Morphology and severity of anemia in underweight 1-6 years old children

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Abstract

Background: Childhood anemia is a public health problem worldwide. Moreover, underweight children suffering from anemia presents a multifaceted health concern requiring comprehensive evaluation and intervention. Multiple studies on prevalence of anemia have been done on healthy growing children and there is scarcity of data on anemia in underweight. Thus, this cross-sectional study was conducted to estimate the proportion of underweight children suffering from anemia and determine its severity and morphological variant.

Methods: Our study included 200 underweight children aged between 1 and 6 years who sought care at the department of Pediatrics of SIMSRH, Tumkur. Information regarding the demographic characteristics of their mothers, prenatal history; as well as demographic characteristics of children (age, gender, preterm birth, and feeding practices) were collected. The hemoglobin concentration was detected to understand the severity of anemia, along with the assessment of morphological type. Further analysis was done to determine the risk factors of anemia.

Results: The mean age of the children was 42.51 ± 16.45 months, with majority being males (53.0%). The prevalence of anemia was estimated to be 78.5%, where mild anemia was the most common variant (51.5%) and majority exhibited the microcytic hypochromic picture (75.8%). The prevalence of anemia was 74.8% and 94.6% in Moderate Malnutrition and Severe Acute Malnutrition children respectively. Also, anemia was severe in majority of SAM children. The proportion of SAM was higher in preschool children (26.0%) while proportion of anemia was more among toddlers (80.3%), comparatively. On further analysis, significant differences were observed primarily in terms of locality, education, socioeconomic status, parity, and breastfeeding practices.

Conclusion: More than three fourth of underweight children aged 1-6 years, were anemic. The most prevalent form of anemia was mild, characterized by a microcytic hypochromic blood profile. Anemia was more prevalent and severe in extent among children with SAM. Preschool children presented more with anemia, while SAM was more common among toddlers.

Key words: Morphological Types, Childhood Anemia, Moderate Malnutrition, Severe malnutrition, underweight

Introduction

Childhood anemia represents a global public health challenge of significant magnitude. Data sourced from the World Health Organization (WHO) reveals a staggering 39.8% prevalence of anemia among children aged 1-5 years on a global scale[1]. However, the situation in India, as indicated by NFHS-5 data, is even more alarming, with approximately 67.1% of children aged 6-59 months found to be anemic[2]. Notably, even in the specific region of Tumkur, a substantial proportion of children, 67.6%, are affected by anemia[3].

The WHO defines "underweight" as a condition where a child's weight-for-age falls below two standard deviations (SD) from the median of the WHO Child Growth Standards. India, the world's second most populous nation with a population of 1.39 billion, sees children constituting 39.0% of its total population[4]. This demographic composition underscores the significance of addressing childhood health issues. Within this context, children aged 1-5 years make up the largest share, accounting for 29.0% of the total population. NFHS 5 data reports a distressing 32.1% prevalence of underweight children under the

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age of 5 in India. Consequently, India is classified among countries grappling with a critical challenge of malnutrition and high child mortality rates[5].

It is crucial to recognize that the first six years of a child's life are pivotal for their growth and development, and this age group is particularly vulnerable to anemia. Anemia can have profound repercussions on children's health, encompassing physical and social development, and may lead to irreversible impairments in motor, cognitive, and behavioral development[6]. Furthermore, when underweight and anemia coexist in children, it introduces a multifaceted health concern that necessitates comprehensive assessment and intervention. The interplay between these two conditions often heightens the risk of compromised growth, cognitive development, and weakened immune function[7]. Therefore, it is imperative to investigate the specific causes and prevalence of anemia with the aim of preventing and treating this condition[8].

The relationship between undernutrition and infection is intertwined, with infections potentially increasing the nutritional requirements of underweight children. Multiple pathogenic and parasitic infections have been found to be associated with anemia in underweight children[9]. Suboptimal nutrition and poor nutritional status elevate the risk of mortality and other related co-morbidities. Childhood undernutrition and micronutrient deficiencies also contribute to delayed growth, impaired cognitive and motor development, and compromised academic performance, resulting in heightened susceptibility to diseases and reduced economic productivity and societal standing in adulthood[10].

To address these complex issues, the implementation of integrated strategies that encompass nutritional rehabilitation and iron supplementation is of paramount importance in mitigating the long-term consequences on child health and overall well-being. While numerous studies have examined the prevalence of anemia in healthy, growing children, there is a noticeable dearth of data pertaining to anemia in underweight children. This is the novelty of the study, as it attempts to find out the prevalence of anemia among undernourished children and compare with the previous literatures. This sort of comparison with the previous data helps in understanding the effectiveness of National Anemia Control Program.

Materials and Methods

The present hospital based cross-sectional study was carried out for a period of 4 months between August and October 2023, on underweight children aged between 1 and 6 years who sought care at the department of Pediatrics of Shridevi Institute of Medical Sciences and Research Hospital, Tumkur. The sample size was calculated using the observations obtained from the recent Indian studies, where prevalence of anemia ranged from 73.5% to 90.0% among undernourished children[11]. Accordingly, 85.0% was regarded as the proportion, and the precision was kept at 10.0% with 95.0% confidence level. Thus the minimum sample size was estimated to be 196.

Total 287 underweight children of age 1 to 6 years were assessed in our study, where 200 children were included for final analysis who visited as an outpatient or admitted as an in-patient for minor ailments. There were 87 exclusions from the study where 45 children with chronic illnesses, genetic syndromes, severe medical conditions, those regularly taking medications or requiring blood transfusions, or those who had been critically ill within the past 3 months were not considered. On other hand, the caretakers of 39 children did not agree for blood investigations, while in case of remaining 3 children, the blood investigations were done from outside the institute.

Children meeting the established eligibility criteria were selected through a simple random sampling method, following the receipt of informed consent from their legal guardians. To collect the necessary data, a pre-designed semi-structured form that had been internally validated was utilized. The information required were the demographic characteristics of their mothers and prenatal history; as well as the characteristics of children (age, gender, preterm birth, and feeding practices).

The indicators of children's nutritional status were acquired by anthropometric measurements (length/height and weight) and their corresponding assessments using WHO Child Growth Standards. Body weight of children was measured using electric scale for children with accuracy of 0.05 kg. Weight for Age was estimated and SD score <-2 was defined as underweight. In our study, all children included were underweight.

All the children were examined for any signs of edema. Length of children aged 1-2 years was measured using an infant scale with accuracy of 0.1 cm; height was measured using a stadiometer for children of 2-6 years with accuracy of 0.1 cm. Weight for Length/ Height and Length/Height for Age were calculated and any deviation was compared with WHO Child Growth Standards.

Table 1: WHO classification of malnutrition

	Moderate Malnutrition	Severe Malnutrition
Symmetrical Edema	No	Yes (Oedematous Malnutrition)
Weight for Height	SD score between -2 and -3	SD score <-3 (Severe Wasting)
Height for Age	SD score between -2 and -3	SD score <-3 (Severe Stunting)

The severity of malnutrition was categorized using WHO classification[12]. (Table 1).

Blood samples were collected from all the subjects for complete blood count, peripheral smear examination. The peripheral hemoglobin concentration was detected using an automated analyzer. As per WHO guidelines, based on the hemoglobin levels, the severity of anemia was classified. Childhood anemia can be classified into several morphological types based on the characteristics of the red blood cells (RBCs) observed under a microscope.

Accordingly, Microcytic Hypochromic anemia with MCV <70 fL where RBCs are smaller than normal (microcytic) and have reduced hemoglobin content (hypochromic); Macrocytic anemia with MCV >90 fL where RBCs are larger than normal (macrocytic); and normocytic normochromic anemia where RBCs are of normal size (normocytic) and have normal hemoglobin content (normochromic). Dimorphic anemia can be defined as microcytic hypochromic erythrocytes with macrocytic; or microcytic hypochromic with normocytic normochromic erythrocytes.

Table 2: WHO classification of anemia in children based on severity with respect to age

Age group	Non-Anemic	Mild	Moderate	Severe
6-59 months	>11	10-10.9	7-9.9	<7
5-11 years	>11.5	11-11.4	8-10.9	<8
12-14 years	>12	11-11.9	8-10.9	<8

Hemoglobin thresholds to define Anemia and its severity as per WHO [13]. (Table 2).

The details compiled from the selected cases were documented in Microsoft Excel. Descriptive statistics, such as means and standard deviations, were used to represent continuous data, while categorical data was expressed in frequencies and proportions. Statistical analysis was carried out using SPSS version 26, employing appropriate tests of significance based on the nature of the data[14].A p-value below 0.05 was considered statistically significant, with adherence to all relevant rules of statistical tests.

Results

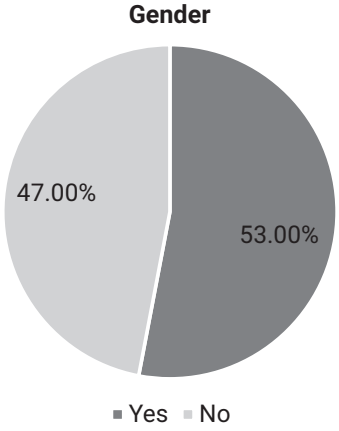

Figure 1: Gender distribution of children

Out of 200 underweight children included in our study, majority i.e., 106 (53.0%) were males, and remaining 94 (47.0%) were females (Figure 1).

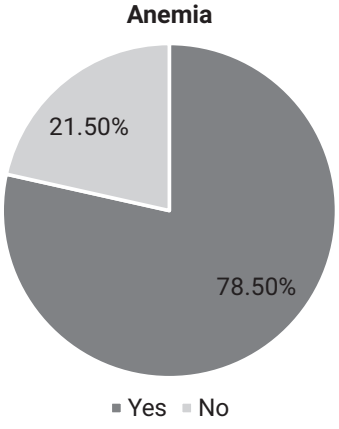

Figure 2: Prevalence of anemia among underweight children of age 1-6 years

On measuring the serum Hb level among all children in our study, the mean Hb level was 6.35 g/dL, ranging between minimum 3.52 g/dL and maximum 13.68 g/dL. About 157 out of 200 children (78.5%) were found to be anemic, and remaining 43 (21.5%) did not have anemia (Figure 2). Thus, the prevalence of anemia was estimated to be 78.5%. Among these 157 anemic children, 103 had mild anemia, 32 presented with moderate anemia, and 22 suffered from severe anemia.

Table 3: Comparison of prevalence of anemia with respect to severity of malnutirion

Subjects (N=200)		Malnutrition		p-value#
		Moderate (N=163)	Severe (N=37)	
Anemia	Yes (N=157)	122 (74.8%)	35 (94.6%)	0.008*
	No (N=43)	41 (25.2%)	2 (5.4%)	

Chi-square test; * Statistically significant

Majority of children in our study i.e., 163 out of 200 (81.5%) were moderately malnourished, while 37 (18.5%) suffered from severe malnutrition. On analysis, about 94.6% of children with severe malnutrition were found to be anemic. This proportion is significantly higher in comparison with 74.8% anemic among moderately malnourished children. This implies that more severe the malnutrition, higher the chances of developing anemia (Table 3).

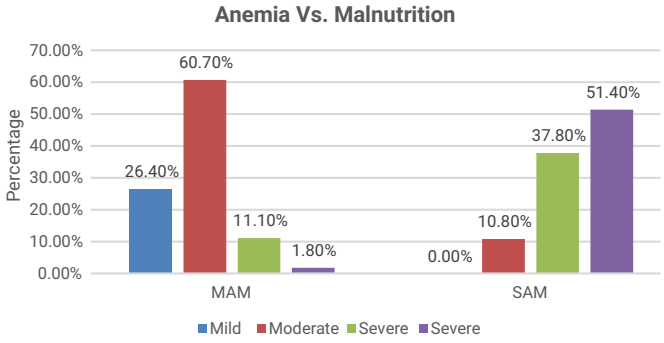

Figure 3: Extent of anemia among children with MAM and SAM

Further on comparing the severity of anemia with the severity of malnutrition, anemia was mild in majority of moderately malnourished (MAM) children. On other hand, majority of children with severe acute malnutrition (SAM), suffered from severe anemia, thereby suggesting that increase in the severity of malnutrition, increases the severity of anemia (Figure-3).

Table 4: Age wise comparison of severity of malnutrition and prevalence of anemia

Subjects (N=200)		Age group		p-value#
		Toddlers (N=127)	Preschool (N=73)	
Malnutrition	Moderate (N=163)	109 (85.8%)	54 (74.0%)	0.037*
	Severe (N=37)	18 (14.2%)	19 (26.0%)	
Anemia	Yes (N=157)	102 (80.3%)	55 (75.3%)	0.409
	No (N=43)	25 (19.7%)	18 (24.7%)	

Chi-square test; * Statistically significant

The mean age of the children was estimated to be 42.51 ± 16.45 months. Majority i.e., 63.5% (127) were toddlers (1-3 years), and about 36.5% (73) were preschool children (3-6 years). On comparison, the proportion of severe malnutrition was higher in preschool children (26.0%) than that among toddlers (14.2%). However the prevalence of anemia was higher in toddlers with an estimate of 80.3%, which was higher than 75.3% prevalence in preschool children (Table 4).

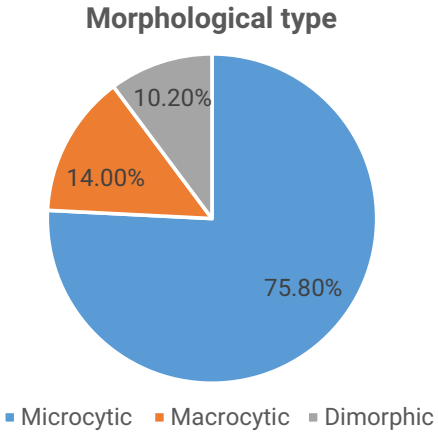

Figure 4: Morphological type of anemia among underweight children

On assessing the morphological type among the 157 anemic children, the majority i.e., 119 children exhibited the microcytic hypochromic variant (75.8%), followed by the macrocytic type in 22 children (14.0%), while the remaining 16 (10.2%) had the dimorphic pattern of anemia (Figure 4).

Table 5: Comparison of prevalence of anemia with respect to characteristics of mothers and their child

Subjects (N=200)		Anemia		p-value#
		Yes (N=157)	No (N=43)	
Age at pregnancy (in years)		26.73±3.54	25.21±4.24	0.056
Locality	Rural	103 (65.6%)	18 (41.9%)	0.004*
	Urban	54 (34.4%)	25 (58.1%)	
Education	School	99 (63.1%)	17 (39.5%)	0.005*
	College	58 (36.9%)	26 (60.5%)	
Occupation	Homemaker	102 (64.7%)	27 (84.1%)	0.791
	Working	55 (35.3%)	16 (15.9%)	
SES	Upper Middle	0 (0.0%)	29 (67.4%)	<0.001*
	Middle	116 (73.9%)	14 (32.6%)	
	Lower Middle	31 (19.7%)	0 (0.0%)	
	Lower	10 (6.4%)	0 (0.0%)	
Parity	1	73 (46.5%)	6 (14.0%)	<0.001*
	2	61 (38.5%)	27 (62.8%)	
	>2	23 (38.6%)	10 (23.2%)	
Gender of child	Male	82 (52.2%)	24 (55.8%)	0.676
	Female	75 (47.8%)	19 (44.2%)	
Preterm	Yes	39 (24.8%)	3 (7.0%)	0.010*
	No	118 (75.2%)	40 (93.0%)	
Immediate BF	Yes	84 (53.5%)	30 (69.8%)	0.050*
	No	73 (46.5%)	13 (30.2%)	
Pre-lacteal Feeds	Yes	48 (30.6%)	4 (9.3%)	0.004*
	No	109 (69.4%)	39 (90.7%)	
Exclusive BF	Yes	107 (68.2%)	41 (95.3%)	<0.001*
	No	50 (31.8%)	2 (4.7%)	

Chi-square test; * Statistically significant

Our study also attempted to compare the prevalence of anemia with certain characteristics of mothers and their child. Significant differences were found primarily in terms of locality, education, socio-economic status, parity, and breastfeeding practices. This indicates that anemia was more prevalent among children of mothers from rural areas, those with limited education, those from lower-middle or lower-class socio-economic backgrounds, those who had delivered more than twice, and children who born prematurely, those who were not breastfed immediately, those given pre-lacteal feeds, and those not exclusively breastfed during the first six months (Table 5).

Discussion

Our study with cross-sectional design was carried out on 200 underweight children aged between 1 and 6 years to determine the prevalence of anemia among them, meanwhile assessing its severity and morphological variations.

Anemia status and its extent in underweight children

Based on the reports from WHO, the global prevalence of anemia was 39.8% in children aged 6-59 months, equivalent to 269 million children with anemia[1]. In India, approximately 67.1% of children were found to be anemic, as per NFHS-5 data[2].

On considering the underweight children of age 1-6 years, the prevalence of anemia in our study was 78.5%. This falls in the prevalence of anemia ranging from 73.5% to 90.0% among children with SAM as per the observations from recent Indian studies[11].

Our study also found that most common variant was mild anemia (51.5%), followed by moderate variant (16.0%) and severe anemia (11.0%). This is quite high compared to the proportions observed globally (Mild 21.9%; Moderate 3.2%; Severe 2.0%) and in India (Mild 45.2%; Moderate 8.8%; Severe 4.0%)[15,16].

Many studies from India have consistently shown an association between anemia and under-nutrition. This is plausible, as calorie deficient children are also very likely to be deficient in other micronutrients, notably iron. A large percentage of children also come from poor background with poor sanitation and environment and are prone to infections. Although various national programs have been successfully implemented in fulfilling the need of iron supplementation, there is still a high prevalence of anemia in this age group, which adversely affects cognitive and physical work performance[17].

Thus there is requirement of more effective strategies. Studies have found that increasing the calorie intake by 20-30% by itself has resulted in improved hemoglobin status in India despite the known low bioavailability of iron in a cereal predominant vegetarian diet. However to increase iron absorption, increase in caloric intake should be accompanied by an increase in consumption of Vitamin C and folic acid rich foods[18].

Severity of malnutrition in toddlers and preschool children

The prevalence of severe malnutrition in our study was 18.5%. This exceeds the global and national prevalence which accounts to about 5.9% and 9.3% respectively[19,20].

When compared with respect to age, SAM was more common in preschool children (26.0%) than that among toddlers (14.2%). This is contrast to the observations made from the previous literatures where SAM was more prevalent among toddlers comparatively[21].

This sort of higher prevalence is due to rapid growth and increased nutritional needs among toddlers. Also they experience a critical phase of development, marked by heightened vulnerability to infections and a transition from breast milk to solid foods. Limited dietary diversity, coupled with fragile immune systems, makes toddlers susceptible to malnutrition. Additionally, factors like inadequate access to nutritious food, and insufficient feeding practices exacerbate the risk. Addressing this issue necessitates targeted interventions focusing on early childhood nutrition, improved healthcare, and community education to mitigate the impact of these factors on toddler health[22].

Morphological type of anemia in underweight children

Microcytic hypochromic variant (75.8%) was the most commonly observed morphological type in our study, followed by the macrocytic type (14.0%), and dimorphic pattern (10.2%) of anemia. However, a study by Verma D et al, found that majority of children had macrocytic anemia (39.6%), followed by microcytic hypochromic in 30.2%[23].

This sort of distribution is due to the fact that undernourished children commonly suffer from Iron, Folate, and Vitamin B12 deficiencies, exacerbating health challenges. Iron deficiency leads to microcytic anemia, hindering oxygen transport and impairing cognitive development. Inadequate folate results in macrocytic anemia and hampers DNA synthesis, impacting growth and immune function[24].

Maternal characteristics associated with anemia

Our study found that anemia was more prevalent among the children of mothers from rural background, mothers with more than 2 children, mothers with just school education, mothers from lower SES.

Women with higher parity often face challenges in providing optimal nutrition to each child, increasing the

risk of anemia. Rural environments may lack adequate healthcare infrastructure and access to diverse, nutritious foods, further contributing to nutritional deficiencies. These factors collectively heighten the likelihood of anemia in children, emphasizing the need for targeted interventions and improved healthcare in rural areas to address and prevent childhood anemia[25,26].

Also mothers with lower education levels may lack awareness of proper nutrition during pregnancy and infancy, leading to insufficient iron intake for their children. Working mothers, may have limited time for infant care and breastfeeding, leading to delayed introduction of iron-rich complementary foods[27].

Families from low socio-economic backgrounds often have limited access to nutritious foods, leading to poor dietary diversity and inadequate iron intake during the critical first years of life. Additionally, poor sanitation and healthcare access in lower socio-economic areas can increase the risk of infections, which can contribute to anemia[28].

Children characteristics associated with anemia

Also anemia was found to be more prevalent among those children who got delivered preterm, who was not breastfed immediately, who received pre-lacteal feeds, and who was devoid of exclusive breastfeeding for first six months.

Children born prematurely often have lower iron stores, as the third trimester is crucial for iron accumulation. Low birth weight infants have reduced iron reserves and may experience delayed cord clamping, further depleting iron. These factors increase susceptibility to iron-deficiency anemia during early infancy. Thus, there's a need for targeted interventions, exclusively for preterm and low birth weight infants, in addition to promoting maternal health to prevent preterm births[29].

Breast milk is the ideal food for infants, as it is packed with nutrients that are essential for their growth and development. In India, many mothers do not breastfeed their infants for long enough. Moreover, insufficient breastfeeding frequency and poor latch can contribute to inadequate iron intake. Another problem is that many Indian mothers introduce solid foods too early, which can lead to anemia, as solid foods often contain less iron than breast milk. Improving breastfeeding education and support, alongside maternal nutrition, is critical to addressing anemia in Indian children and ensuring they receive the necessary iron for healthy development[30].

Conclusions

Our study documented that more than three fourth of underweight children aged 1-6 years, were anemic. The most prevalent form of anemia was mild, characterized by a microcytic hypochromic blood profile. Anemia was more prevalent and severe in extent among children with SAM. Preschool children presented more with anemia, while SAM was more common among toddlers.

Several factors showed a significant association with anemia in underweight children, including preterm birth, inadequate feeding practices, and specific maternal characteristics such as increased parity, rural background, lower education levels, and lower socio-economic status.

Limitations

Our study is not population based and hence the results cannot be generalized. We couldn't work on cause of anemia like iron profile, Vitamin B12, and folic acid. Also no follow-up was done in our study.

Recommendations

We highly recommend a proactive approach to addressing anemia in underweight children, coupled with consistent follow-up, as it proves instrumental in averting potential long-term repercussions on child health and overall well-being. Additionally, there is a need for further research with comparable objectives, particularly focusing on undernourished children, a facet currently underexplored in the Indian context.

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