financial instability. The prevalence of homemakers (62%) among mothers may reflect traditional gender roles but also points to the potential lack of financial autonomy, which can affect intra-household food allocation and childcare practices. The caste-wise distribution, with a large proportion of ST and SC populations, is consistent with the regional tribal and marginalized demographic in the study area of Jharkhand. These groups are often subjected to systemic deprivation and social exclusion, further compounding health and nutrition risks. Lastly, the nuclear family predominance (60%) may have implications for childcare support systems, particularly during peak agricultural or labour seasons when parents are away for work.

The findings depict a marginalized and socio-economically challenged population, consistent with the tribal and backward regions of Jharkhand. The household income pattern, with 85% earning less than ₹15,000/month, reflects a widespread economic vulnerability. This level ofincome is below the national poverty line threshold, limiting household access to nutritious food, quality education, and healthcare services. The parental education level, especially maternal literacy (with 33% illiteracy overall), is considerably lower than the NFHS-5 (Jharkhand) data, which reports female literacy at 61.3%. Low maternal education has been consistently linked with poor dietary diversity and higher child undernutrition (CNNS, 2019). This calls for community awareness and educational interventions, especially targeting tribal mothers. The caste composition aligns with state demographics, where ST and SC groups face higher risk of malnutrition. According to CNNS (2019), ST children in Jharkhand showed the highest prevalence of stunting (50.2%), which could be related to socioeconomic barriers, food insecurity, and poor maternal health literacy—all evident in the present findings. Most mothers (62%) are homemakers, suggesting limited economic independence, which can affect decision-making power in food and health-related matters. This gender dynamic reinforces the importance of women-centric nutrition and livelihood programs in tribal and rural Jharkhand. The occupational profile of fathers—dominated by daily wage labor and farming—indicates seasonal and insecure income. These families are often dependent on public welfare schemes (e.g., PDS, ICDS), and any gap in these services could directly affect child dietary adequacy. Moreover, the high proportion of nuclear families (60%) may result in reduced support for child care during seasonal work peaks. This has implications for meal frequency, food quality, and child supervision, especially in households where mothers are engaged in agricultural or wage labor.

Table 2: Association Between Socioeconomic Variables (Chi-square Test Results)

Cross-tabulation	χ^2 Value	df	p-value	95% CI	Association
Family Income vs Parental Education	28.62	12	0.004	(0.01 - 0.07)	Significant
Caste vs Father's Occupation	23.47	12	0.024	(0.02 - 0.08)	Significant
Type of Family vs Mother's Occupation	6.73	2	0.035	(0.01 - 0.10)	Significant

Table 2 illustrates the associations among key sociodemographic variables. Chi-square tests were conducted for socioeconomic variables. Family Income and Parental Education: A statistically significant association was found between family income and parental education level ($\chi^2 = 28.62$, $df = 12$, $p = 0.004$), suggesting that higher family income levels were linked to better educational attainment among parents. Notably, families earning above ₹15,000/month had the highest proportion of parents with matriculation and above-matriculation qualifications. Caste and Father's Occupation: A statistically significant association was observed between caste and father's occupation ($\chi^2 = 23.47$, $df = 12$, $p = 0.024$). Most Scheduled Tribe (ST) fathers were found to be daily wage laborers, while Other Backward Class (OBC) and General caste respondents showed more occupational diversity, including city-based employment and semi-skilled jobs. Type of Family and Mother's Occupation: The type of family (nuclear vs joint) was significantly associated with mother's occupation ($\chi^2 = 6.73$, $df = 2$, $p = 0.035$). Homemakers were more prevalent in nuclear families, whereas joint families had higher representation in agricultural and labor roles, likely due to shared economic responsibilities.

Discussion

These findings underscore the strong interrelationship

between socioeconomic status and education and employment outcomes in rural area. Income-Education Link: Consistent with recent studies (Kumar *et al*., 2021; Patel & Joshi, 2022), this study confirms that higher household income enables greater educational investment, particularly for secondary and higher education. Educational attainment, in turn, plays a crucial role in breaking intergenerational cycles of poverty and underemployment. Caste-Based Occupational Patterns: The significant caste-occupation association reflects persistent structural inequalities. Studies such as by Das & Mishra (2023) [4] have highlighted that Scheduled Tribes and Scheduled Castes remain overrepresented in low-income, unskilled occupations, with limited mobility. Affirmative actions and skill-building programs tailored to these communities are imperative. Gender and Family Structure: The distribution of mothers' occupation by family type reveals gendered labor patterns. Joint families allow for shared child-rearing and domestic duties, enabling women's participation in agriculture and wage labor. In contrast, nuclear households often restrict women to homemaking roles due to caregiving burdens.

Table 3: Comparison of Actual Intake of nutrients with RDA and Percentage Excess/Deficit among Children (7-9 years, N=200)

Nutrient	RDA	Boys (n=100) (Mean ± SD)	Girls (n=100) (Mean ± SD)	Boys Excess/ Deficit	Boys % Excess/ Deficit	Girls Excess/ Deficit	Girls % Excess/ Deficit
Energy (kcal)	1950	1339.0 ± 38.7	1331.3 ± 231.6	-611 kcal	-31.3%	-619 kcal	-31.7%
Protein (g)	41	34.8 ± 10.6	38.6 ± 17.9	-6.2 g	-15.2%	-2.4 g	-5.8%
Fat (g)	25	13.0 ± 1.9	13.2 ± 3.9	-12.0 g	-47.8%	-11.8 g	-47.2%
Calcium (mg)	400	283.0 ± 33.4	232.3 ± 156.7	-117 mg	-29.3%	-168 mg	-42.0%
Iron (mg)	20	13.3 ± 20.6	12.3 ± 18.5	-6.7 mg	-33.6%	-7.7 mg	-38.5%
Vit. B1 (mg)	1.2	0.96 ± 0.87	0.78 ± 0.65	-0.24 mg	-20.0%	-0.42 mg	-35.0%
Vit. B2 (mg)	1.2	0.96 ± 1.08	0.00 ± 0.00	-0.24 mg	-20.0%	-1.20 mg	-100.0%
Vit. C (mg)	40	88.2 ± 18.4	29.7 ± 15.7	+48.2 mg	120.4%	-10.3 mg	-25.7%
Beta- carotene (µg)	400	803.0 ± 16.5	345.3 ± 59.5	-1597 µg	-66.5%	-2055 µg	-85.6%

[The intake data for energy, protein, fat, calcium, iron, vitamins B1, B2, C, and beta carotene among boys and girls were compared against RDA standards (ICMR, 2020)]

Table 3 highlights a significant gap between recommended and actual nutrient intakes among 7-9-year-old children in the sampled population. Both boys and girls showed substantial deficits across multiple macronutrients and micronutrients, with girls faring worse in several parameters. Energy and Protein Deficiency: Intake was notably low in both groups, reflecting possible food insecurity or poor meal planning. While boys had a higher protein deficit (15.2%) than girls (5.8%), both remained below optimal intake, which could adversely affect growth and immunity. Fat Intake: The intake was nearly half of the recommended value, suggesting a low-fat dietary pattern that might impact the absorption of fat-soluble vitamins. Whereas the Micronutrients, Calcium and Iron: Both essential for skeletal and cognitive development, these showed moderate-to-severe deficits, especially among girls. Riboflavin (Vitamin B2): Critically absent in girls, highlighting a possible risk for skin disorders, growth retardation, and anaemia. Vitamin C: Only boys exceeded RDA, likely due to better fruit/vegetable consumption. Girls' intake fell short by ~25.7%. Beta- Carotene: Alarmingly low in both groups, with girls showing an 85.6% shortfall, raising concerns about vitamin A deficiency and visual health.

Table 4: Comparison of Mean Food Intake of School Children (7-9 Years, N=200)

Food Group	Std. Value (g)	Mean Intake (g)	Mean Intake (g)	% Adequacy cy	% Adequacy cy	Mean Deficit (g)	Mean Deficit (g)	Interpretation
		Boys	Girls	Boys	Girls	Boys	Girls	
Cereals	250	170	185	68%	74%	80	65	Moderately inadequate
Pulses	70	50	45	71%	64%	20	25	Inadequate
GLV	50	40	35	80%	70%	10	15	Slightly inadequate
Other Vegetables	75	50	40	67%	53%	25	35	Inadequate
Fruits	50	55	25	110%	50%	0	25	Surplus in boys, deficit in girls
Milk	250	150	150	60%	60%	100	100	Significantly inadequate
Fats & Oils	25	10	10	40%	40%	15	15	Severely inadequate
Meat, Fish, Egg	30	45	40	150%	133%	0	0	Surplus in both
Sugar & Jaggery	25	25	20	100%	80%	0	5	Adequate in boys, mildly deficient in girls

Table 4 revealed critical shortfalls across several food groups, particularly milk, fats & oils, and vegetables. Boys met approximately 68-110% of the dietary requirements in most categories except milk (60%) and fats (40%). Girls had a higher deficit, with adequacy ranging between 40- 74%, except for meat, fish, and egg consumption, which exceeded the recommended values. Milk and dairy products showed the highest deficit (40% adequacy), affecting calcium and protein intake. Fats and oils were consumed at less than half the required levels, which could impact energy intake and fat-soluble vitamin absorption. Intake of green leafy vegetables and other vegetables was also significantly below standards, especially in girls, indicating risk of micronutrient deficiencies. Fruits were adequately consumed by boys but remained inadequate in girls, showing gender disparity in access or preference. Surprisingly, meat, fish, and egg intake exceeded the standards, possibly due to better supply or mid-day meal inclusion. These findings are consistent with Vijayapushpam *et al*. (2003), who also reported that urban school children received only 30-40% of recommended daily food quantities. These results underscore the urgent

need to improve the quality and quantity of school meals, especially in protein, calcium, iron, and fat sources, while also promoting vegetable and fruit consumption for micronutrient adequacy.

Table 5: NAR Values of Food Group Intake Among Boys and Girls

Food Group	ICMR Standar d (g)	Actual Intake (Boys)	NAR (Boys)	Actual Intake (Girls)	NAR (Girls)
Cereals	250	170	0.68	160	0.64
Pulses	70	50	0.71	45	0.64
GLV	75	40	0.53	50	0.67
Other Vegetables	50	45	0.90	40	0.80
Fruits	50	25	0.50	25	0.50
Milk	250	90	0.36	90	0.36
Fats and Oils	25	15	0.60	10	0.40
Meat/Fish/Eggs	50	40	0.80	30	0.60
Sugar & Jaggery	30	25	0.83	20	0.67
Mean NAR	-	-	0.66	-	0.59
MAR	-	-	0.72	-	0.67
AOR	-	-	0.656	-	0.643

[NAR= Nutrient Adequacy Ratio; MAR= Mean adequacy ratio; AOR= Average overall Ratio]

Table 5 revealed suboptimal dietary patterns in both boys and girls when compared to ICMR (2020) standards. The Mean NAR was 0.66 for boys and 0.59 for girls, indicating widespread inadequacy. The highest adequacy was observed in the intake of other vegetables and sugar/jaggery, whereas milk and green leafy vegetables (GLVs) showed the greatest deficiency. None of the children met the recommended dietary intake for milk, where NARs fell below 0.5. The Mean Adequacy Ratio (MAR) was 0.72 for boys and 0.67 for girls, indicating moderate dietary adequacy. These value suggest that boys met 72% and girls 67% of their recommended intake across major food groups, with deficits noted especially in fruits, milk, and green leafy vegetables. The Average Overall Ratio (AOR), reflecting total food intake against ICMR recommendations, was 0.643 for girls. This means both groups consumed only about 65 % of the total recommended daily quantity.

The low NAR values in several essential food groups suggest that the Studied population is at risk of micronutrient deficiencies, particularly calcium (due to low milk intake), iron and folate (due to low GLVs and fruits). The results align with previous studies. Sinha *et al*. (2022) also reported low fruit and vegetable intake among tribal children in Jharkhand. Poor dietary intake during critical growth years can impair physical and cognitive development. Gender disparities were observed, with girls showing lower NARs than boys, possibly due to gender bias in intra-household food distribution. The findings indicate a significant deficiency in dietary intake of essential food groups among school children aged 7-9 years, particularly for milk (NAR: 0.36) and fruits (0.50). The mean NAR of 0.66 for boys and 0.59 for girls reflects a broader inadequacy. The gender gap, with girls consistently receiving less than boys across all categories, points to persistent socio-cultural biases. Intake of GLVs, fruits, and milk revealed widespread dietary insufficiency in both quality and quantity. These findings highlight the need for improved dietary diversity to ensure nutritional especially micronutrients adequacy.

Table 6: Association between gender and micronutrient adequacy

Sl. No.	Nutrients	χ2 Value	Degree of freedom	P-value	Association with gender
1	Energy (kcal)	0.066	1	0.797	Not Significant
2	Protein (g)	0.192	1	0.661	Not Significant
3	Fat (g)	0.032	1	0.858	Not Significant
4	Calcium (mg)	2.500	1	0.114	Not Significant
5	Iron (mg)	3.330	1	0.068	Borderline significance
6	Vit. B1 (mg)	1.060	1	0.303	Not Significant
7	Vit. C (mg)	0.866	1	0.352	Not Significant
8	Beta-carotene (µg)	1.905	1	0.167	Not Significant

A chi-square test of independence was conducted to examine the relationship between gender and adequacy of dietary intake across eight key nutrients. Nutrient adequacy was classified as achieving
≥ 90% of the RDA as per ICMR (2020). The results indicated no statistically significant association between gender and intake adequacy for energy, protein, fat, calcium, vitamin B-1(Thiamin), vitamin C, or beta carotene. However, iron showed a borderline significant association with gender, suggesting that boys may be somewhat more likely to meet the iron requirement than girls. The widespread inadequacy of micronutrients across both genders reflects a common pattern of undernutrition, linked to low dietary diversity, poor quality of food, and socio economic limitations. Iron intake showed a borderline significant difference by gender, with girls appearing more deficient than boys. This may be attributed to biological differences, cultural food distribution practices, or early onset of iron depletion in girls due to growth and menstrual demands in later years. The findings is consistent with previous research on micronutrient malnutrition in children.

Although not statistically significant, the consistent inadequacy of beta-carotene across genders is noteworthy. This points to potential risks for vitamin A deficiency, which could have long-term implications on vision and immunity.

Conclusion

The present nutritional surveillance study highlights significant gaps in nutrient adequacy, poor dietary patterns, and suboptimal diet quality among rural children aged 7-9 years. Their diets were largely cereal dominated with inadequate intake of fruits, vegetables, and milk resulting in poor diet diversity and low quality index scores. Socioeconomic factors, especially maternal education and family income, were strongly associated with dietary adequacy and quality.

Recommendations

- Strengthen and diversify school feeding programme (e.g., Mid-day Meal scheme) to include more micronutrient-rich foods.
- Community -level nutrition education targeting parents, especially mothers, to promote diverse and balanced diets.
- Encourage kitchen gardening and incorporating of local nutrient-rich foods into daily home cooked meals.

Ethical Consideration

- Ethical approval was obtained from the head of the institutions.
- Informed consent from parents were taken after explaining the study purpose.
- Participation was voluntary, and confidentiality of all data was strictly maintained.

Conflict: None.

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