ORIGINAL RESEARCH ARTICLE

Epidemiological Determinants of Underweight, Wasting, and Stunting Among Children Aged 6-59 Months: A Cross-Sectional Study in India

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ABSTRACT

Background: Undernutrition is still one of the main reasons for sickness and death in children across the world. In India, even though there are many national nutrition programmes, the problem is still very common. This study was done to find out how widespread undernutrition is among children under five years of age and to understand the main factors causing it, with special focus on the situation in this region.

Methods: A cross-sectional study was conducted from February to August 2022 in Belagavi district, Karnataka, among preschool children aged 6 months to 6 years with suspected or confirmed malnutrition.

Results: A large number of children were found to be malnourished 81.3% were underweight, 66.3% were stunted and 58.1% were wasted. Children above 12 months of age had a higher chance of being stunted and wasted. Fathers who were literate were less likely to have underweight children and mothers with education seemed to protect their children from wasting. Wasting was more common in children with higher birth order and when the gap between births was more than two years. Babies born with a weight above 2.5 kg and those with full-term gestation had lower chances of being underweight and stunted. Children who had incomplete immunization were more likely to be stunted. Not giving prelacteal feeds was found to reduce the risk of both underweight and stunting, while giving top milk reduced the chances of underweight.

Conclusion: This study shows very high levels of undernutrition, especially stunting and wasting, among children under five years in urban India. Factors like parents' education, birth conditions and feeding practices were found to have a strong effect on children's nutrition. These results point to the urgent need for focused, local strategies to tackle childhood undernutrition and reduce its harmful impact on health.

Keywords: Undernutrition, Wasting, Stunting, Child Nutrition

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INTRODUCTION

Malnutrition, particularly in children under five years old, is a major health problem around the world that contributes to nearly half of the infant deaths, particularly in low- and middle-income countries.[1] It comes in many forms, but undernutrition is the most common one. Stunting (low height for age; Z-value: -2 SD), wasting (low weight for height; Z-value: -2 SD), and underweight (low weight for age; Z-value: -2 SD) are all signs of undernutrition.

According to the UNICEF and the WHO, stunting is an indicator of long-term malnutrition which has been caused by poor nutrient intake and repeated infections, while wasting is linked to acute malnutrition, often due to food shortage or illness. Underweight is considered a combined indicator, reflecting both stunting and wasting.[2]

The Global Nutrition Report 2021 says that about 14.9 crore children under five were stunted and 4.5 crore were wasted around the world. This shows how widespread and complicated the child malnutrition is.[3] Undernutrition among children remains a significant issue in India, despite economic growth and various nutrition initiatives. The National Family Health Survey (2019-21) has found that 36% of Indian children under five are stunted, 19.3% are wasted and 32.1% are underweight. This still shows that malnutrition is a public health emergency in India as the improvement is just a fraction of the past numbers.[4]

The consequences of early-life undernutrition are grave and frequently enduring. Children who are malnourished have weaker immune systems, which makes them more likely to get infections like diarrhoea, pneumonia, and measles.[1,5] Stunting is associated with delayed cerebral development, suboptimal academic performance, and diminished educational attainment. Many of the studies have already demonstrated that childhood malnutrition results in reduced adult height, diminished productivity and an increased risk of non-communicable diseases. It has also been observed that longer adult height has been linked to higher wages, showing how undernutrition can hurt the economy in the long run.[6]

To reach Sustainable Development Goal 2 (SDG-2), which aims to "end hunger, achieve food security, and improve nutrition" by 2030, it is important to deal with malnutrition. India has the maximum number of malnourished children and it is unlikely that these SDG goals will be met without focused and effective action, especially in places with a high poverty and poor healthcare systems.

There are many reasons why children don't get enough food, and they are all connected. These include environmental, social, economic, and health-related factors.[7] Short birth intervals and poor spacing between pregnancies deplete maternal nutritional reserves, resulting in low birth weight and subsequent malnutrition in offspring. Infections such as measles, diarrhoea and acute respiratory illnesses exacerbate malnutrition by diminishing appetite and nutrient absorption. Poverty, food insecurity, poor sanitation and inaccessibility to health care are also important factors. Children living in poor neighbourhoods, especially in urban slums and rural areas that don't get enough services, are at greater risk because they don't have enough healthy food, safe water, or health care facilities.

India has several national nutritional programs to help with malnutrition, including the Mid-Day Meal Scheme, Poshan Abhiyaan, and the Integrated Child Development Services (ICDS).[8,9] In 2022, the Ministry of Women and Child Development introduced Mission Saksham Anganwadi and Poshan 2.0 to provide integrated nutritional support through the Supplementary Nutrition Programme Early Childhood Care and Education for children aged 6 months to 6 years.[10] But their coverage and effectiveness are different in different areas. Karnataka shows moderate performance according to the composite nutritional index.[11] Most research in India has looked at rural areas or trends at the national level. Research from the Tier two cities like Belagavi, Karnataka is still limited. These rapidly growing cities often have problems that are different from those in other cities, such as more people living in slums, more cases of both infectious and lifestyle diseases, and unequal access to public health resources. The COVID-19 pandemic has made the problem of undernutrition in children even worse. Closure of anganwadis and schools interrupted the mid-day meal services. Lockdowns caused people to suffer financially and affected the healthcare and nutrition programs, which further made food insecurity worse. A 2025 study done in the rural area near Belagavi, showed that the pandemic had long-lasting effects on the economy, especially among people in their working years and those with comorbidities. This shows that the households are still vulnerable to food and financial instability in the area.[12]

In this context, the current study was conducted to assess the prevalence of undernutrition, stunting, and wasting, and to identify the principal epidemiological and socio-demographic factors associated with malnutrition among children aged 6-59 months in Belagavi City, Karnataka.

METHODOLOGY

Study Design and Setting: This community based cross-sectional study was done in six months from February to August 2022, covering all twelve talukas of the Belagavi district, Karnataka. The study aimed to evaluate the prevalence and determinants of undernutrition in children aged 6 to 59 months. The Belagavi district has both urban and rural people, and their socioeconomic and dietary patterns are different.

Participants and the Study Population: The study population comprised children aged 6 to 59 months with suspected or diagnosed malnutrition, along with their primary carers, predominantly mothers, cohabitating in the same household.

Inclusion criteria: caregivers with at least one eligible child living in Belagavi district. Exclusion criteria: children with congenital anomalies, those outside the specified age range, or caregivers unwilling to participate.

Sample Size and Sampling Technique: The required sample size was calculated as 664, based on a prevalence (p) of 70.4% for inadequate calorie intake as reported by David SM et al[13], with 5% relative precision and an additional 10% for non-response.

A systematic random sampling technique was applied (Figure 1). All the twelve taluks were included in the study to ensure geographic representation. From each one, anganwadi centres and households were listed to create a sampling frame. The sampling interval (k) was determined by dividing the total number of eligible households by the desired sample size. A random starting point within the first interval was chosen and every kth household was visited until the necessary sample size was reached.

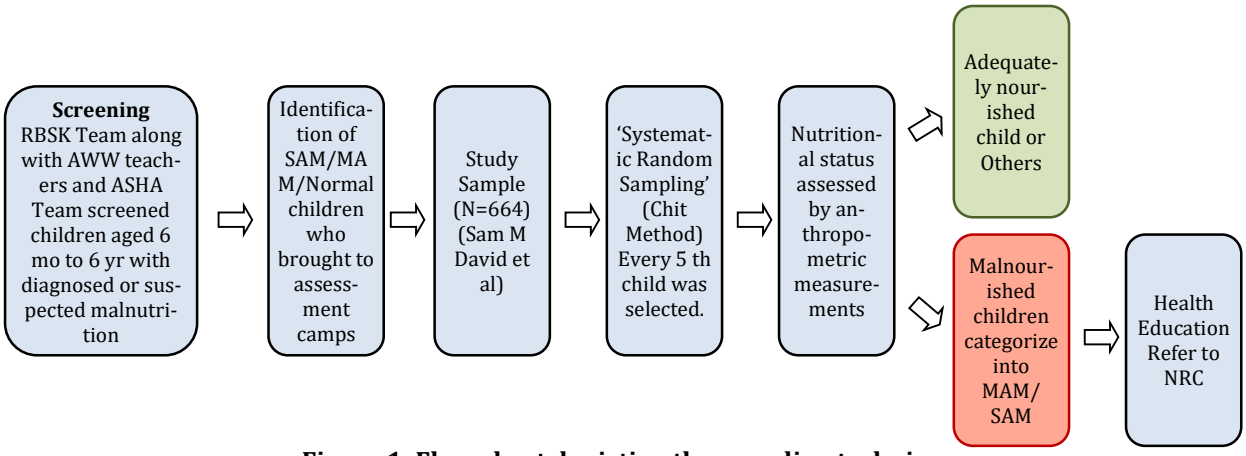


Figure 1: Flow chart depicting the sampling technique

Data Sources and Measurement: We gathered data by conducting face-to-face interviews with a predesigned, semi-structured questionnaire in Kannada or Marathi to make sure everyone understood. The tool had parts about sociodemographic information, the mother's and baby's health before and after birth, feeding habits and the child's illness. Before collecting data, experts in the field looked over the questionnaire, tested it on 30 caregivers who were not part of the study, and made it clearer and more reliable.

Anthropometric Measurements: Following the WHO guidelines, standard calibrated tools were used to take anthropometric measurements.[14] Using a digital scale, weight was measured to the nearest 0.1 kg; height/length was measured to the nearest 0.1 cm using a stadiometer or infantometer as needed; and mid-upper arm circumference (MUAC) was measured using non-stretchable measuring tapes. All measurements were taken twice and the average was recorded. Before the commencement of the study, data collectors were trained and standardised to reduce observer bias. Using the WHO growth standards from 2006, we figured out the Z-scores for weight-for-age, height-for-age and weight-for-height.

Operational Definitions:

Underweight, stunting, and wasting were dependent variables, and they were grouped using WHO-defined Z-scores.

Severe Acute Malnutrition (SAM): weight-for-height/ length Z <-3 SD, or MUAC <115 mm, or presence of nutritional oedema.

Moderate Acute Malnutrition (MAM): weight-for-height/ length Z between -3 SD and -2 SD, or MUAC 115-125 mm without oedema.

Independent variables included child's age, sex, parental education, birth order, birth weight, feeding practices, and immunization status.

Bias and Study Size Considerations: Selection bias was minimized by including all taluks and using systematic random sampling. To deal with recall bias, event-based recall cues were used and cross checked with child health records when they were available. The sample size was adequate to detect meaningful associations with 95% confidence and 80% power.

Statistical Methods: Data were entered in Microsoft Excel and analyzed using IBM SPSS version 20.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean ± SD, and categorical variables as frequencies and percentages. Bivariate analysis was performed using the Chi-square test, and variables with p <0.2 were included in multivariate logistic regression to estimate adjusted odds ratios (AORs) with 95% confidence intervals. A p-value <0.05 was considered statistically significant.

Ethical Considerations: Ethical clearance was obtained from the Institutional Ethics Committee, Bela-

gavi Institute of Medical Sciences (Approval No. BIMS-IEC/72/2021-22). Written informed consent was obtained from all caregivers prior to participation. For illiterate participants, the consent form was read aloud and thumb impressions were taken in the presence of a witness. Data confidentiality and anonymity was ensured throughout the study period.

RESULTS

The study included 664 children between the ages of 6 and 59 months with 313 (47.1%) males and 351 (52.9%) females. Majority (92.8%) were older than 12 months, and only 7.2% were 12 months old or younger (Table 1).

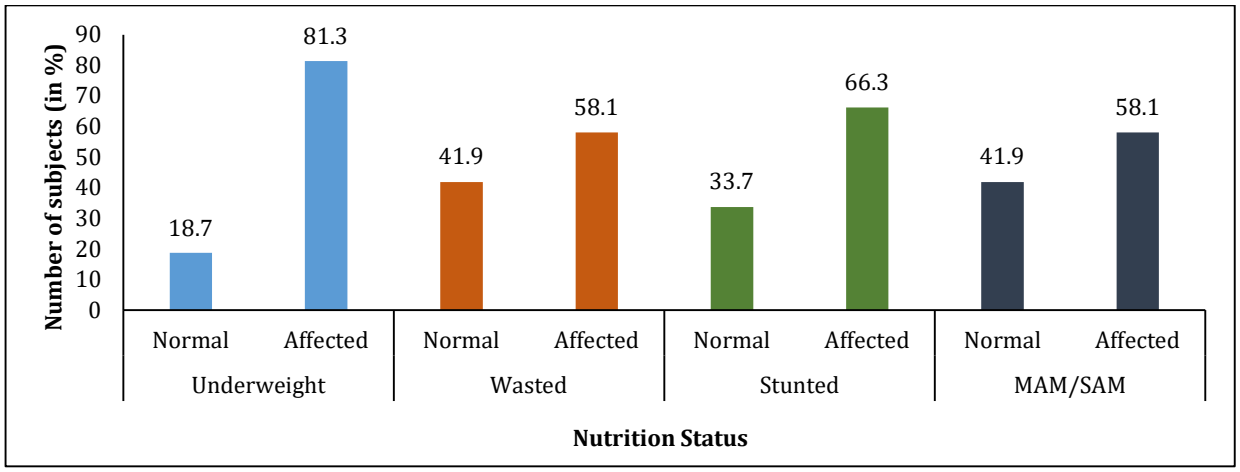
Figure 2 shows high rates of malnutrition among the children. In total, 81.3% of children were underweight (WAZ < -2 SD), 58.1% were wasting (WHZ < -2 SD), and 66.3% were stunting (HAZ < -2 SD). A total of 58.1% of participants had moderate and severe acute malnutrition (MAM/SAM) which shows that both chronic and acute undernutrition are a big problem in the study area.

The analysis by age revealed that malnutrition escalated with advancing age (Table 2). Seventy percent of children aged 6 to 11 months were underweight, 85.1% of those aged 36 to 47 months were underweight, and 82.0% of those aged 48 to 59 months were underweight. The prevalence of wasting rose from 41.7% in the youngest cohort to 62.9% and 63.2% in the 36-47-month and 48-59-month cohorts, respectively. Stunting also followed a similar trend, affecting 50.0% of infants aged 6-11 months and involving two-third (68%) children in the age group of 12-47 months. These results indicated that both acute & chronic malnutrition numbers increased with age, signifying prolonged exposure to the underlying risk factors.

Table 3 shows the descriptive statistics for the anthropometric indices used to determine how healthy the study children were. Missing values were negligible (1.1% for HAZ and 2.7% for WHZ). The mean weight-for-age Z-score (WAZ) was -2.92 ± 0.07, with values ranging from -8.93 to 27.37 and a median of -3.03 (IQR = 1.435). This showed that majority were underweight. The average height-for-age Z-score (HAZ) was -2.68 ± 0.12 (range: -26.67 to 30.66; median = -2.65, IQR = 2.07), which again showed that the majority were stunted. The average weight-for-height Z-score (WHZ) was -2.13 ± 0.07 (range: -12.9 to 30.63; median = -2.175, IQR = 1.72), which even showed similar findings. The overall negative mean Z-scores for all the three indices indicated a substantial prevalence of malnutrition within the study cohort.

Table 1: Demographic characteristics of participants (n=664)

Characteristics	Children (%)
Age (in months)	
≤12	48 (7.2)
>12	616 (92.8)
Gender	
Female	351 (52.9)
Male	313 (47.1)
Mother Education	
Illiterate	69 (10.4)
Literate	595 (89.6)
Father Education	
Illiterate	80 (12)
Literate	584 (88)
Mother Occupation	
Working women	146 (22)
House wife	518 (78)
Father Occupation	
Employed	292 (44)
Unemployed	372 (56)
Income level	
Lower class	628 (94.6)
Lower middle	27 (4.1)
Upper Lower	6 (0.9)
Upper Middle	3 (0.5)
Underweight	540 (81.3)
Stunted	440 (66.3)
Wasted	386 (58.1)



Percentage (%) underweight (WAZ < -2 SD), wasted (WHZ < -2 SD), and stunted (HAZ < -2 SD)

Figure 2: Prevalence of malnutrition among study children (n = 664)

Table 2: Prevalence of Underweight / Wasting / Stunting by age groups (n, %)

Age group (months)	Total (%)	Underweight (%)	Wasting (%)	Stunting (%)
6-11	48 (7.2)	34 (70.8)	20 (41.7)	24 (50.0)
12-23	157 (23.6)	122 (77.7)	80 (50.9)	107 (68.2)
24-35	151 (22.7)	126 (83.4)	92 (60.9)	102 (67.5)
36-47	175 (26.4)	149 (85.1)	110 (62.9)	118 (67.4)
48-59	133 (20.0)	109 (82.0)	84 (63.2)	89 (66.9)

Table 3: Descriptive statistics for anthropometric indices

Variable	Observed	Missing (%)	Mean	SD	Min, Max	Median (IQR)
WAZ (Weight-for-age Z)	664	0 (0)	-2.92	0.07	-8.93, 27.37	-3.03 (1.435)
HAZ$ (Height-for-age Z)	664	7 (1.1%)	-2.68	0.12	-26.67, 30.66	-2.65 (2.07)
WHZ$ (Weight-for-height Z)	664	18 (2.7%)	-2.13	0.07	-12.9, 30.63	-2.175 (1.72)

Table 4: Association of Socio-demographic Determinants with Underweight among Children (n = 664)

Variables	Underweight (%)	Not Underweight (%)	Overall (%)	Chi-square	P value
Sex					
Male	250 (46.3)	63 (50.8)	313 (47.1)	0.82	0.364
Females	290 (53.7)	61 (49.2)	351 (52.9)		
Age in months					
less than 12	34 (6.3)	14 (11.3)	48 (7.2)	6.99	0.136
13 - 24	122 (22.6)	35 (28.2)	157 (23.6)		
25 - 36	126 (23.3)	25 (20.2)	151 (22.7)		
37 - 48	149 (27.6)	26 (21)	175 (26.4)		
49 & above	109 (20.2)	24 (19.4)	133 (20)		
Education of mother					
Illiterate	60 (11.1)	9 (7.3)	69 (10.4)	3.27	.195
Upto middle	232 (43)	48 (38.7)	280 (42.2)		
High school & above	248 (45.9)	67 (54)	315 (47.4)		
Education of father					
Illiterate	73 (13.5)	7 (5.6)	80 (12)	6.70	0.035
Upto middle	176 (32.6)	39 (31.5)	215 (32.4)		
High school & above	291 (53.9)	78 (62.9)	369 (55.6)		
Occupation of father					
Self/Entrepreneurship	328 (60.7)	80 (64.5)	408 (61.4)	0.61	0.436
Wage-Based	212 (39.3)	44 (35.5)	256 (38.6)		
Occupation of mother					
Self/Entrepreneurship	124 (23)	22 (17.7)	146 (22)	1.60	0.205
House wife	416 (77)	102 (82.3)	518 (78)		
Income					
lower class	512 (94.8)	116 (93.5)	628 (94.6)	1.78	0.619
Lower middle	21 (3.9)	6 (4.8)	27 (4.1)		
Upper Lower	4 (0.7)	2 (1.6)	6 (0.9)		
Upper Middle	3 (0.6)	0 (0)	3 (0.5)		
Family Type					
Nuclear	281 (52)	65 (52.4)	346 (52.1)	0.005	0.93
Extended	259 (48)	59 (47.6)	318 (47.9)		
Religion					
Hindu	479 (88.7)	116 (93.5)	595 (89.6)	2.54	0.110
Muslim & Christian	61 (11.3)	8 (6.5)	69 (10.4)		

Table 4 shows the bivariate distribution of demographic and socioeconomic factors related to children being underweight. Among the 664 children, no statistically significant association was identified between sex, age, maternal education, parental occupation, income, family type, or religion and underweight status. A significant association was identified between the father's educational attainment and underweight status (χ^2 = 6.70, p = 0.035), suggesting that children of fathers with higher education levels were less prone to being underweight than those with illiterate fathers. Other factors, like the mother's job and the family's income, showed trends but were not statistically significant. This suggests that paternal education played a key role in influencing child undernutrition in this study population.

Table 5 shows bivariate distribution of socio-demographic factors associated with wasting. The study found out a significant association between age group and wasting (χ^2 = 12.14, p = 0.016), indicating that infants exhibited a higher prevalence of wasting compared to children over one year of age. Other factors such as sex, parental education, parental occupation, family income, family type, and religion did not demonstrate any significant associations with wasting (p >0.05). The results indicate that age significantly impacted acute malnutrition.

Table 5: Association of Socio-demographic Determinants with Wasting among Children (n = 664)

Variables	Wasting (%)	No Wasting (%)	Overall	Chi-square	P value
Sex					
Male	186 (48.2)	127 (45.7)	313 (47.1)	0.41	0.523
Females	200 (51.8)	151 (54.3)	351 (52.9)		
Age in months					
less than 12	20 (5.2)	28 (10.1)	48 (7.2)	12.14*	0.016
13 - 24	80 (20.7)	77 (27.7)	157 (23.6)		
25 - 36	92 (23.8)	59 (21.2)	151 (22.7)		
37 - 48	110 (28.5)	65 (23.4)	175 (26.4)		
49 & above	84 (21.8)	49 (17.6)	133 (20)		
Education of mother					
Illiterate	48 (12.4)	21 (7.6)	69 (10.4)	4.38	0.112
Upto middle	162 (42)	118 (42.4)	280 (42.2)		
High school & above	176 (45.6)	139 (50)	315 (47.4)		
Education of father					
Illiterate	51 (13.2)	29 (10.4)	80 (12)	1.59	0.452
Upto middle	127 (32.9)	88 (31.7)	215 (32.4)		
High school & above	208 (53.9)	161 (57.9)	369 (55.6)		
Occupation of father					
Self/Entrepreneurship	238 (61.7)	170 (61.2)	408 (61.4)	0.02	0.894
Wage-Based	148 (38.3)	108 (38.8)	256 (38.6)		
Occupation of mother					
Self/Entrepreneurship	92 (23.8)	54 (19.4)	146 (22)	1.83	0.175
House wife	294 (76.2)	224 (80.6)	518 (78)		
Income					
lower class	362 (93.8)	266 (95.7)	628 (94.6)	1.98	0.577
Lower middle	19 (4.9)	8 (2.9)	27 (4.1)		
Upper Lower	3 (0.8)	3 (1.1)	6 (0.9)		
Upper Middle	2 (0.5)	1 (0.4)	3 (0.5)		
Family type					
Nuclear	210 (54.4)	136 (48.9)	346 (52.1)	1.95	0.162
Extended	176 (45.6)	142 (51.1)	318 (47.9)		
Religion					
Hindu	346 (89.6)	249 (89.6)	595 (89.6)	0.001	0.977
Muslim & Christian	40 (10.4)	29 (10.4)	69 (10.4)		

Table 6: Association of Socio-demographic Determinants with Stunting among Children (n = 664)

Variables	Stunting (%)	No Stunting (%)	Overall (%)	Chi-square	P value
Sex					
Male	214 (48.6)	99 (44.2)	313 (47.1)	1.17	0.278
Females	226 (51.4)	125 (55.8)	351 (52.9)		
Age in months					
less than 12	24 (5.5)	24 (10.7)	48 (7.2)	6.17	0.186
13 - 24	107 (24.3)	50 (22.3)	157 (23.6)		
25 - 36	102 (23.2)	49 (21.9)	151 (22.7)		
37 - 48	118 (26.8)	57 (25.4)	175 (26.4)		
49 & above	89 (20.2)	44 (19.6)	133 (20)		
Education of mother					
Illiterate	49 (11.1)	20 (8.9)	69 (10.4)	1.05	0.591
Upto middle	187 (42.5)	93 (41.5)	280 (42.2)		
High school & above	204 (46.4)	111 (49.6)	315 (47.4)		
Education of father					
Illiterate	58 (13.2)	22 (9.8)	80 (12)	2.29	0.318
Upto middle	136 (30.9)	79 (35.3)	215 (32.4)		
High school & above	246 (55.9)	123 (54.9)	369 (55.6)		
Occupation of father					
Self/Entrepreneurship	254 (57.7)	154 (68.8)	408 (61.4)	7.61*	0.005
Wage-Based	186 (42.3)	70 (31.3)	256 (38.6)		
Occupation of mother					
Self/Entrepreneurship	94 (21.4)	52 (23.2)	146 (22)	0.30	0.586
House wife	346 (78.6)	172 (76.8)	518 (78)		
Income					
lower class	422 (95.9)	206 (92)	628 (94.6)	6.00	0.118
Lower middle	12 (2.7)	15 (6.7)	27 (4.1)		
Upper Lower	4 (0.9)	2 (0.9)	6 (0.9)		
Upper Middle	2 (0.5)	1 (0.4)	3 (0.5)		
Family type					
Nuclear	234 (53.2)	112 (50)	346 (52.1)	0.60	0.437
Extended	206 (46.8)	112 (50)	318 (47.9)		
Religion					
Hindu	391 (88.9)	204 (91.1)	595 (89.6)	0.78	0.378
Muslim & Christian	49 (11.1)	20 (8.9)	69 (10.4)		

Table 7: Multivariate Logistic Regression Analysis of Factors Associated with Underweight, Wasting, and Stunting in Children (n = 664)

Predictor	Children (%)	Univariate		Multivariate	
		COR (95% CI)	p value	AOR (95% CI)*	p value
Underweight					
Father Educated	584 (88)	0.38 (0.2-0.9)	0.019	0.38 (0.2-0.8)	0.018*
Gestation period > 9m	552 (83.1)	0.47 (0.3-0.9)	0.020*	0.45 (0.2-0.9)	0.014*
Top milk provided	304 (45.8)	0.61 (0.4-0.9)	0.015*	0.94 (0.5-1.6)	0.81
Prelacteal feeds	224 (33.7)	0.51 (0.3-0.8)	0.001*	0.53 (0.3-0.9)	0.022*
Wasting					
Mother Educated	595 (89.6)	0.58 (0.3-1)	0.044*	2.02 (1.1-3.7)	0.023*
Birth order >1	428 (64.5)	1.46 (1.1-2)	0.020*	1.51 (1.1-2.1)	0.013*
Screen devices TV	145 (21.8)	0.62 (0.4-0.9)	0.012*	0.63 (0.4-0.9)	0.015*
Stunting					
Age >12 months	616 (92.8)	2.08 (1.2-3.8)	0.015*	2.05 (1-4.1)	0.039*
Birth weight > 2.5 kg	381 (57.9)	0.67 (0.5-0.9)	0.019*	0.55 (0.4-0.8)	0.004*
Gestation period > 9m	552 (83.1)	0.57 (0.4-0.9)	0.019*	0.71 (0.4-1.2)	0.216
Screen Tantrum	326 (51.9)	1.52 (1.1-2.1)	0.014*	1.48 (1-2.2)	0.049*
Nap duration (hrs)	509 (76.7)	1.32 (1.1-1.7)	0.014*	1.28 (1-1.6)	0.037*

*Significant at 5% level; Univariate associations were performed using logistic regression.
Variables with p <0.20 were selected for inclusion in the multivariate model to control for potential confounding.
The table presents crude odds ratios (COR) and adjusted odds ratios (AOR) with corresponding 95% confidence intervals (CI).

Table 6 presents the bivariate distribution of socio-demographic determinants in relation to stunting. A statistically significant association was also observed with father's occupation (χ^2 = 7.61, p = 0.005), indicating that the children whose fathers were engaged in wage-based work had a higher prevalence of stunting. Other factors like child's sex, age group, parental education, mother's occupation, family income, family type, and religion, did not show statistically significant associations with stunting (p >0.05).

Multivariate logistic regression identified the factors associated with underweight, wasting and stunting among the study children (n = 664). Children whose fathers were educated had lower odds of being underweight (AOR: 0.38; 95% CI: 0.2-0.8; p = 0.018), as did children with a gestation period longer than nine months (AOR: 0.45; 95% CI: 0.2-0.9; p = 0.014). The provision of prelacteal feeds was also associated with reduced odds of underweight (AOR: 0.53; 95% CI: 0.3-0.9; p = 0.022), whereas the association with top milk provision was not statistically significant in the adjusted model. For wasting parameter, maternal education above the primary level was associated with higher odds (AOR: 2.02; 95% CI: 1.1-3.7; p = 0.023), and higher birth order (>1) increased the odds (AOR: 1.51; 95% CI: 1.1-2.1; p = 0.013). Use of Television as a screen device was associated with lower odds of wasting (AOR: 0.63; 95% CI: 0.4-0.9; p = 0.015). Regarding stunting, children older than 12 months had increased odds (AOR: 2.05; 95% CI: 1.0-4.1; p = 0.039), whereas birth weight above 2.5 kg was associated with reduced odds (AOR: 0.55; 95% CI: 0.4-0.8; p = 0.004). Screen tantrums (AOR: 1.48; 95% CI: 1.0-2.2; p = 0.049) and longer nap durations (AOR: 1.28; 95% CI: 1.0-1.6; p = 0.037) were also associated with stunting. Other demographic, maternal, neonatal, behavioral and environmental factors were not significantly associated with the measured outcomes (p > 0.05).

DISCUSSION

This study assessed the prevalence and socio-epidemiological determinants of wasting, stunting, and underweight among preschool-aged children in Belagavi, Karnataka. It was found that underweight was the most common form of malnutrition with prevalence rates of 81.3%, second to 66.3% for stunting and 58.1% for wasting figures that are alarmingly high.

Compared with national NFHS-5 (2019-21) averages stunting 35.5%, wasting 19.3%, and underweight 32.1% our study's prevalence of underweight (81.3%), stunting (66.3%), and wasting (58.1%) are markedly higher.[4] Quantitatively, the underweight prevalence observed in our cohort (81.3%) is approximately 2.53 times the national NFHS-5 estimate (32.1%) and 2.46 times the Karnataka NFHS-5 state estimate (~33%).[15] The absolute difference in underweight prevalence is +49.2 percentage points compared with the national figure. These large discrepancies likely reflect a combination of true local variation and methodological differences between surveys.

District-level NFHS-derived data for Belagavi/Belgaum also indicate substantially lower prevalence than reported here: district nutrition profiles and NFHS-5 district factsheets show underweight prevalence in the Belagavi/Belgaum area around 31-33% (NFHS-5 district/state factsheets/District Nutrition Profile: Belgaum).[15]

Possible explanations for the much higher prevalence in our sample might be attributed to the sampling frame and setting that concentrates vulnerability; slum-based or clinic-based samples usually report higher malnutrition than household surveys. Age-range and case definition differences NFHS reports are for children <5 years; if our study restrict-

ed to a narrower preschool age group (e.g., 9-36 months) or used different z-score cutoffs or WHO growth standards, prevalence estimates may not be directly comparable.[4,14] Smaller sample size, seasonal timing and measurement or recording differences which can inflate point estimates. Contextual determinants rapid urbanization, localized food insecurity, slum living conditions, and pockets of poor service coverage can produce micro-epicenters of high malnutrition even when district/state averages are lower. District Nutrition Profile data and local reports highlight such intra-district disparities.[16]

Our findings were also higher than a study from the same area, which reported stunting at 44%, wasting at 11%, and underweight at 25%. This variation shows that there are differences between regions that are caused by socioeconomic conditions, environmental factors, and how easy it is to get healthcare in different states.[17]

Therefore, while our results indicate a serious local burden that merits targeted interventions, it is important to acknowledge these methodological and contextual explanations and caution against directly extrapolating our point estimates to the whole district/state without considering sampling and setting differences.

The rapid growth of cities like Belagavi may also be linked to higher rates of undernutrition in our study. This is because it leads to further poverty, food insecurity and changes access to healthcare. The UNICEF Global Nutrition Report (2021) says that malnutrition is especially common in urban slums, where the children have to deal with both inadequate food intake and higher non-communicable diseases (NCDs).[18]

A different study from another state, West Bengal also found lower numbers, 33.9% of participants were underweight, 26.1% were stunted, and 19.4% were wasting.[19]

Additionally, our study highlighted children's age and maternal/paternal literacy as important sociodemographic factors associated with undernutrition. Children older than 12 months were found to be twice as likely to suffer from wasting and stunting. The children who are less than 24 months old are more likely to be malnourished because they are not getting enough complementary foods and are more likely to get sick. When children stop breastfeeding and start eating solid foods, giving them complementary foods that aren't healthy or are contaminated can often lead to poor growth in younger children.[20]

This is also noted in a global study by Li H et al that nutritional deficiency primarily occurred in children aged 1-4 years.[21]

Maternal literacy was found to be a significant protective factor, with children of literate mothers being less likely to be underweight. A study from Nepal also backs up these results. It found that mothers who had an education were more likely to feed their babies correctly, keep good hygiene, and get medical care when they needed it. Paternal literacy was also found to lower the risk of being underweight which means that fathers' involvement in childcare and nutrition decisions is just as important as the mother.[22]

Interestingly, in this study, maternal factors like iron and folic acid supplementation and antenatal care visits did not show a significant association with child nutrition. This could be due to differences in healthcare utilization, maternal healthcare practices, and/or regional variations not fully captured by the present study.

It was observed that the children with incomplete or delayed immunization had higher chances of stunting. This finding is further consistent with other South Asian studies emphasizing the protective role of immunization. By preventing common infections such as diarrhoea, pneumonia and measles which are major contributors to growth faltering, immunization helps reduce the burden of childhood malnutrition.[23,24]

Feeding practices also influenced nutritional outcomes. Children who were fed top milk (formula or animal milk) had a lower likelihood of being underweight. The finding corresponds with NFHS-5 data, which highlighted poorer nutritional outcomes in children who were not exclusively breastfed. Prelacteal feeding, though common in many parts of India, was also significantly associated with lower chances of being underweight and stunting in our population. Other studies have also shown that delayed initiation of breastfeeding and pre-lacteal supplementation are barriers to exclusive breastfeeding that negatively affect growth. These findings emphasize the need to strengthen maternal and child health programs by various strategies including but not limited to timely initiation and exclusive breastfeeding.[25]

The association between screen time and stunting was another intriguing discovery in the present study. Stunted children are more likely to have tantrums during or after screen time, possibly due to irregular eating habits, sedentary behaviour, and decreased physical activity. Even though these mechanisms are not entirely understood, this is a crucial area for additional research, particularly considering how common screen devices are in urban homes.

In our study, the effect of sleep duration was also noteworthy, with longer daytime naps linked to stunting. Insufficient sleep can impact young children's immune systems, metabolism, and general development which is another area that warrants further research. Comprehensive malnutrition intervention programs must incorporate behavioural factors like these.

Finally, environmental factors such as access to clean water and sanitary facilities showed weak correlations with malnutrition outcomes. However, this does not diminish the importance of improving envi-

ronmental health for children. A cohort study has demonstrated that the burden of malnutrition in low-income countries is greatly increased by contaminated water, inadequate sanitation, and improper garbage disposal.

LIMITATIONS

This study due to its design was not determine the temporal relationship between exposures and outcomes, such as whether low birth weight caused stunting. Selection bias may also have transpired as the children with suspected or diagnosed malnutrition were incorporated, potentially exaggerating prevalence estimates. Furthermore, dependence on caregiver-reported feeding and health data introduces recall and social desirability bias, resulting in potential measurement inaccuracies.

CONCLUSION

In the context of Belagavi district, undernutrition persisted at higher levels with significant correlations observed among parental education, birth weight, gestational duration, and feeding practices. These multivariate results underscore the need for localised and evidence-based interventions. Enhancing ICDS centres and community nutrition outreach can facilitate the implementation of these insights into effective prevention and management of undernutrition in preschool-aged children.

FUTURE SCOPE

As India advances towards achieving the "Zero Hunger" goal under Sustainable Development Goal 2, further similar studies with a cohort design in the area should concentrate more on post-COVID nutritional recovery, interventions in urban slums, and the impact of parental literacy and immunization in averting the recurrence of malnutrition. Combining these kinds of studies with the ICDS and Poshan 2.0 frameworks could make community-based monitoring and early response strategies stronger.

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