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Original Research Article

Spatial mapping and assessment of nutritional status and socio-demographic determinants among under-five children in a rural region of Southern Karnataka: a cross-sectional study

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ABSTRACT

Background: Malnutrition remains a significant public health concern among under-five children, particularly in low- and middle-income countries. It includes both undernutrition and the rising issue of overnutrition. The objectives of the study were to assess the nutritional status of children under-five years of age and to identify socio-demographic factors influencing it.
Methods: A community-based cross-sectional study was conducted among 255 under-five children. These children were selected by simple random sampling in the rural field practice area of a medical college in southern Karnataka. Anthropometric measurements were taken and nutritional status was assessed using WHO Z-score classifications. Data analysis was carried out using Epi-Info and WHO Anthro Survey Analyser. Associations were assessed using Chi-square and Fisher's exact tests.
Results: Out of 255 children, 31.76% (81) were stunted, 20% (51) were underweight and 15.69% (40) were wasted, showing significant undernutrition. Also, 9.02% (23) and 12.55% (32) were overweight/obese by weight-for-length and BMI-for-age, respectively, indicating emerging overnutrition. This reflects the double burden of malnutrition in the group. Stunting was most prevalent among children aged 1 to 2 years. Underweight and wasting were more common in boys. A significant association was noted between socioeconomic status and underweight (p=0.035), with the highest prevalence of malnutrition in Class IV. No significant associations were found between other sociodemographic details and nutritional status.
Conclusions: The study reported a high burden of malnutrition, especially stunting and underweight, with an emerging trend of overweight and obesity. Socioeconomic status significantly influenced nutritional outcomes, highlighting the need for a multipronged approach.

Keywords: Karnataka, Malnutrition, Under-five

INTRODUCTION

Nutrition is an important pillar for a child's growth and development. Malnutrition is responsible for one-third of all child deaths. A child is more prone to infection if he/she is malnourished, thereby increasing morbidity and mortality. Malnutrition violates children's rights, while good nutrition is essential for their growth and development. Although progress has been made over the past two decades, global estimates from UNICEF, WHO and the World Bank show that we remain far behind from ending malnutrition. This slows down the progress of the nation. Regular data collection is now more crucial than ever, especially post-COVID-19, to track progress towards achieving Sustainable Development Goals (SDG) Target 2.2: ending all forms of malnutrition by 2030.[1,2]

Malnutrition includes both undernutrition and overnutrition.[3] There are various ways of assessing the nutritional status of a child, like anthropometry, clinical signs and biochemical indicators. Anthropometry is the single earliest, easiest and cost-effective way of identifying the nutritional status of a child.[4] According to World Health Organization (WHO), globally in 2022, 37 million under-five aged children were overweight/ obese, 45 billion were wasted and 149 million were stunted. Nearly half of all deaths among children under-five are associated with undernutrition, with the majority occurring in low- and middle-income countries. Also, there is a recent trend of an increase in overweight and obesity in these countries.[3] According to National Health and Family Survey Data 4 (NHFS-4) in India, 35.8% of children were underweight, 38.4% stunted, 21% wasted and 7.5% were severely wasted.[5] Acute and chronic malnutrition are high in 7 states in India and Karnataka is amongst them.

Further, studies have shown a wide variation in the nutritional status of under-five children between states. In Maharashtra (2017), among 375 children between 1-6 years of age, 59% were stunted, 20% were wasted and 53% were underweight.[6] In a study done in Tamil Nadu (2017) among 75 children of 1-5 years, 52.8 % were stunted and 62.3% were wasted.[7] In a study done in Thrissur, Kerala (2016), 28.3% of 360 under-fives were underweight and 14 % were stunted.[8] Previous studies from different Indian states reveal wide regional variations in child nutritional status, indicating disparities in health and development outcomes. Therefore, this study was undertaken with the objectives: To assess the nutritional status of children under-five years of age and to determine the socio-demographic factors associated with the nutritional status of under-five children.

METHODS

A community-based cross-sectional study was conducted in the rural field practice area of a Medical College, Bengaluru, from October to December 2022. The study focused on children under-five years of age residing in the area. Inclusion criteria were children living in the locality for at least six months whose parents or caregivers provided informed written consent. Exclusion criteria included children with chronic illnesses and those unavailable even after three home visits. The sample size was determined using the National Family and Health Survey-4 Data (NFHS-4), where the prevalence of underweight children in rural areas was 38.3%. With a precision of 6% and a 95% confidence interval, the calculated sample size was 252, rounded to 255.

A line list of all eligible children was prepared and participants were selected through simple random sampling. An informed written consent from parents/guardians who agreed to participate in the study. Data collection involved a pretested semi-structured questionnaire including sociodemographic details of the family and anthropometric measurements like height, weight and mid-upper arm circumference. Measuring a child's growth.

Measurement of height

Children <2 years (Recumbent length)

Measured with a self-retracting metal measuring tape while the child lay flat.

Children ≥2 years (Standing height)

Measured using a stadiometer. The child stood erect with feet apart, barefoot, wearing minimal clothing. Heels, calves, buttocks, shoulder blades and occiput touched the stand, hands hung naturally by the sides and the head was positioned so that the line from the ear canal to the lower eye socket was parallel to the baseboard. Readings were recorded to the nearest 0.1 cm.

Measurement of weight

The weight of the child was measured using Omron digital weighing machine with an accuracy of 100 g.

Children <2 years or unable to stand

The mother, without footwear, was first weighed alone. Then, holding the child, both were weighed together. The child's weight was obtained by subtracting the mother's weight from the combined weight.

Children ≥2 years

The child stood on an Omron digital weighing machine (accuracy: 100 g), barefoot, wearing light clothing, feet slightly apart and looking straight ahead.

Measurement of mid-upper arm circumference[10]

The child stood with arms relaxed by the side, wearing minimal clothing to expose the upper arm. The mid-point was located by flexing the elbow to 90º with the palm facing up, marking the acromion (shoulder tip) and olecranon (elbow tip) and identifying the midpoint between them. With the arm hanging slightly away from the body, a measuring tape or Shakir tape was placed at this midpoint, ensuring correct tension neither too tight nor loose. The measurement was recorded to the nearest 0.1 cm. This systematic approach ensured accurate anthropometric assessment to evaluate the nutritional status of children in the study area.

Ethical approval

Obtained institutional ethical committee clearance.

Statistical analysis

The data was entered first in Microsoft Excel. The z-scores and nutritional status were assessed using the WHO Anthro Survey analyser.[11] Further analysis was done using Epi-Info-TM version 7.2.3. Data was summarised and presented in percentages, proportions, mean and standard deviation. Chi-square test was applied to identify the factors associated with the nutritional status of the child. P value<0.05 was considered statistically significant.

RESULTS

A total of 255 children were included in the study, of whom 141 (55.3%) were males and 114 (44.7%) were females. The majority, 249 (97.6%), belonged to the Hindu religion, while only 6 (2.4%) were non-Hindus. Regarding family structure, 128 children (50.2%) were from nuclear families, 93 (36.5%) from three-generation families and 34 (13.3%) from joint families. Most children were aged less than one year (22.7%) and 120 (47.1%) were of birth order one. The majority of mothers (87.7%) were aged between 20 and 30 years, as were 49.4% of fathers. Among the parents, 16 mothers (6.3%) and 14 fathers (5.5%) were illiterate. Based on the Modified BG Prasad Classification, 22 children (8.6%) were from Class III, 144 (56.5%) from Class IV and 89 (34.9%) from Class V. None belonged to Class I or II. Additionally, 128 families (50.2%) possessed a Below Poverty Line (BPL) card.

Table 1 presents the nutritional status of children aged under five years according to various categories of Z-scores (N=255). The nutritional status of 255 children was assessed using WHO Z-score classifications across four anthropometric indices: length-for-age, weight-for-age, weight-for-length and BMI-for-age. Stunting, indicated by length-for-age, was observed in 31.76% of children (7.84% severely and 23.92% moderately), indicating a high prevalence of chronic undernutrition. Underweight based on weight-for-age was present in 20% (7.06% severely and 12.94% moderately). Wasting, assessed by weight-for-length, affected 15.69% of children, while 9.02% were overweight. BMI-for-age data revealed that 16.47% of children were thin and 12.55% were either overweight or obese. Notably, 66–75% of children fell within the normal range across all indices. These findings indicate a double burden of malnutrition, with both undernutrition and overnutrition.

Figure 1 illustrates the age-specific distribution of nutritional status among under-five children (N=255), categorized into wasting, underweight and stunting. The highest prevalence of stunting was observed in the 1 to <2 years age group (42%), followed by <1 year (37%) and 3 to <4 years (30.3%), indicating that chronic undernutrition is most pronounced in early childhood. Underweight status peaked in the <1 year age group (31.48%), gradually declining with increasing age.

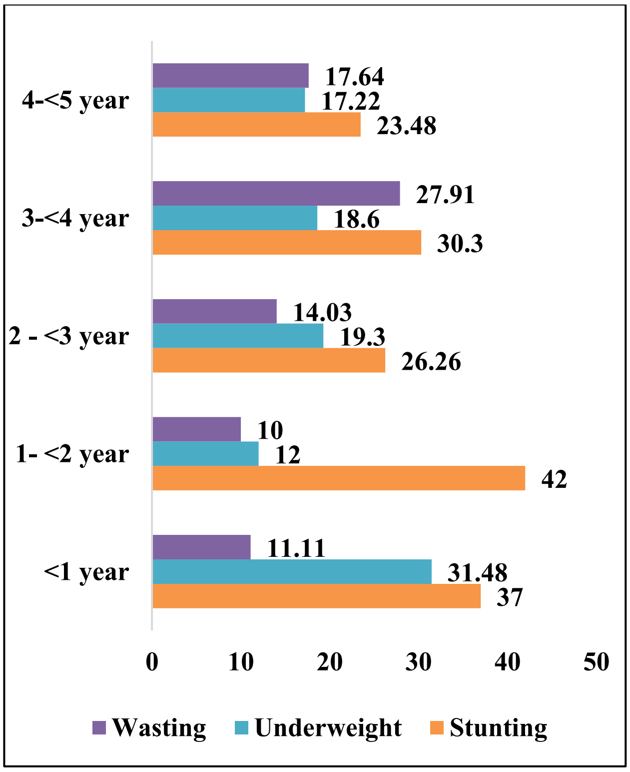

Figure 1: Age-specific distribution of nutritional status (N=255).

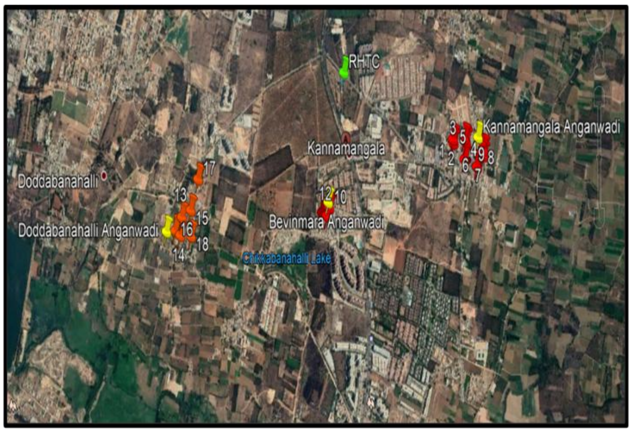

Figure 2: Spatial distribution of households of malnourished children.

Wasting, which reflects acute malnutrition, was most prevalent in the 3 to <4 years age group (27.91%), followed by the 4 to <5 years group (17.64%). While undernutrition indicators such as stunting and underweight are more concentrated in the younger age groups, wasting was more observed in older preschool children, possibly due to recurrent infections or inadequate dietary practices over time. Table 2 shows the gender-specific distribution of nutritional status among under-five children (N=255), comparing boys and girls across five categories: stunting, underweight, wasting, overweight and obesity. The prevalence of stunting was nearly equal between genders, with 32.46% of girls and

31.21% of boys affected, indicating a high burden of chronic undernutrition across both sexes. Underweight and wasting were more common among boys (24.82% and 18.44%, respectively) than girls (14.03% and 12.28%, respectively), suggesting boys may be more vulnerable to both chronic and acute forms of undernutrition. Conversely, overweight and obesity were slightly higher among girls (6.14% and 3.51%, respectively) compared to boys (2.84% and 5.67%, respectively), reflecting early signs of overnutrition among females. This highlights a gender disparity in nutritional outcomes. Table 3 depicts the nutritional status of children aged 1–5 years based on mid-upper arm circumference (MUAC) measurements (N=201), a simple and effective tool to assess acute malnutrition. This reveals that a majority of children (82%) had a normal nutritional status. Mild to moderate malnutrition was observed in 16% of children, suggesting early signs of undernutrition and severe malnutrition in 2% of children. This highlights the importance of routine MUAC screening at the community level for early detection and management of acute malnutrition among children.

To assess the association between socio-demographic variables and the nutritional status of children, various variables like age, gender, religion, birth order, type of family, number of family members, parental age and education and BPL card status were included. These variables were evaluated for their association with anthropometric indicators such as stunting (length-for-age), underweight (weight-for-age), wasting (weight-for-height) and BMI-for-age. Of all these variables, only the socioeconomic status of was found to be significantly associated with the nutritional status of the child and is explained. Table 2 presents the nutritional status of children across different socioeconomic classes (Classes III, IV and V) based on the Modified B.G. Prasad Classification. For the length-for-age indicator, only 3.66% of children from Class III were stunted. Stunting was more prevalent among Class IV (57.31%) and Class V (39.02%) children, reflecting poorer growth outcomes with lower socioeconomic status. However, the association was not statistically significant (p=0.289). For the weight-for-age indicator, a statistically significant association was found (p=0.035). The highest proportion of underweight children was seen in Class IV (72.55%), followed by Class V (21.57%) and Class III (5.88%). Notably, children above 3 SD indicative of overweight were more concentrated in Class V (61.54%), suggesting the emergence of a dual burden of malnutrition in this group. Regarding the weight-for-height indicator, Class IV had the highest proportion of wasting (70.73%), followed by Class III (9.76%) and Class V (19.51%), though the association was not statistically significant (p=0.217). The proportion of overweight/obesity was slightly higher in Class V (39.13%) compared to Class IV (52.17%) and Class III (8.70%), again showing signs of excess nutrition coexisting with undernutrition.

Table 1: Nutritional status of children aged under-five years according to various categories of Z-scores (n=255).

Z-score categories	Z-length for age number (%)	Z-weight for age number (%)	Z-weight for length number (%)	Z-BMI for age number (%)
<-3 SD	20 (7.84)	18 (7.06)	22 (8.63)	23 (9.02)
-3 SD-<-2 SD	61 (23.92)	33 (12.94)	18 (7.06)	19 (7.45)
-2 SD-<2 SD	169 (66.27)	191 (74.9)	192 (75.29)	181 (70.98)
2 SD-<3 SD	1 (0.39)	10 (3.92)	11 (4.31)	21 (8.24)
> 3 SD	5 (1.57)	3 (1.81)	12 (4.71)	11 (4.31)
Total	255 (100)	255 (100)	255 (100)	255 (100)

Table 2: Gender-specific distribution of nutritional status (n=255).

Nutritional status	Boys (%)	Girls (%)
Stunting	31.21	32.46
Underweight	24.82	14.03
Wasting	18.44	12.28
Overweight	2.84	6.14
Obese	5.67	3.51

Table 3: Nutritional status of children 1-5 years of age according to mid-upper arm circumference (n=201).

Nutritional status	%
Normal	82.09
Mild to moderate malnutrition	15.92
Severe malnutrition	1.99
Total	100.00

Table 4: Relationship between Socio-demographic factor and Nutritional Indicator (n=255).

Nutritional indicator	Socioeconomic Status (Modified B G Prasad Classification)				
	Class III N (%)	Class IV N (%)	Class V N (%)	Total (%)	Fisher Exact (P value)
Length for age-stunting	3 (3.66)	47 (57.31)	32 (39.02)	82 (100)	4.654 (0.289)
Length for age-normal	19 (11.31)	94 (55.95)	55 (32.74)	168(100)	
Length for age->3 SD	0 (0)	3 (60.0)	2 (40.0)	5 (100)	
Weight for age-underweight	3 (5.88)	37 (72.55)	11 (21.57)	51 (100)	9.772 (0.035)
Weight for age-normal	18 (9.42)	103 (53.93)	70 (36.65)	191 (100)	
Weight for age->3 SD	1 (7.69)	4 (30.77)	8 (61.54)	13 (100)	
Weight for height-wasted	4 (9.76)	29 (70.73)	8 (19.51)	41 (100)	5.569 (0.217)
Weight for height-normal	16 (8.38)	103 (53.93)	72 (37.70)	191 (100)	
Weight for height–overweight/ obese	2 (8.70)	12 (52.17)	9 (39.13)	23 (100)	
BMI for age–wasted	4 (9.30)	31 (72.09)	8 (18.60)	43 (100)	6.679 (0.144)
BMI for age–normal	16 (8.89)	95 (52.78)	69 (38.33)	180 (100)	
BMI for age-overweight/obese	2 (6.25)	18 (56.25)	12 (37.50)	32 (100)	

For BMI-for-age, wasting was more prevalent in Class IV (72.09%) and Class III (9.30%) than in Class V (18.60%), although this was not statistically significant (p=0.144). Overweight/obesity was observed across all classes, with slightly higher proportions in Class IV (56.25%) and Class V (37.50%) compared to Class III (6.25%). This shows that children from poorer families are more likely to be undernourished. At the same time, some children, especially from lower-income groups, are also becoming overweight. This means both undernutrition and overnutrition are double burden of malnutrition and need to be addressed together. Figure 2 presents the spatial distribution of households with malnourished children in the field practice area of a Rural Health and Training Centre (RHTC), visualized using a geotagged satellite map. The households are marked by colored pins, each representing locations associated with undernutrition among children. The clusters are notably concentrated around three Anganwadi centers. The green pin for RHTC signifies the central point for health service delivery and outreach activities. This spatial visualization aids in identifying high-burden zones of malnutrition.

DISCUSSION

In the present study, among 255 children, 31.76% (81) were stunted, 20% (51) underweight and 15.69% (40) wasted, indicating significant undernutrition. Additionally, 9.02% (23) and 12.55% (32) were overweight/obese by weight-for-length and BMI-for-age, respectively. Underweight was significantly associated with socioeconomic status, particularly among Class IV families.

In Palghar district, Maharashtra, Ghosh et al reported higher prevalence of stunting (59%), underweight (53%) and wasting (20%) among tribal children aged 1–6 years, largely attributed to poor dietary diversity and food insecurity.[6] Compared to this, the current study shows a lower prevalence for all three indicators but a notable presence of overnutrition, absent in the Maharashtra cohort, depicting regional and socio-cultural differences in food access. The Tamil Nadu study by Gladius et al among preschool children aged 1–5 years in Pullipakkam village found high rates of stunting (52.8%) and wasting (62.3%), exceeding the rates observed in the present study. About 73.3% of children had inadequate calorie intake but found no significant association between calorie intake and anthropometric indicators, likely due to illness-related nutritional setbacks.[7] In contrast, the present study found a significant association between socioeconomic status and underweight (p=0.035), with poorer outcomes in lower-class families. Other indicators showed no significant associations. Lower stunting and wasting here may be due to better health service access and food diversity in peri-urban Bengaluru compared to rural Tamil Nadu.

In Thrissur, Kerala, Priyanka et al reported underweight in 28.3% and stunting in 14% of 360 under-five children. Underweight prevalence was higher, but stunting was lower in the present study. The Kerala study linked undernutrition to low birth weight, inadequate protein intake, recurrent infections and partial immunization.[8] Unlike Kerala, the current study found that only underweight was significantly associated with socioeconomic status.

Bhukya et al reported similar trends, with 50% underweight, 40.7% wasted and 39.7% stunted children admitted to a tertiary care setting.[12] The prevalence of stunting in both studies is high, indicating chronic undernutrition. Bhukya et al, also observed a significant association between stunting and higher birth order, which aligns with the socio-demographic profile in the present study. Kumar et al examined socioeconomic inequality in child malnutrition in EAG states using NFHS data (2005–06, 2015–16) and found inequality in stunting unchanged, while underweight inequality slightly decreased. Household wealth, maternal education and maternal nutritional status explained nearly 80% of stunting and nearly 90% of underweight inequality.[13] Both their findings and ours confirm the strong link between low socioeconomic status and higher undernutrition, especially stunting and underweight. However, our study additionally reveals an emerging dual burden, with overweight/obesity present alongside undernutrition less emphasized in NFHS analyses. The relatively lower undernutrition rates in this study, compared to some other regions, could be due to better healthcare access, improved awareness and food diversity in peri-urban Bengaluru. Yet, the simultaneous presence of overnutrition suggests a nutrition transition and changing dietary patterns, likely influenced by market access and lifestyle shifts.

Limitations include the geographic scope being restricted to one rural field practice area, limiting generalizability. Also, clinical and biochemical assessments were not included, which could have strengthened the findings by complementing anthropometry.

Despite these, the study adds valuable evidence on the coexistence of undernutrition and emerging overnutrition in rural Karnataka, underscoring the need for targeted, context-specific interventions. Strategies must address both inadequate and excessive nutrition, while focusing on socioeconomically disadvantaged families to reduce disparities.

CONCLUSION

The study reveals that children in rural Karnataka face a dual burden of malnutrition, where significant undernutrition, strongly linked to lower socioeconomic status, exists alongside an emerging problem of overweight and obesity. This pattern reflects a regional nutrition transition driven by changing dietary habits and lifestyles. Addressing this challenge requires context-specific interventions that simultaneously tackle nutrient deficiencies and excessive calorie intake, while giving priority to socioeconomically disadvantaged families to reduce health inequities.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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