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ORIGINAL ARTICLE

Assessing Malnutrition among Tribal Children: A cross-district Analysis of Child Health in West Bengal

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ABSTRACT
Tribal populations in India continue to face a critical public health problem of malnutrition, especially among children. The objective of this study was to assess the nutritional status of tribal children aged 1 to 9 years in the districts of Purulia, Bankura and Paschim Medinipur, West Bengal. The prevalence of undernutrition, wasting and stunting was assessed using anthropometric measurements such as weight for age, height for age and weight for height. A descriptive correlational study design was used. Structured interview schedule was used to collect data and simple random sampling was used to select 526 tribal children. The macro and micronutrient deficiencies in the children's nutritional intake were compared with the Indian Council of Medical Research's Recommended Dietary Allowances (RDA). We also analyzed sociodemographic variables, such as family type, housing conditions and parental occupations, as potential risk factors for malnutrition.
Keywords: *Tribe, Children, Nutrition, Malnutrition, Indigenous Knowledge, Community.*

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INTRODUCTION
Public health problem of malnutrition is pervasive and affects vulnerable populations worldwide. Of these, tribal communities continue to be at high risk because of their unique socio-economic, cultural, and geographic circumstances. Tribal children in India face the compounded effects of poverty, food insecurity, poor health care access, and poor sanitation with higher rates of under nutrition, stunting, and wasting. Childhood malnutrition is a multifaceted and complex problem which is influenced by socio demographic variables, household food security, maternal education and access to health care services [1]. Various studies on several tribal population residing in different regions of India have found them nutritionally, socially, and economically disadvantaged [2-6]. In tribal areas, locally available traditional diets are nutritionally imbalanced foods, can lead to deficiencies in essential nutrients, such as protein, calcium and vitamins [7-9]. In addition, nutritional disparities are compounded by cultural practices, gender biases, and seasonal food availability [10-11]. The prevalence and causes of malnutrition in particular tribal populations must be understood in order to develop effective public health interventions. The anthropometric indicators used in this study, weight for age, height for age, and weight for height, are important indicators of nutritional status of children [12]. Weight for age measures overall undernutrition, height for age is a measure of chronic malnutrition or stunting, and weight for height is a measure of acute malnutrition or wasting. These measurements are critical to identify at risk children and timely use of corrective measures [13-15]. The objective of the study is to fill the knowledge gap on the nutritional health of tribal children in these regions and to offer data-driven recommendations to improve their nutritional outcomes. The socio-economic profile of the tribal populations of Purulia, Bankura and Paschim Medinipur is quite different. In these districts, most of the people are in agricultural labors or homemakers, who have restricted entry into educational as well as health services. Hence housing conditions also vary, with many families living in kutcha and semi pucca houses as indicative of

lower socio-economic status. However, children's nutritional status can also be affected by the type of family structure (nuclear or joint) since joint families generally provide more social and economic support. Despite a host of government initiatives seeking to improve nutritional health of children-like the Integrated Child Development Services (ICDS) and the Mid Day meal scheme-malnutrition is prevalent in tribal areas. It demonstrates that it is necessary to target interventions at the specific needs of tribal communities. This study uses analysis of the nutritional status of children from these districts to provide valuable insights for policymakers, healthcare providers, and community leaders interested in reducing malnutrition in tribal populations. Findings can inform the development of culturally appropriate and sustainable nutrition programs for tribal communities in West Bengal and elsewhere, including the women and children who are its primary beneficiaries.

MATERIAL AND METHODS

A descriptive correlational research design was used in the study to investigate the nutritional status of tribal children aged 1 to 9 years in Purulia, Bankura and Paschim Medinipur districts. This design enabled a thorough examination of both the extent of malnutrition and socio demographic factors underpinning it. The study population consisted of 526 tribal children aged between 1 to 9 years from the districts of Purulia, Bankura, and Paschim Medinipur in West Bengal. These districts were selected due to their significant tribal population and the reported prevalence of child malnutrition. The inclusion criteria required participants to be permanent residents of the study area and belong to recognized tribal communities. Exclusion criteria included children with chronic illnesses, disabilities, or those already enrolled in specialized nutrition programs to avoid data bias. The study population was divided into three age groups: 1-3 years, 4-6 years, and 7-9 years. This stratification allowed for age-specific analysis of nutritional deficiencies and developmental impacts. Community health workers and local leaders played a vital role in identifying eligible participants and facilitating their participation in the study. Efforts were made to ensure gender balance in the sample to capture gender-specific disparities in nutritional status. A multi-stage simple random sampling technique was employed to ensure representative participation from the selected districts. The first stage involved identifying villages within each district using census data. The second stage focused on listing households with children aged 1 to 9 years, verified through community health records. In the final stage, children were randomly selected from the list of eligible households. The sampling process was designed to achieve proportional representation from each district to reflect the diversity of the tribal population. Random number tables were used to select participants, ensuring that every eligible child had an equal chance of being included in the study. This method minimized selection bias and enhanced the reliability of the findings.
Multiple tools were used to collect data to capture comprehensive information on socio demographic characteristics, nutritional status and dietary intake of the participants. A pilot study was conducted to pretest the tools to ensure accuracy, cultural relevance and feasibility.
1. Structured Interview Schedule; 2. Anthropometric Measurements; 3. **Dietary Intake Assessment; and 4. Ethical Considerations**
The collected data were entered into a statistical software package for thorough analysis. Descriptive and inferential statistical methods were used to interpret the data and identify significant trends and associations.

RESULT

There was a total of 526 tribal children in the age group of 1 to 9 years, of which 280 (53.23%) were male and 246 (46.77%) were female. Almost 80% of fathers were agriculture laborers and 90% of mothers were homemakers. The main findings of the study are discussed in the following tables.

Table 1: Socio-demographic characteristics of tribal children in the districts of Purulia, Bankura & Paschim Medinipur in West Bengal (n = 526)

Socio-demographic variables		N	%
Age (years)	1	42	7.98
	2	54	10.26
	3	51	9.69
	4	55	10.45
	5	50	9.50
	6	75	14.25
	7	79	15.01
	8	71	13.49
	9	49	9.31
Gender	Male	280	53.23
	Female	246	46.77
Type of house	Kutcha	157	29.84
	Semi pucca	322	61.21
	Pucca	47	8.93
Type of family	Nuclear family	237	45.05
	Joint family	289	54.94

Table 2. Showing the under nutrition (weight for age) of tribal children in the districts of Purulia, Bankura & Paschim Medinipur in West Bengal

Age Group	MALE			FEMALE		
	Mean wt. in kg	Less wt. in kg	% of under nourish children	Mean wt. in kg	Less wt. in kg	% of under nourish children
1-3 Yr	11.6	1.3	59.27	11.05	1.85	63.27
4-6 Yr	15.1	3.2	60.32	14.5	3.8	63.56
7-9 Yr	21.5	3.8	60.07	21.1	4.2	61

Table 3. Showing the wasting and stunting % of tribal children in the districts of Purulia, Bankura & Paschim Medinipur in West Bengal

Age Group	MALE		FEMALE	
	% of wasting children	% of stunting children	% of wasting children	% of stunting children
1-3 years	53.12	54.37	Nil	55.42
4-6 years	52.57	51.51	57.21	55.33
7-9 years	41.23	51.12	47.35	44.25

Table 4. Showing mean nutrient intake per consumption unit per day among tribal children between 1 – 3 years age group

Nutrient intake	1 – 3 years age group			
	Male		Female	
	Consumed	RDA	Consumed	RDA
Calories (kcal)	1020	1110	1009	1110
Protein (gm)	11.4	12.5	9.8	12.5
Calcium (mg)	360.6	500	330	500
Iron (mg)	9.2	8	8.3	8
Zinc (mg)	3.4	3.3	2.9	3.3
Vitamin A (µg)	220	390	233	390
Thiamin (mg)	0.72	0.7	0.7	0.7
Riboflavin (mg)	0.9	1.1	0.8	1.1
Niacin (mg)	8.56	7	8.81	7
Vitamin C (mg)	32.3	30	28.25	30
Folic acid (µg)	105	120	107	120
Vitamin B_{12} (µg)	1.0	1.2	1.1	1.2

Table 5. Showing mean nutrient intake per consumption unit per day among tribal children between 4 – 6 years age group

Nutrient intake	4 – 6 years age group			
	Male		Female	
	Consumed	RDA	Consumed	RDA
Calories (kcal)	1155	1360	1110	1360
Protein (gm)	12	16.0	11.5	16.0
Calcium (mg)	380	550	369	550
Iron (mg)	12.5	11	13	11
Zinc (mg)	4.0	4.5	4.2	4.5
Vitamin A (μg)	255	510	265	510
Thiamin (mg)	1.0	0.9	1.1	0.9
Riboflavin (mg)	1.35	1.3	1.22	1.3
Niacin (mg)	10.5	9	8.55	9
Vitamin C (mg)	39	35	41	35
Folic acid (μg)	115	135	125	135
Vitamin B_{12} (μg)	2.4	2.2	2.0	2.2

Table 6. Showing mean nutrient intake per consumption unit per day among tribal children between 7 – 9 years age group

Nutrient intake	7 – 9 years age group			
	Male		Female	
	Consumed	RDA	Consumed	RDA
Calories (kcal)	1600	1700	1555	1700
Protein (gm)	22	23.0	18.5	23.0
Calcium (mg)	400	650	455	650
Iron (mg)	19	15	17.5	15
Zinc (mg)	7.2	5.9	5.75	5.9
Vitamin A (μg)	405	630	395	630
Thiamin (mg)	1.6	1.1	1.2	1.1
Riboflavin (mg)	1.9	1.6	2.1	1.6
Niacin (mg)	14	11	12.3	11
Vitamin C (mg)	55	45	49	45
Folic acid (μg)	165	170	185	170
Vitamin B_{12} (μg)	2.6	2.2	2.1	2.2

Table 7. Showing the gradation of malnutrition among tribal children between 1 – 3 years age group

Gradation of malnutrition	Male		Female		Total	
	No.	%	No.	%	No.	%
Weight For Age						
Normal	41	45.56	21	36.85	62	42.18
Grade – I	19	21.11	12	21.05	31	21.09
Grade – II	16	17.78	11	19.30	28	19.05
Grade – III	14	15.55	13	22.8	26	17.68
Total	90	100	57	100	147	100
Height For Age						
Normal	46	51.11	25	43.85	71	48.30
Grade – I	14	15.56	11	19.30	25	17.0
Grade – II	17	18.89	11	19.30	28	19.05
Grade – III	13	14.44	10	17.55	23	15.65
Total	90	100	57	100	147	100
Weight For Height						
Normal	42	46.67	20	35.09	62	42.17
Grade – I	17	18.89	15	26.31	32	21.77
Grade – II	16	17.77	11	19.30	27	18.37
Grade – III	15	16.67	11	19.30	26	17.69
Total	90	100	57	100	147	100

Table 8. Showing the gradation of malnutrition among tribal children between 4 – 6 years age group

Gradation of malnutrition	Male		Female		Total	
	No.	%	No.	%	No.	%
Weight For Age						
Normal	37	41.11	33	36.67	70	38.89
Grade – I	19	21.11	21	23.33	40	22.22
Grade – II	17	18.89	20	22.22	37	20.56
Grade – III	17	18.89	16	17.78	33	18.33
Total	90	100	90	100	180	100
Height For Age						
Normal	44	48.89	40	44.44	84	46.67
Grade – I	16	17.78	18	20.0	34	18.89
Grade – II	15	16.67	16	17.78	31	17.22
Grade – III	15	16.66	16	17.78	31	17.22
Total	90	100	90	100	180	100
Weight For Height						
Normal	43	47.78	38	42.22	81	45.0
Grade – I	17	18.89	19	21.11	36	20.0
Grade – II	16	17.78	18	20.0	34	18.89
Grade – III	14	15.55	15	16.67	29	16.11
Total	90	100	90	100	180	100

Table 9. Showing the gradation of malnutrition among tribal children between 7 – 9 years age group

Gradation of malnutrition	**Male**		**Female**		**Total**	
	No.	**%**	**No.**	**%**	**No.**	**%**
Weight For Age						
Normal	**42**	**42**	**36**	**36.36**	**78**	**39.20**
Grade – I	**26**	**26**	**27**	**27.27**	**53**	**26.63**
Grade – II	**19**	**19**	**22**	**22.22**	**41**	**20.60**
Grade – III	**13**	**13**	**14**	**14.14**	**27**	**13.57**
Total	**100**	**100**	**99**	**100**	**199**	**100**
Height For Age						
Normal	**48**	**48**	**41**	**41.41**	**89**	**44.72**
Grade – I	**22**	**22**	**27**	**27.27**	**49**	**24.62**
Grade – II	**18**	**18**	**17**	**17.17**	**35**	**17.59**
Grade – III	**12**	**12**	**14**	**14.14**	**26**	**13.07**
Total	**100**	**100**	**99**	**100**	**199**	**100**
Weight For Height						
Normal	**49**	**49**	**43**	**43.43**	**92**	**46.23**
Grade – I	**20**	**20**	**23**	**23.23**	**43**	**21.61**
Grade – II	**18**	**18**	**18**	**18.18**	**36**	**18.09**
Grade – III	**13**	**13**	**15**	**15.15**	**28**	**14.07**
Total	**100**	**100**	**99**	**100**	**199**	**100**

DISCUSSION

Age Distribution

The age distribution of tribal children in the districts of Purulia, Bankura and Paschim Medinipur provides some important insights into the population structure of the studied cohort (Fig 1). The largest cohort from the dataset is age group 7 years, which comprises 15.01% of the total population, followed closely by children aged 6 years (14.25%) and 8 years (13.49%). This implies a hint of bulge in population size at middle childhood stage, perhaps owing to increased rates of birth during some years or increased child survival in these cohorts. A declining birth rate among the tribal populations may be reflected in the relatively low percentage of children in the youngest age group. This is a trend that is consonant with the broader national patterns seen in some rural and tribal parts of India where access to family planning resources and education do effect population growth rates. In addition, variations in healthcare access including prenatal and neonatal care may affect survival during the first year of life. In order to embrace the larger cohorts in the 6-8 years age range, school enrolment policies and primary healthcare services need to be synchronized. Additionally, the relatively small percentage of younger children highlights the need to strengthen maternal and child health services to close potential service gaps in the child space.

Gender Distribution

The gender distribution among the tribal children (Fig.2) studied was slightly male predominant with 280 boys (53.23%) and 246 girls (46.77%). The observed gender ratio is approximately balanced compared to national statistics for tribal populations which have well documented instances of gender imbalance in large part attributable to preferential treatment for male children. But even those differences in survival rates may not be solely due to variability in access to nutrition, healthcare or culture. Family lineage, economic support, all these most frequently are invested in male children, and in their health and education, and hence they are often perceived as bearing of family lineage and economic support. On the other hand, female children may get systemic neglect, in the form of high rates of malnutrition and illness.

House Type Distribution

The distribution of house types among the tribal population shows that there are significant socio-economic disparities in the studied regions. Semi pucca houses (61.21%) are the most common type of houses followed by kutcha houses (29.84%) and pucca houses (8.93%). These are their numbers, but their levels of economic stability and reach to resources differ (Fig 3). A semi pucca house built out of a combination of temporary and permanent material signifies transition in economic status per se. But these families may not have much access to financial resources, but they are trying to improve their living conditions. Although the high number of houses constructed in kutcha material is indicative of a significant element of the population living in substandard conditions, exposed to vulnerabilities of poor sanitation, exposure to extreme weather and poor security. Pucca houses though limited indicate better socio-economic conditions and access to infrastructure. Kutcha houses are generally associated with poor housing conditions such as high incidences of respiratory disease, water borne and vector borne diseases. Improving housing quality is therefore an important part of public health strategies in these regions.

Family Type Distribution

The family structure of the tribal population is mainly joint family (54.94%) and nuclear family (45.05%). The socio-cultural dynamics of tribal communities are indicative of extended family system playing major role in social and economic support, which is a cause of such trend. Multiple generations living together in a joint family has many advantages. They offer a pretty solid support system, are willing to take the economic risks, and their culture is preserved. In tribal contexts, where collective farming and sharing of resources are the norm, this structure proves particularly beneficial.

Under Nutrition (Weight for Age)

Weight for age data on under nutrition gives a complete picture of malnutrition among male and female tribal children of different age groups. Under nutrition prevalence for children aged 1-3 years is 59.27% for males and 63.27% for females. The gender disparity continues in the 4-6 years age group with under nutrition rates of 60.32% for males and 63.56% for females. Rates of under nutrition are relatively similar between males and females in the 7-9 years cohort, at 60.07% for males and 61% for females. Persistently elevated undernourishment rates reflect inadequate nutritional intakes, likely due to socioeconomic obstacles, poor dietary variety, and inadequate health care access. Prevalence rates are consistently higher in females, not explaining biological factors, but probably biased towards male fertility. The data also shows a worrying development in that the nutritional deficits are not corrected as children grow up, which underscores the need for sustained nutritional approaches.

Wasting and Stunting

Acute and chronic malnutrition are indicated by wasting and stunting respectively. Wasting rates among males decrease with age from 53.12% in the 1-3 years group to 41.23% in the 7-9 years group. On the other hand, females show a fluctuating trend with wasting rates of 55.42% in the youngest group, 57.21% in the 4–6 years group, and 47.35% in the oldest group. The age variation in child vulnerability and recovery capacity in this pattern may reflect variation.By comparison, stunting rates, defined as a height for age below the median, are alarmingly high among all age groups and especially among females aged 1-3 years, the highest prevalence of 55.42%. However, males still have a slightly lower but still significant stunting rate of 54.37% in the youngest group and 51.12% in the 7-9 years cohort. These numbers point to long term nutritional deficits and repeated exposure to bad conditions, including bad diets, poor sanitation and no access to health care.

Nutrient Intake (1-3 years)

Nutrient intake chart for children aged 1-3 years shows large gaps between actual consumption and recommended dietary allowances (RDA). Male children consume 1020 kcal, while females consume slightly less at 1009 kcal, but both exceed the RDA of 1110 kcal. Males also consume less protein than the RDA, at 11.4 g vs. 12.5 g, and females at 9.8 g. Particularly deficient are calcium and vitamin A, with males consuming 360.6 mg of calcium and 220 µg vitamin A, far below the RDAs of 500 mg and 390 µg respectively. An exception is iron intake, for males who eat 9.2 mg compared with an RDA of 8 mg. Vitamin C intake is also higher than RDAs, with males and females consuming 32.3 mg and 28.25 mg, respectively, compared to the RDA of 30 mg. They may be anomalies that reflect dietary patterns that emphasize iron-rich and citrus foods at the expense of other essential nutrients.

The data demonstrates the need for targeted nutritional programs to encourage balanced diets based on food rich in calcium and vitamin A.

Nutrient Intake (4-6 years)

Compared to the younger cohort, the nutrient intake for children aged 4-6 years shows slight improvements but remains far below recommended dietary allowances (RDA). Males consume 1155 kcal which is less than RDA of 1360 kcal and females consume 1110 kcal. However, males at 12 g and females at only 11.5 g continue to fall far short of RDA guidelines of 16 g. Macronutrient deficits directly impact growth and energy levels, adding to, and making worse, trends in undernutrition. Similar deficiencies are shown in micronutrient consumption, with males consuming 380 mg of calcium and females 369 mg, compared to the RDA of 550 mg. But both sexes exceed the RDA for iron intake, with men consuming 12.5 mg and women 13 mg, perhaps due to dietary staples high in iron. In both men and women, including the RDA of 35 mg, vitamin C intake is also above this, particularly from men eating 39 mg and women 41 mg, suggesting a possible preference in some dietary patterns for citrus or other vitamin C-rich foods. These marginal improvements notwithstanding, the data underscores the basic need for nutritional interventions aimed at correcting calcium and protein deficiencies. Such programs as fortified school meals and community-based nutrition education could well fill such program gaps.

Nutrient Intake (7-9 years)

Progressive improvements in meeting RDAs for several nutrients are observed in the nutrient intake of children aged 7-9 years. Male children consume 22 g of protein, close to the RDA of 23 g, while females consume 18.5 g. Vitamin C intake also matches up with RDAs, with males consuming 55 mg and females 49 mg, compared to the RDA of 45 mg. But it may be the result of better feeding practices or the collective effects of interventions earlier in development. Nevertheless, calcium and vitamin A intakes remain significantly deficient. Male children consume 400 mg of calcium and 405 µg of vitamin A, and females consume 455 mg and 395 µg, which are less than RDAs of 650 mg and 630 µg, respectively. Deficits in these micronutrients can have long term consequences for bone health, immunity and growth.

Gradation of Malnutrition (1-3 years)

The gradation of malnutrition chart classifies children aged 1-3 years as normal, Grade I, Grade II, and Grade III. There is higher percentage of normal nutritional status in males (45.56%) than in females (36.85%). But females have a higher prevalence of severe malnutrition (Grade III) at 22.80% compared to 15.55% in males. This data highlights the importance of gender sensitive approaches to nutrition. These disparities depend as much on factors like preferential feeding practices, maternal education or access to healthcare, as on issues related to weight. Solving these problems requires culturally tailored interventions emphasizing equitable care and nutrition.

Gradation of Malnutrition (4-6 years)

The gradation chart for children aged 4-6 years shows a decline in normal nutritional status compared to younger groups. Only 41.11% of males and 36.67% of females are normal. Grade I and Grade II malnutrition is still common, and there is a gradual progression of nutritional deficits with age. 18.89% of males and 17.78% of females are affected by Grade III malnutrition, suggesting that the problem of severe cases remains unresolved. Regular nutritional assessment, as well as a school-based feeding program, is important during this stage. These interventions can point out at-risk children and offer prompt help to avoid a further decrease in nutritional status.

Gradation of Malnutrition (7-9 years)

The gradation chart shows a slight improvement in normal nutritional status among children aged 7–9 years with 42% of males and 36.36% of females being normal. Nevertheless, a large number of children continue to suffer from Grade I malnutrition, with rates of 26% among males and 27.27% among females. Grade III malnutrition or severe malnutrition is less common but still strongly present, among children in highly vulnerable socio-economic conditions. The findings highlight the need for sustained nutritional support, particularly for moderate malnutrition through community health initiatives, parental education and school-based interventions. These challenges need to be addressed by coordinated actions needed to improve long-run child nutrition and health.

Malnutrition and Anthropometric Indicators

The anthropometric results showed that a large proportion of children were underweight, stunted, or wasted. Particularly alarming was stunting rates for both females (55.42 percent) aged 1–3 years and males (54.37 percent) in the same cohort who were chronically malnourished. These rates are consistent with published rates by Kumar et al. (2024), where in Maharashtra tribal children's prevalence for stunting exceeded 50% [10]. Wasting rates among females aged 4–6 years (57.21%) are also similar to findings of several workers. Examination of the patterns indicates an imperative for immediate nutritional interventions aimed at both chronic and acute malnutrition. On a contrasting note, the same study of Jharkhand showed a comparatively lesser undernourished child population (46.3%) owing to broad-spread government programs like ICDS and greater food security [5]. This emphasizes the disparities between regions in regard to malnutrition outcomes and the possibility of the impact of policy-driven initiatives in nutrition deficit reduction.

Nutrient Deficiencies

This study identified critical gaps in the intake of essential nutrients, including calcium, vitamin A, and protein. Table 1 below summarizes the findings and compares them with similar studies.

Nutrient	Study Findings (1–3 years)	Study Findings (7–9 years)	Comparable Studies	Key Implications
Calcium	28–34% below RDA	38% below RDA	Odisha: 30% below RDA [4]	Long-term deficits lead to poor bone health.
Vitamin A	42–45% below RDA	33–34% below RDA	Maharashtra: 40% below RDA [10]	Linked to impaired vision and immunity.
Protein	12–28% below RDA	25–30% below RDA	Gujarat: 20–30% below RDA [4]	Contributes to wasting and stunting.
Iron	Meets or exceeds RDA	Meets or exceeds RDA	Similar trends in Rajasthan [11]	Prevents anemia and supports development.

Children consumed 28–38% less than the recommended intake of calcium, and this was the most pronounced observed deficiency. This finding agrees with Das et al. (2024) who also observed bonding trends in Odisha where low calcium deficits were associated with dependence on cereals rather than dairies [4]. Females consistently had protein intake below the RDA. Sahu. (2018) in their study of Gujarat's tribal children highlight this gap, as it exacerbates wasting and stunting. These results highlight the urgent need for dietary diversification to include protein rich foods [14].

Gender Disparities in Nutritional Outcomes

This study was characterized by striking gender-based disparities in nutritional status. Undernutrition, stunting and wasting were consistently higher in female children than in male children. For example, females aged 1–3 years had stunting prevalence of 55.42% compared to 54.37% in males. The socioculture practices that are associated with this pattern that genders male privileged in food allocation and access to healthcare. Similar gender disparities have also been observed by Modugu et al. (2022) in Rajasthan where households reported higher medical intervention rates for boys than for girls [11]. Generally, this bias stems from older view that men are future economic providers - a cause of neglect of female children's nutritional and healthcare needs. In addition, micronutrient intake between the genders differed. Table 2 shows that females consumed significantly less calcium and protein than males in all age groups. These findings are consistent with Radhakrishna and Ravi (2004) who found that such nutritional inequities perpetuate long term health and developmental deficits in girls [13]. These findings also observed that such nutritional inequities perpetuate long-term health and developmental deficits in girls.

Housing Conditions

We find that housing quality is a significant determinant of nutritional outcomes. The rates of malnutrition were higher in children living in kutcha houses (29.84%) than in semi pucca or pucca houses. This echoed the findings of Rao et al. (2019), who found that presence of substandard housing in

Chhattisgarh increased risk of stunting by nearly double of that due to poor sanitation and minimal access to safe drinking water [16]. The study stresses that housing improvement programs should be integrated with nutritional programs. Improving living conditions has been demonstrated by government schemes such as Pradhan Mantri Awas Yojana to have supplanted living conditions, which indirectly improve health outcomes.

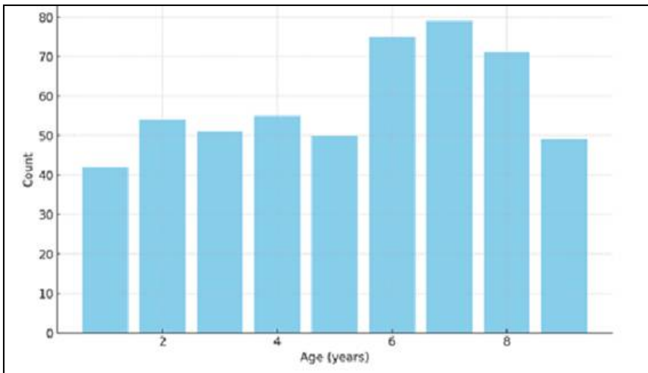

Fig 1: Age distribution among tribal children.

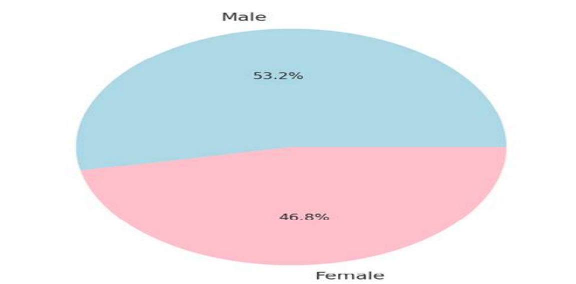

Fig 2: The gender distribution among tribal children.

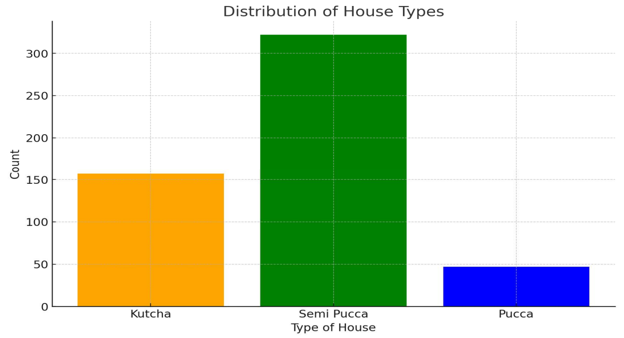

Fig 3: The house type among tribal children.

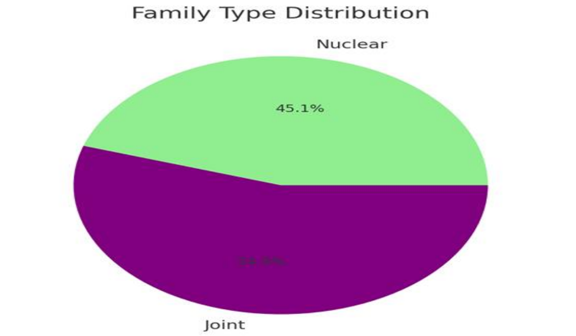

Fig 4: The family type among tribal children.

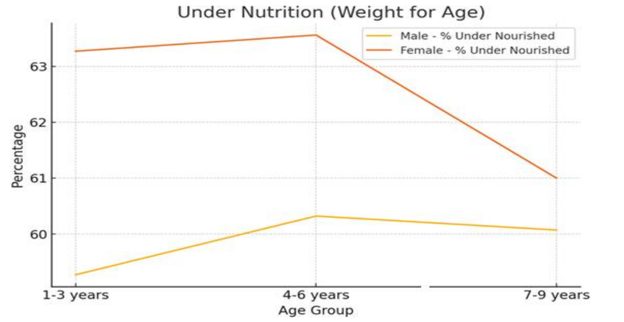

Fig 5: The chart visualizes the data from Table-2 [Under Nutrition (Weight for Age)].

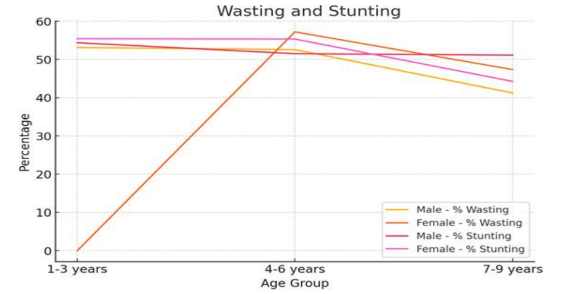

Fig 6: The chart visualizes the data from Table 3 [Wasting and Stunting].

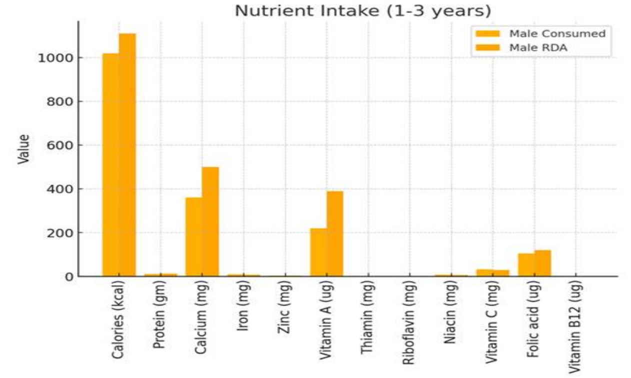

Fig 7: The chart visualizes the data from Table 4 [Nutrient Intake (1-3 years)].

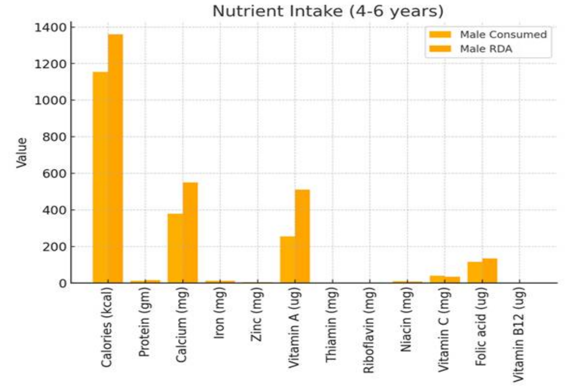

Fig 8: The chart visualizes the data from Table 5 [Nutrient Intake (4-6 years)].

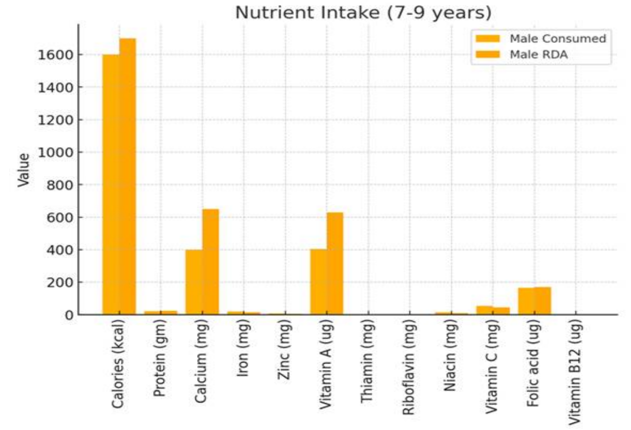

Fig 9: The chart visualizes the data from Table 6 [Nutrient Intake (7-9 years)].

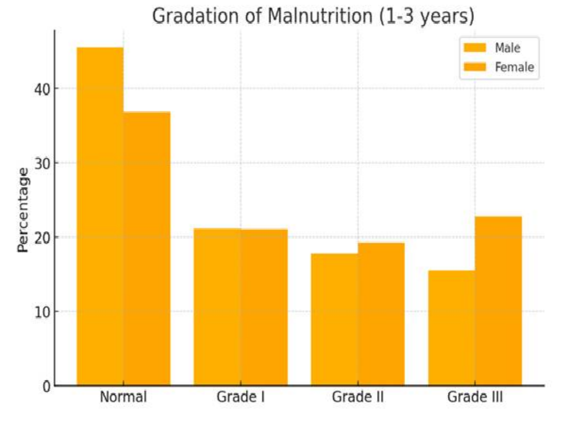

Fig10: The chart illustrates the gradation of malnutrition for 1-3 years.

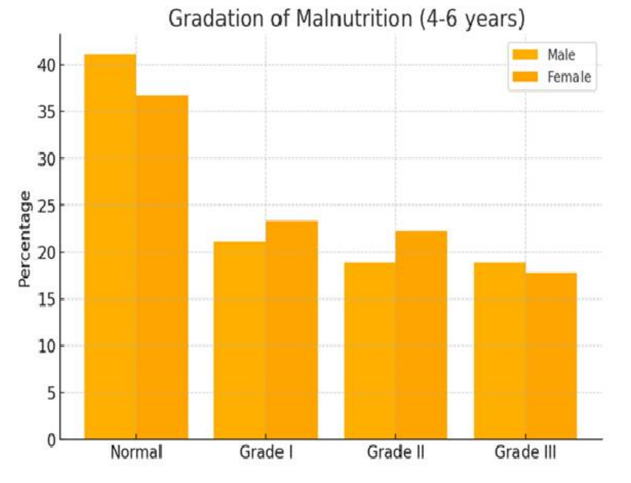

Fig 11: The chart illustrates the gradation of malnutrition for 4-6 years.

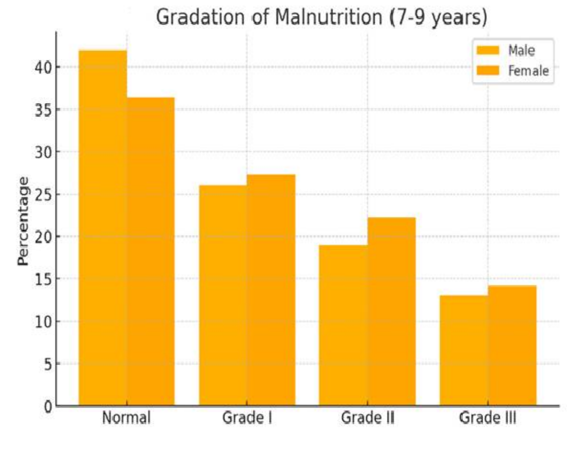

Fig 12: The chart illustrates the gradation of malnutrition for 4-6 years.

Family Structure

Children from joint families (54.94%) had slightly better nutritional outcomes than children from nuclear families (45.05%). This result echoes that of Bhasin et al. (2019) who unveiled the conveniences of joint family systems in tribal communities by providing financial resource pooling and the sharing of child rearing responsibilities [17]. But the transition to nuclear households because of urban migration and economic pressures creates problems of adequate nutrition in small households.

Comparisons Across Age Groups

Table 2 provides a detailed comparison of age-specific nutritional trends observed in this study against similar research.

Age Group	Key Findings	Comparable Studies
1–3 years	Wasting rates: 53.12% (males), 55.42% (females).	Consistent with Odisha [4].
4–6 years	Marginal improvement in nutrient intake.	Similar trends in Jharkhand [5]
7–9 years	Protein intake nearing RDA for males.	Matches improvements in Gujarat [14].

Over 50% of the youngest cohort (1–3 years) was wasted, and it was the most vulnerable cohort. Das et al. (2024) in Odisha also find similar findings, highlighting the importance of early life nutritional interventions. Sahu. (2018) found that school-based meal programs showed potential benefits for older children (7–9 years) with slight improvements in protein intake.

Nutrient Intake Analysis

A detailed analysis of nutrient intake revealed significant shortfalls in calcium, vitamin A, and protein, with age- and gender-specific variations. Table 3 below highlights these findings.

Nutrient	1–3 years	4–6 years	7–9 years
Calcium	28–34% below RDA	31–33% below RDA	38% below RDA
Vitamin A	42–45% below RDA	41–43% below RDA	33–34% below RDA
Protein	12–28% below RDA	25–28% below RDA	25–30% below RDA

Younger children had the greatest deficits in calcium and vitamin A intake, which were related to inadequate maternal nutrition and breastfeeding practices. Our findings are in line with Rao et al. (2019) who highlighted the importance of maternal health for determining early childhood nutrition outcomes [16]. The study describes a detailed investigation of the nutritional status and malnutrition levels among tribal children aged 1–9 years in Purulia, Bankura and Paschim Medinipur, West Bengal. The analysis shows the presence of significant macro and micronutrient deficiencies, and data is interpreted using the Recommended Dietary Allowances (RDA) based on the Indian Council of Medical Research (ICMR) and National Institute of Nutrition (NIN) guidelines. Results identify disparities by gender and age and suggest that targeted nutritional interventions are needed.

ENERGY AND PROTEIN DEFICIENCY

- **Energy Deficit:**
  Across all age groups, calorie intake falls significantly short of ICMR-NIN RDAs, reflecting limited access to diverse and calorie-dense foods:
  - **1–3 years**: The RDA was 1060 kcal/day, and males consumed an average of 1020 kcal/day and females 1009 kcal/day. Thus, the deficit corresponds to a shortfall of roughly 4–5% and may lead to atrophy of growth and activity levels at their optimum values.
  - 4–6 years: Males had an intake of 14% below the RDA of 1350 kcal/day (1155 kcal/day) and females had an intake of 18% below the RDA of 1350 kcal/day (1110 kcal/day). This magnitude of chronic energy deficits can result in stunting and reduced physical performance.
  - **7–9 years**: Males consumed 1600 kcal/day and females 1555 kcal/day, compared to an RDA of 1690 kcal/day. These values indicate a shortfall of about 5–8%, indicating a modest improvement but not enough to meet increasing energy needs.

Protein Deficiency:

Protein consumption remained consistently below the RDA across all age groups, compounding the issue of inadequate energy intake:

- **1–3 years:** The RDA was 13 g/day, and males consumed 11.4 g/day and females 9.8 g/day. This is a deficit of 12% and 25% for males and females, respectively.
- **4–6 years**: Intake levels of 12 g/day (males) and 11.5 g/day (females) were 25% and 28% below the RDA of 16 g/day.
- **7–9 years**: Males also peaked at 22 g/day, significantly shy of the RDA in excess of 25 g/day, while females actually declined further behind to 18.5 g/day, nearly 30% behind the RDA.

Calcium Deficiency

Calcium intake was consistently inadequate, affecting bone health and growth:

- 1–3 years: The RDA for 500 mg/day was exceeded by male children consuming 360.6 mg/day and females consuming 330 mg/day. This is 28% and 34% below.

- 4–6 years: Males and females had intake levels of 380 mg/day and 369 mg/day, respectively, which were shortfalls of 31% and 33% of the RDA of 550 mg/day.
- 7–9 years: Males consumed 400 mg/day and females 455 mg/day, which is 38% and 30% below the RDA of 650 mg/day.

Vitamin A Deficiency

The intake of vitamin A was insufficient across all age groups:

- 1–3 years: Males consumed 220 µg/day and females 233 µg/day, which was below an RDA of 400 µg/day, indicating deficits of 45% and 42%, respectively.
- 4–6 years: Shortfalls of 43% and 41% were found in consumption, which was 255 µg/day (males) and 265 µg/day (females) vs. an RDA of 450 µg/day.
- 7–9 years: Intake levels were 405 µg/day (males) and 395 µg/day (females), which were 33% and 34% below the RDA of 600 µg/day.

Iron Deficiency

Iron intake varied, with males generally meeting or exceeding RDAs but females showing occasional deficits:

- **1–3 years**: Males consumed 9.2 mg/day, while females consumed 8 mg/day, which is the RDA.
- **4–6 years**: Consumption of 12.5 mg/day by males and 13 mg/day by females exceeded the RDA (11 mg/day) by both sexes.
- **7–9 years**: For males, intake levels were 19 mg/day, and for females, 17.5 mg/day, exceeding the RDA of 15 mg/day by 27% and 17%.

Vitamin C Deficiency

Vitamin C intake consistently exceeded the RDA, supporting iron absorption and immune function:

- **1–3** years: Males consumed 32.3 mg/day (7.6% above RDA) and females consumed 28.25 mg/day (6% below RDA).
- **4–6** years: Males consumed 39 mg/day (11% above RDA) and females consumed 41 mg/day (17% above RDA).
- **7–9** years: Males consumed 55 mg/day (22% above RDA) and females consumed 49 mg/day (9% above RDA).

Zinc Deficiency

Zinc intake was below the RDA across all age groups, impairing growth and immunity:

- **1–3 years**: Intake levels of 3.4 mg/day (males) and 2.9 mg/day (females) were 17% and 29% below the RDA of 4.1 mg/day.
- **4–6 years**: Males consumed 4.0 mg/day and females consumed 4.2 mg/day, slightly below the RDA of 4.5 mg/day.
- **7–9 years**: This deficit was 10%, as males consumed 7.2 mg/day, compared to an RDA of 8 mg/day.

B-Complex Vitamins and Folic Acid

Deficiencies in riboflavin and folic acid intake were moderate but noteworthy:

- **Riboflavin**: Intake was 18% below the RDA of 1.1 mg/day (males, 1–3 years) at 0.9 mg/day.
- **Folic Acid**: Females aged 4–6 years consumed 125 µg/day, 7% below the RDA of 135 µg/day.

Gender and Age Disparities

- **Gender Disparities:** Nutrient intake was lower and more was malnourished in females. These disparities are likely due to sociocultural norms that favour sons while gender-sensitive nutritional policy is important.
- **Age Disparities:** More significantly, intake of nutrients improved marginally with age, nevertheless gaps remained, especially calcium and vitamin A, showing the need for early life interventions to prevent long-term impact.

RECOMMENDATIONS

- Ensure compliance with ICMR guidelines for nutrient content in fortified complementary foods for children under five years of age.
- Incorporating locally sourced, nutrient-dense ingredients such as green leafy vegetables, legumes, and dairy products into the existing school-based MDM scheme.
- Serve fortified milk or fortified snacks during school hours to cover up any energy and micronutrient gaps.
- Give age-specific supplements of iron, folic acid, and vitamin A to correct immediate deficiencies, particularly in children with Grade II or Grade III malnutrition.

- Supportive programs of calcium and zinc supplementation for high-risk age groups (1–3 years and 7–9 years) to support bone growth and immune function.
- Support community kitchens or village level service centers (Anganwadis) that provide meals containing cereals, pulses, animal proteins, fruits and vegetables for combating protein energy malnourishment.
- Utilize locally available resources like millets, which are rich in calcium and iron, to enhance meal quality.
- Regularly hold workshops and training of mothers and caregivers on the feeding of children with the preparation of balanced meals from locally available foods.
- Produce building blocks such as brochures, videos, and posters of easy-to-understand translations in the regional languages to promote the understanding of age-applicable feeding practices.
- Run awareness programmes that deconstruct the biases rooted in culture, that favor male children. Emphasis on food distribution within the household to show the importance of equitable distribution of food to girls, such that they would not suffer a chance of malnutrition.
- Make decisions on choosing food as well as healthcare access as women.
- Promote complete breastfeeding exclusive for six months and the early introduction of complementary feeding.
- Ensure supplementary nutrition to lactating mothers through community centers in order to improve their health and in the quality of lactating mothers breast milk.
- Routine health checkup of children at Anganwadi centers to measure growth parameters as weight for age, height for age, weight for height.
- Design and develop an integrated health system to manage development of early signs of malnutrition and to refer patient as soon as possible to healthcare facilities.
- Screening community level for anemia and other micronutrient deficiencies such as vitamin A deficiency using community level screening programs. Take this to make tailored interventions.

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