Journal of Healthcare Administration and Public Health (JHAPH)
Volume 1 • Issue 1 • Article jhaph25v1i1a1 • August 2025

Nutritional and Haematological Profile of School Children in Government Schools of Rural Areas of Coastal Karnataka: A Cross-Sectional Study

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Academic Editors: Dr. Midhuna Vijayan, Dr. Gwendolen Rodrigues, Dr. Tarushree Bari

Abstract

Introduction: Childhood malnutrition has always been an issue of concern in rural regions of India, with scope of improvement for physical development and long-term wellbeing. This study aims to evaluate the nutritional status of school-aged children in a rural South Indian community by examining key anthropometric measures along with haemoglobin concentrations. **Methods:** A cross-sectional study was done involving 391 students between the ages of 10 and 14 years studying at a government-aided school around Mangalore. A stratified random sampling technique was utilized to have a balanced representation across age and gender groups. Anthropometric measurements, including height, weight, and Body Mass Index (BMI), were collected and interpreted using the WHO growth reference standards. Statistical analysis was conducted using SPSS version 25. **Results:** A total of 391 school-aged children (173 males and 218 females) were assessed in this study. The overall prevalence of underweight and thinness was 43.5% and 62.1%, respectively. Thinness was slightly more among females (62.4%) when compared to that of males (61.9%). Age-wise, children who were 13 years demonstrated the highest rates of both underweight (33.5%) and thinness (30.5%). The mean hemoglobin level across the study population was 11.21 ± 0.94

g/dL, with 41.5% of children were classified as anemic. Hemoglobin values were seen to be marginally higher in males (11.31 ± 0.92 g/dL) than females (11.13 ± 0.95 g/dL). Among blood groups, B positive (32.2%) and O positive (30.1%) turned most prevalent. **Discussion:** The significant burden of malnutrition and anemia identified in this study show the critical need for regular school-based nutritional health checkup camps and intervention programs in rural settings. Encouraging community awareness, improving dietary food habits, and implementing programmed nutrition and health education programs are at most priority to these issues.

Key words: Malnutrition, anthropometry, haematological profile, coastal Karnataka

Introduction

Childhood is a basic phase in human development, where nutrition has indispensable role in shaping physical growth, cognitive ability, and emotional stability. The World Health Organization (WHO) recognizes malnutrition as a pressing global health concern, particularly affecting children belonging to low and middle-income countries such as India. Malnutrition among children can be seen in several forms including stunting (low height-for-age), underweight (low weight-for-age), thinness (low BMI-for-age), and deficiencies in essential micronutrients. Each of these conditions is associated with severe outcomes extending into adulthood, that include compromised immunity, reduced attention span and decreased economic productivity.[1]

Despite haven taken some economic strides, India still continues to struggle with a high burden of childhood malnutrition. The National Family Health Survey-5 (NFHS-5) reports that 35.5% of children that are under the age of five are stunted, while 32.1% are underweight.[2] This burden is notably seen more in rural regions, where socioeconomic differences, restricted healthcare access, poor dietary diversity, and inadequate hygiene contribute to adverse health outcomes. Schools, are the place where children spend a significant portion of their years growing up, that have a great strength for shaping child health. However, the current literature states that malnutrition remains prevalent among school-aged children in rural societies indicating the dire need for systematic health monitoring and support services. A cross-sectional study in rural Mangalore found that

51.4% of school-going children were classified as thin, 21.3% as stunted, and 54.6% as underweight.[3]

These statistics prove the concern for and indicate the need for implementing routine nutritional assessments, community-driven interventions, and adequate policy measures required to meet to local needs. Screening for nutrition at an early age not only reflect current dietary requirements but also serve as indicators of broader structural determinants such as food security, poverty, and parental awareness. In this context, school-based evaluations function not only as diagnostic tools but also as the base for broader nutritional health promotion.

While national schemes like the Mid-Day Meal Program aim to address hunger and malnutrition, regional disputes and indifferences in implementation and a lack of strict monitoring systems often hinder their effectiveness.[4]

The present study seeks to evaluate the nutritional status of school-aged children in a selected rural area of South India through the collection of anthropometric measurements specifically, height, weight, and Body Mass Index (BMI) analyzed across different age and gender groups. In addition, hemoglobin levels and blood group data were collected together to provide a deeper understanding of the children's health profiles. Addressing iron-deficiency anemia, a condition that affects over 40% of Indian children and is known to impair concentration, energy levels, and overall development is a key component of this investigation.[2]

The aim of this research is to gather evidence that can help school health initiatives and contribute to improved health outcomes in rural settings. While national surveys provide valuable research data, community-level insights are an important tool for designing targeted interventions that address region-specific challenges. This study also explores age and gender-based difference in malnutrition, offering right direction for developing focused strategies. In conclusion, this study provides an important public health issue amid the ongoing challenges of child malnutrition reinforcing the need for routine school-based nutritional surveillance.

Materials and Methods

Study Design and Setting

A cross-sectional study was conducted across ten government-aided schools in the rural region around Mangalore, Karnataka. The schools were selected to represent rural populations. Data were collected from students aged 10–14 years.

Study Population and Sampling Technique

The study population involved 391 school-going children between the ages of 10 and 14 years. A stratified random sampling technique was used to ensure proportional representation across age and gender categories. The sample depicts students from classes 5 to 9. Prior to the commencement of the study, formal permission was obtained from the Block Education Officer and the principals of the respective schools. Written informed consent was secured from the parents or legal guardians of all participating children.

Data Collection Tools and Procedure

Demographic details such as age and gender were verified using official school records. Anthropometric measurements were conducted on-site using standardized protocols:

- **Weight** was measured using a calibrated floor-type weighing scale. Each child was weighed without shoes and wearing light clothing, with readings recorded to the nearest 0.5 kg.
- **Height** was measured using a non-stretchable measuring tape fixed against a flat vertical wall. Students stood barefoot with their heels, buttocks, and occiput aligned against the wall. Measurements were taken to the nearest 0.5 cm.

Body Mass Index (BMI) was calculated using the standard formula: weight (kg) divided by height in meters squared (kg/m^2). Nutritional status was assessed using the World Health Organization (WHO) growth reference standards. Underweight was classified based on weight-for-age scores, thinness was evaluated using BMI-for-age scores, and stunting would typically be assessed by height-for-age scores, although it appears this data may not have been directly analyzed.

Capillary blood samples were obtained under aseptic conditions to estimate haemoglobin concentration using the standard cyanmethemoglobin method. Haemoglobin values were recorded in grams per decilitre (g/dL), and mean values were stratified by age and gender.

Statistical Analysis

All data were entered and analyzed using SPSS Statistics Version 25.0. Descriptive statistics, including mean and standard deviations for continuous variables (e.g., height, weight, hemoglobin levels) and frequencies with percentages for categorical variables (e.g., gender, nutritional status indicators, blood groups), were used to summarize the study population.

Results

The present study assessed the nutritional and hematological status of 391 students that are aged 10–14 years from ten government schools in Mangalore, Karnataka. Anthropometric measurements (height, weight, BMI), hemoglobin levels, and blood group types were recorded and analyzed by age and gender to identify patterns of undernutrition and anemia within this school-aged population.

1. Age and Gender Distribution

Table 1: Depicts the Age -Gender distribution of study participants:

Age (years)	**Gender**		**Total n (%)**
	Male n (%)	**Female n (%)**	
10	24 (13.87)	18 (8.25)	42 (10.74)
11	52 (30.05)	124 (56.88)	176 (45.01)
12	44 (25.43)	30 (13.76)	74 (18.92)
13	38 (21.96)	42 (19.26)	80 (20.46)
14	15 (8.67)	24 (11.00)	39 (9.97)

Total	173	218	391

As shown in Table 1, the study population comprised 173 males (44.2%) and 218 females (55.8%). The highest representation was observed in the 11-year age group (45.01%), particularly in females (56.88%). This might reflect actual school enrolment patterns, age-specific attendance, or trends in rural schooling systems.

2. Anthropometric Assessment – Weight and Height

Table 2: Depicts mean and standard deviation of height and weight of study participants.

Age (years)	Gender	Number	Weight (Mean ± SD)	Height (Mean ± SD)
10	Male	24	28.80 (6.69)	130.50 (5.81)
	Female	18	28.04 (3.03)	133.50 (5.76)
11	Male	52	32.49 (5.70)	138.40 (5.87)
	Female	124	32.26 (5.84)	136.37 (5.36)
12	Male	44	35.24 (5.26)	138.47 (4.68)
	Female	30	32.71 (4.76)	141.36 (3.96)
13	Male	38	36.07 (5.86)	141.68 (7.12)
	Female	42	37.88 (5.33)	142.30 (8.09)
14	Male	15	36.90 (4.95)	141.06 (8.28)
	Female	24	40.96 (7.49)	144.62 (8.25)
Overall age	Male	173	33.81 (5.98)	138.87 (7.08)
	Female	218	34.01 (6.64)	138.27 (6.95)
Total		391	33.94 (6.35)	138.61 (7.02)

Table 2 presents the mean and standard deviation of weight and height across age and gender groups. Males had a mean weight of 33.81 ± 5.98 kg and mean height of 138.87 ± 7.08 cm, while females had comparable values of 34.01 ± 6.64 kg and 138.27 ± 6.95 cm. Although overall averages appear similar, age-wise variations were evident. Notably, girls in the 14-year age group demonstrated higher mean weight (40.96 ± 7.49 kg) and height (144.62 ± 8.25 cm) compared to their male counterparts (36.90 ± 4.95 kg and 141.06 ± 8.28 cm), suggesting possible earlier onset of pubertal growth in females. These findings align with established biological growth trajectories, where girls typically enter puberty earlier than boys.

3. Prevalence of Undernutrition

Table 3: Depicts Gender distribution of Under-weight (Weight-for-age)

Under weight	Present	Absent	Total
Male	75 (43.35)	98 (56.65)	173
Female	95 (43.58)	123 (56.42)	218
Total	170	221	391

As shown in Table 3, underweight status (based on weight-for-age) was present in 170 children (43.48%). The distribution was nearly identical among males (43.35%) and females (43.58%), suggesting that undernutrition is widespread and not significantly gender-biased in this cohort.

4. Thinness (BMI-for-Age)

Table 4: Depicts Gender distribution of Thinness (BMI-for-Age)

Thinness	Present	Absent	Total
Male	107 (61.85)	66 (38.15)	173
Female	136 (62.38)	82 (37.62)	218

Total	243	148	391

Table 4 highlights a high prevalence of thinness, affecting 243 children (62.15%). Thinness was slightly more common in females (62.38%) than males (61.85%). This uniformly high prevalence points to chronic energy deficiency, a hallmark of poor dietary quality and inadequate caloric intake, especially in growing children.

5. Age-wise Analysis of Undernutrition

Table 5: Depicts Age distribution of Stunting, Underweight and Thinness:

Age (years)	**Under weight**			**Thinness**		
	Male	**Female**	**Total**	**Male**	**Female**	**Total**
10	8 (10.66)	4 (4.21)	12 (7.05)	12 (11.21)	7 (5.14)	19 (7.81)
11	8 (10.66)	35 (33.25)	43 (25.29)	19 (11.17)	57 (41.91)	76 (31.27)
12	17 (22.66)	14 (14.73)	31 (18.23)	21 (12.35)	20 (14.70)	41 (16.87)
13	30 (40.00)	27 (28.42)	57 (33.52)	41 (24.11)	33 (24.26)	74 (30.45)
14	12 (16.00)	15 (15.78)	27 (15.88)	14 (8.23)	19 (13.97)	33 (13.58)
Total	75	95	170	107	136	243

Table 5 provides an age-wise distribution of underweight and thinness. The highest proportion of underweight cases was observed in the 13-year age group (33.52%), followed by 11 years (25.29%) and 12 years (18.23%). Similarly, thinness peaked at 13 years (30.45%) and 11 years (31.27%). This pattern highlights mid-adolescence as a vulnerable period for nutritional compromise. On the other hand, girls aged 11 years showed markedly higher underweight prevalence (33.25%) compared to boys of the same age (10.66%), suggesting a need to investigate dietary practices and gender-based food allocation at home.

6. Blood Group Distribution

Table 6: Depicts Gender distribution of Blood group

Blood group	Male n (%)	Female n (%)	Total n (%)
A positive	55 (19.78)	54 (31.21)	109 (27.88)
B positive	65 (29.81)	61 (35.26)	126 (32.22)
O positive	76 (34.96)	42 (24.27)	118 (30.10)
AB positive	13 (5.96)	16 (9.24)	29 (7.39)
O negative	3 (1.37)	0 (0)	3 (0.76)
B negative	6 (2.75)	0 (0)	6 (1.52)
TOTAL	218	173	391

Table 6 shows that the most frequently observed blood group was B positive (32.22%), followed by O positive (30.10%) and A positive (27.88%). AB positive and negative blood groups were relatively rare. These results are consistent with regional blood group distribution trends in India.

7. Hemoglobin Status and Anemia

Table 7: Depicts the Age -Gender distribution of Haemoglobin

Age (years)	Gender	Number	Haemoglobin (Mean $\pm$ SD)
10	Male	24	10.89 (0.69)
	Female	18	11.37 (1.17)
11	Male	52	10.90 (0.90)
	Female	124	11.05 (0.91)

12	Male	44	11.57 (0.78)
	Female	30	11.00 (1.18)
13	Male	38	11.61 (0.99)
	Female	42	11.18 (0.81)
14	Male	15	11.98 (0.51)
	Female	24	11.45 (0.79)
Overall age	Male	173	11.31 (0.92)
	Female	218	11.13 (0.95)
Total		391	11.21 (0.94)

Hemoglobin analysis in Table 7 shows a mean haemoglobin level of 11.21 ± 0.94 g/dL across the study population. Gender-wise, the study shows that males had a slightly higher average hemoglobin level (11.31 ± 0.92 g/dL) compared to females (11.13 ± 0.95 g/dL). The lowest mean hemoglobin levels were noted among 10- and 11-year-old boys (10.89 ± 0.69 and 10.90 ± 0.90 g/dL, respectively), both below WHO-recommended cut-offs for their age group. Although females generally have higher risk for iron deficiency, in this study, younger boys presented with lower values, potentially due to rapid linear growth and higher iron requirements during early school years.

Overall, 41.5% of the sample population was found to be anemic. This is consistent with the NFHS-5 data, which highlights anemia as a widespread public health concern among Indian children. The co-occurrence of anemia with underweight and thinness further underscores the multifaceted nature of nutritional challenges in this setting.

Discussion

The present cross-sectional study provides an overall insight on the nutritional and haematological status of school-aged children enrolled in government schools located in rural areas surrounding Mangalore. The findings reflect a significant burden of undernutrition and anemia, with 43.5% of children classified as underweight and 62.1% as thin, based on WHO reference standards. The mean haemoglobin level across all

participants was 11.21 g/dL, with girls showing slightly lower values compared to boys (11.13 vs. 11.31 g/dL), a trend commonly observed in similar studies.

The prevalence of thinness observed in our study is notably higher than national and regional estimates. For instance, studies from rural Wardha and Bengaluru have reported lower,albeit concerning, levels of undernutrition among school-going children, indicating regional variability influenced by dietary patterns, socioeconomic factors, and local health infrastructure[6,9,11]. The heightened levels of thinness and underweight in our study underscore the persistent nutritional vulnerabilities among rural school-aged children, despite the existence of national programs aimed at improving child health.

The WHO Growth Reference for school-aged children and adolescents, used in our study to classify anthropometric data, stresses the need for robust and globally standardized metrics to monitor growth and detect malnutrition early[7]. However, there remains a need for more contextually sensitive growth standards that reflect the unique nutritional landscapes of developing countries[5].

Anemia remains a critical public health concern, particularly among adolescents in South Asia, where dietary iron deficiency, parasitic infections, and menstrual blood loss in girls compound the risk[8]. The mean haemoglobin levels in our study, while not severely low, suggest the presence of mild to moderate anaemia, consistent with patterns observed in other rural Indian contexts[6,12]. Such findings align with the broader epidemiological landscape, underscoring the multifactorial aetiology of anaemia in low- and middle-income countries[10].

Gender-based trends in the data also show alarming concern. While girls demonstrated a higher prevalence of underweight and thinness than boys, they also showed slightly higher hemoglobin levels in the younger age groups. This contrasts with some literature, where adolescent girls are more prone to both nutritional deficiencies and anemia due to their biological and reproductive health needs[8,11]. These discrepancies highlight the importance of age-stratified interventions.

The nutritional gaps identified are particularly concerning given the established links between child undernutrition, cognitive development, school performance, and future economic productivity[10,15]. The Mid-Day Meal Scheme, though widely implemented, may not be sufficiently comprehensive or effectively executed in some rural contexts, as suggested by studies[14]. Further qualitative inquiry into food quality, frequency, and community participation may depict potential agendas for strengthening these interventions.

Moreover, the absence of obesity or overweight cases in this cohort contrasts with emerging concerns about the double burden of malnutrition, where undernutrition coexists with increasing rates of overweight and obesity in low-resource settings.[9,10] This absence could reflect low caloric intake and high physical activity in rural children, although surveillance for the double burden should remain a policy priority.

Global strategies like those outlined by the WHO and UNICEF stress the importance of integrated approaches combining nutrition-specific and nutrition-sensitive interventions to address the complex causes of child undernutrition[16,15]. The findings of our study show the necessity of early screening, school-based supplementation programs, nutrition education, and community engagement to sustainably improve health outcomes among rural children.

In conclusion, this study contributes to the evidence depicting that school-aged children in rural India remain at high risk for nutritional and haematological deficiencies. Holistic, evidence-based interventions at the local level and supported by national frameworks such as the National Nutrition Strategy are imperative to address this critical public health challenge[13].

Acknowledgement: We acknowledge all the children for their enthusiastic participation

Source of funding: Nil

Conflict of interest: None declared

Data availability statement: Data regarding the present study can be obtained by request to the corresponding author.

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