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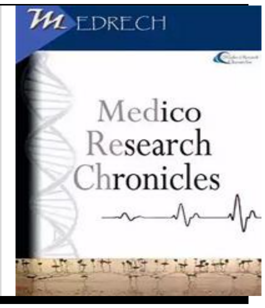

Prevalence and Pattern of Anemia and Micronutrient Deficiencies in Children with Severe Acute Malnutrition at a Tertiary Care Center: A Cross-sectional Study

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Background: Severe acute malnutrition (SAM) remains a major health concern in developing countries like India, significantly contributing to pediatric morbidity and mortality. Children with SAM are particularly vulnerable to infections and anemia due to impaired immune response and nutritional deficiencies. This study aimed to assess the prevalence and severity of anemia in children under 60 months diagnosed with SAM.

Method: A cross-sectional study was conducted over 11 months at Pravara Institute of Medical Sciences DU, Loni involving 48 children with SAM. Detailed demographic profiles and medical histories were collected using a predesigned proforma. Anthropometric measurements and laboratory investigations, including hemoglobin, serum iron, ferritin, folate, and vitamin B12 levels, were performed. Anemia was classified based on hemoglobin levels into mild, moderate, and severe categories.

Results: Results revealed that 37 (77.1%) children were anemic, with 9 (24.3%) having mild anemia, 25 (67.6%) moderate anemia, and 3 (8.1%) severe anemia. Low serum iron levels were identified in 21 (43.8%) children, with a higher prevalence in females. Abnormal ferritin levels were observed in 24 (50%), folate deficiency in 15 (31.3%), and vitamin B12 deficiency in 29 (60.4%) children.

Conclusion: Addressing anemia in children with SAM requires early interventions, starting with maternal nutrition during pregnancy and promoting exclusive breastfeeding for the first six months. Continued breastfeeding, appropriate complementary feeding, and caregiver education during routine child health visits are essential. Preventing, detecting, and managing anemia in children with SAM can significantly reduce associated morbidity and mortality.

INTRODUCTION

In developing countries like India, Severe Acute Malnutrition (SAM) resulting in significant pediatric morbidity and mortality continues to be a major public health concern. Despite its widespread prevalence, malnutrition often remains underrecognized [1]. According to the National Family Health Survey (NFHS) data, there has been a concerning trend in the prevalence of SAM among children below 60 months of age, rising from 6.4% in NFHS-3 (2005-06) to 7.4% in NFHS-4 (2015-16), and further increasing to 7.7% in NFHS-5 (2019-20) [2,3,4]. This rising trend has been potentially exacerbated by the COVID-19 pandemic, which has pushed many families into poverty, reducing household incomes and leading to increased food insecurity [5].

SAM is defined by the World Health Organization (WHO) as a severely low weight-for-height or weight-for-length (Z score < -3 SD according to WHO child growth standards) and/or a mid-upper arm circumference (MUAC) of less than 11.5 cm, and/or the presence of bilateral pedal edema [6]. Several factors contribute to the development of SAM, including inadequate breastfeeding practices, delayed initiation of complementary feeding, provision of nutritionally inadequate foods, recurrent infections, poverty, and lack of awareness.

Children with SAM are particularly vulnerable to diseases due to compromised immunological response. These children are highly susceptible to infections, and nutritional deficiencies often lead to anemia, which can be either a direct or indirect cause of increased morbidity and mortality. The frequent occurrence of respiratory and gastrointestinal infections further aggravates their nutritional status. Research has shown that children with SAM are nine times more likely to face mortality compared to well-nourished children [7,8].

The primary objective of this study was to investigate the prevalence of anemia among children under 60 months of age with SAM in our setting, with a sample size of 48 patients. Additionally, we aimed to assess the severity of anemia and evaluate serum iron, ferritin, folic acid, and vitamin B12 levels in these children to provide appropriate therapeutic interventions.

MATERIALS AND METHODS

Study Design and Setting

This observational cross-sectional study was conducted at Pravara Institute of Medical Sciences DU, Loni for a duration from 1/10/2023 to 30/9/2024, focusing on children with SAM aged less than 60 months. The study protocol was approved by Institutional Ethics Committee [9].

Study Population

The study included 48 children with SAM who either attended outpatient services or were admitted to the hospital's nutritional rehabilitation center. This sample size was determined based on the hospital's admission patterns and study duration.

Inclusion and Exclusion Criteria

We included all children below 60 months of age who met the WHO criteria for SAM and whose parents provided written informed consent. Children with SAM who had underlying structural disorders of cardiac, renal, or other systems were excluded. Additionally, we excluded neonates, children already receiving hematinics or blood transfusions, and those whose parents declined participation [9,10].

Data Collection Procedures

After obtaining written informed consent from legal guardians, we collected detailed medical histories and demographic profiles using a predesigned proforma. Anthropometric measurements were conducted following standardized protocols to identify children with SAM [11].

The criteria for diagnosing SAM were age-specific:

- For children 6-60 months:
  (i) weight-for-height/length Z-score below -3 SD of WHO child growth standards,
  (ii) MUAC < 11.5 cm, or
  (iii) presence of bilateral pedal edema [12].
- For infants under 6 months:
  (i) visible severe wasting,
  (ii) weight-for-length Z scores less than -3 SD, or
  (iii) bilateral pedal edema [13].

Laboratory Investigations

We collected 3 ml of venous blood from each participant, with 1 ml in EDTA vacutainer for complete blood picture (CBP) and 2 ml in plain vacutainer for biochemical analysis. Hemoglobin levels were measured using a five-part hematology analyzer [Name of Analyzer]. Anemia was classified based on hemoglobin levels as:

- Mild: 10-10.9 g/dl
- Moderate: 7-9.9 g/dl
- Severe: <7 g/dl [14]

Serum iron, ferritin, folate, and vitamin B12 levels were analyzed using a fully automated chemiluminescence analyzer. The following cut-off values were used:

- Serum iron: 50 mcg/dl
- Ferritin: 50 ng/ml
- Folate: 5 ng/ml
- Vitamin B12: 350 ng/L [15]

Anthropometric Measurements

MUAC was measured using a standard color-coded tape. Weight was recorded using a calibrated digital weighing scale with minimal clothing. Length/height was measured using an infantometer/stadiometer as appropriate for age. Weight-for-length Z-score (WLZ) and weight-for-height Z-score (WHZ) were calculated using WHO growth reference charts [16].

Statistical Analysis

Data was collected using standardized forms and analyzed using IBM SPSS Statistics Version 28.0 (IBM Corp., Armonk, NY, USA). Results were presented as frequencies, percentages, means, and standard deviations as appropriate. The relationship between variables was assessed using appropriate statistical tests with a significance level of $p<0.05$ [17].

RESULTS

Demographic Profile

Of the 48 children included in this study, 4 (8.3%) were aged less than 6 months and 44 (91.7%) were in the age group of 6-60 months. The overall gender distribution showed 20 (41.7%) males and 28 (58.3%) females. In the age group of <6 months, there were 3 males and 1 female, while in the 6-60 months group, there were 17 males and 27 females.

Table 1: Demographic Distribution of Study Population (N=48)

Age Group	Males n(%)	Females n(%)	Total n(%)
<6 months	3 (6.3%)	1 (2.1%)	4 (8.3%)
6-60 months	17 (35.4%)	27 (56.3%)	44 (91.7%)
Total	20 (41.7%)	28 (58.3%)	48 (100%)

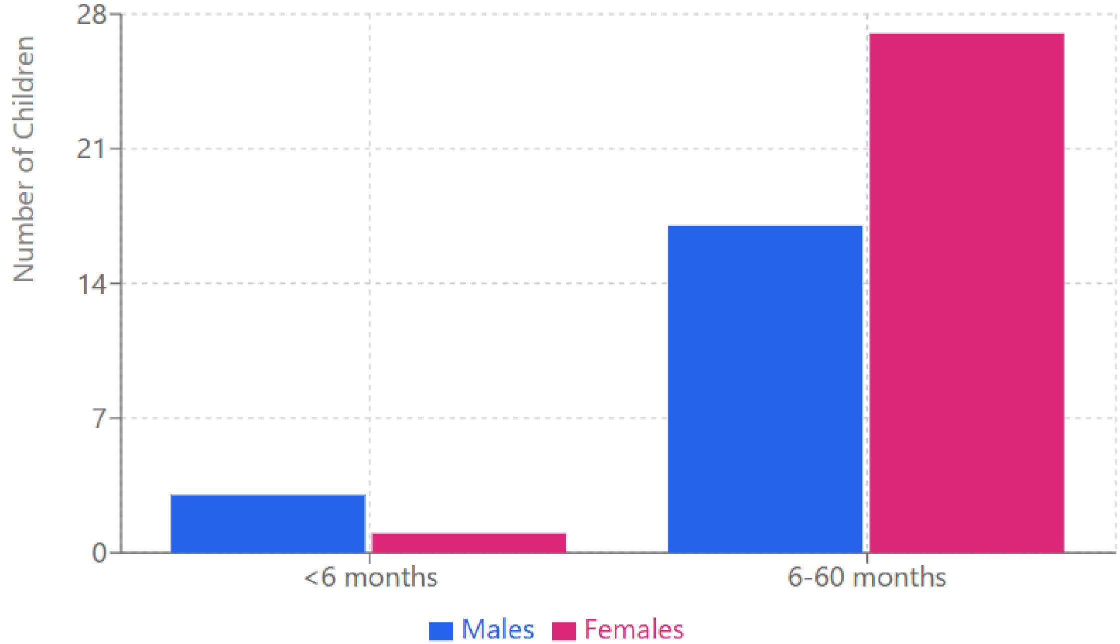

Fig 1: Age and gender distribution

Anthropometric Measurements

Among the 48 SAM children, MUAC was less than 11.5 cm in 31 (64.6%) children. The weight for height/length Z-score distribution was as follows:

- -2 SD to -3 SD: 4 (8.3%) cases
- -3 SD to -4 SD: 32 (66.7%) cases
- <-4 SD: 12 (25%) cases Edematous malnutrition was observed in 2 (4.2%) children.

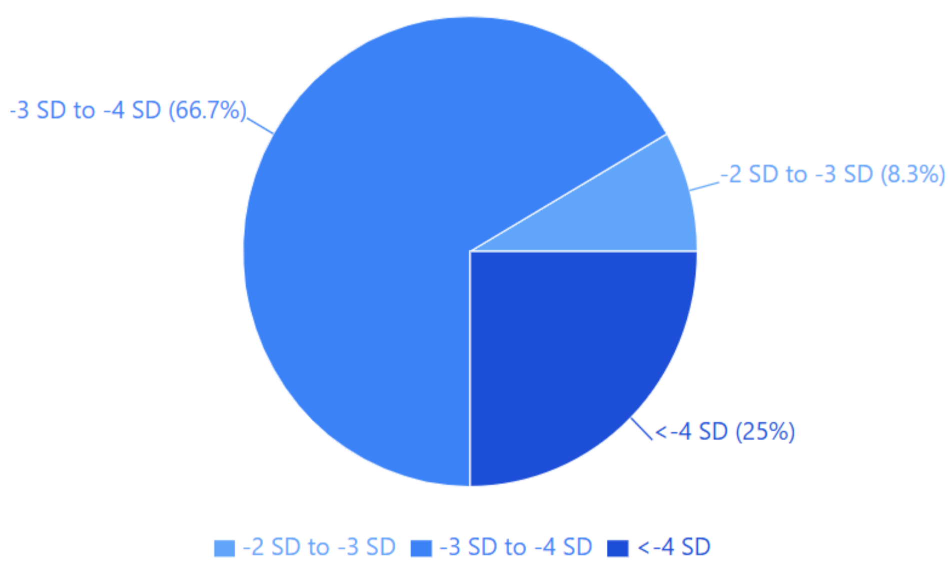

Fig 2: Pie chart showing distribution of Z-scores

Prevalence and Severity of Anemia

Of the total 48 children, 37 (77.1%) were found to be anemic. The severity distribution was as follows:

Table 2: Distribution of Anemia Severity (N=37)

Severity	Hemoglobin Range	Number of Cases	Percentage
Mild	10-10.9 g/dl	9	24.3%
Moderate	7-9.9 g/dl	25	67.6%
Severe	<7 g/dl	3	8.1%

Micronutrient Deficiencies Analysis of serum parameters revealed the following:

Table 3: Distribution of Micronutrient Deficiencies (N=48)

Parameter	Deficient n(%)	Normal n(%)	Mean Value
Iron	21 (43.8%)	27 (56.2%)	127.8
Ferritin	24 (50%)	24 (50%)	76.9
Folate	15 (31.3%)	33 (68.7%)	9.8
Vitamin B12	29 (60.4%)	19 (39.6%)	375.4

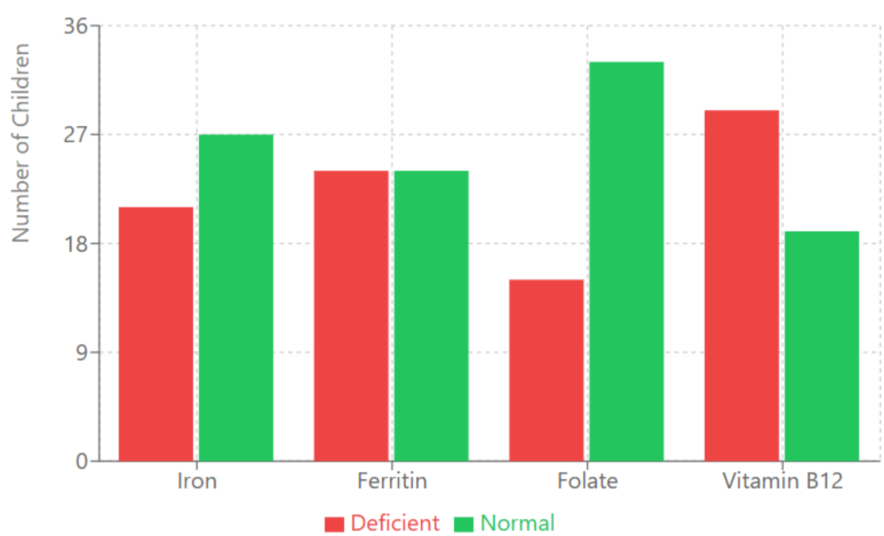

Fig 3: Deficient vs Normal levels for each parameter

Associated Morbidities

The most common morbidities observed were:

- Gastrointestinal infections: 21 cases (43.8%)

- Respiratory tract infections: 14 cases (29.2%)
- Sepsis: 4 cases (8.3%)
- Seizures: 2 cases (4.2%)
- Other conditions (including UTI, measles, skin infections): 7 cases (14.5%)

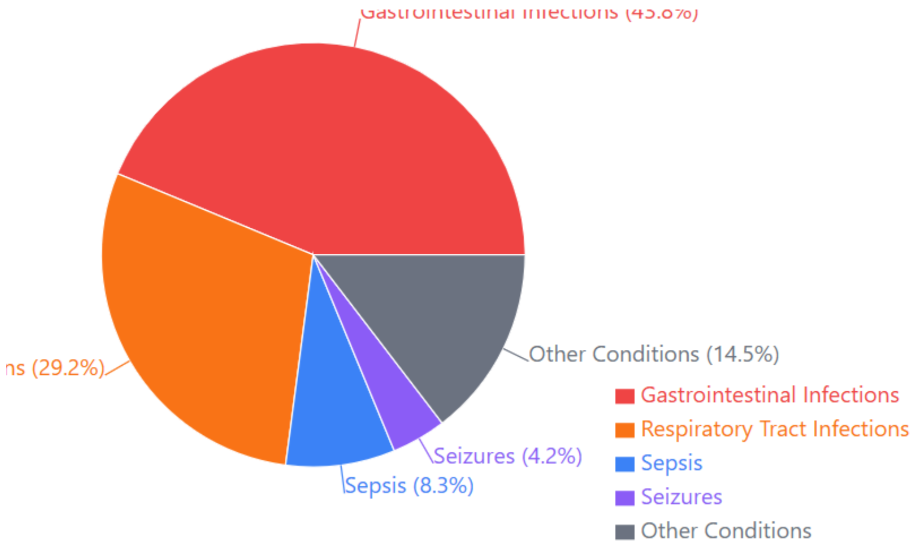

Fig 4: Pie chart showing distribution of morbidities

For statistical relationships, we found a significant correlation between vitamin B12 deficiency and the severity of anemia ($p<0.05$). Iron deficiency was more prevalent in females compared to males ($p<0.05$).

DISCUSSION

Our study of 48 children with SAM revealed important findings regarding the prevalence and patterns of anemia and associated micronutrient deficiencies. The overall prevalence of anemia in our study population was 77.1%, which aligns with findings from similar studies. For instance, Sharma et al. reported an anemia prevalence of 73.5% in their study of SAM children, while Arya et al. found an even higher prevalence of 95% [15,18].

The gender distribution in our study showed a female predominance (58.3%), which is consistent with findings by Sharma et al., who reported 60% female representation in their study [15]. This gender disparity might reflect underlying sociocultural factors affecting nutritional status among female children in developing countries.

Regarding the severity of anemia, our study found moderate anemia (67.6%) to be the most common presentation, followed by mild anemia (24.3%) and severe anemia (8.1%). This pattern differs from some previous studies. For instance, Thakur et al. reported a higher proportion of severe anemia (67.3%) in their study population [1]. The variation might be attributed to differences in geographical locations, socioeconomic factors, and timing of presentation to healthcare facilities.

The analysis of micronutrient deficiencies in our study population revealed vitamin B12 deficiency as the most prevalent (60.4%), followed by ferritin deficiency (50%) and iron deficiency (43.8%). This hierarchy of deficiencies mirrors the findings of Yaikhomba et al., who also found vitamin B12 deficiency to be more common than iron or folate deficiencies in SAM children [14]. Similarly, Murthy et al. reported vitamin B12 deficiency in 45% of their study population [16].

Our observation of low serum ferritin levels in 50% of cases, while iron deficiency was present in 43.8%, suggests that many children might be in the early stages of iron deficiency anemia. This finding supports the importance of early intervention and regular monitoring of iron status in SAM children. The phenomenon of ferritin being an acute phase reactant might mask true iron deficiency in some cases, as noted in previous studies [13].

The co-existence of multiple micronutrient deficiencies observed in our study emphasizes the complex nature of nutritional deficiencies in SAM. This finding aligns with observations by Chandra et al., who emphasized the importance of assessing multiple hematopoietic micronutrients in SAM children [11]. The significant correlation we found between vitamin B12 deficiency and anemia severity supports findings by Shukla et al., who reported similar associations [13].

Regarding associated morbidities, gastrointestinal infections (43.8%) and respiratory tract infections (29.2%) were the most common in our study population. This pattern is consistent with findings by Kumar et al., who reported diarrhea (55%) and respiratory tract infections (27.8%) as predominant comorbidities [20]. The high prevalence of infections might be attributed to the immunocompromised state associated with SAM, as suggested by Pravana et al. [8].

The impact of vitamin B12 deficiency on child development, though not directly assessed in our study, has been highlighted by Atiq et al., who found significant associations between B12 deficiency and developmental delays in SAM children [12]. This underscores the importance of addressing micronutrient deficiencies as part of comprehensive SAM management.

The findings of our study have important implications for clinical practice, particularly in resource-limited settings. The high prevalence of multiple micronutrient deficiencies suggests the need for comprehensive nutritional assessment and supplementation strategies. Additionally, the predominance of moderate anemia in our population highlights the importance of early detection and intervention before progression to severe anemia.

CONCLUSION

Anemia represents a significant comorbidity in children with severe acute malnutrition, with our study revealing its presence in 77.1% of cases. The predominance of moderate anemia, coupled with multiple micronutrient deficiencies, particularly vitamin B12, iron, and folate, underscores the complex nutritional challenges these children face. The high prevalence of vitamin B12 deficiency (60.4%) compared to other micronutrient deficiencies suggests the need for particular attention to this often-overlooked nutrient in SAM management protocols.

Prevention of anemia and malnutrition requires a comprehensive approach beginning during pregnancy through maternal nutrition optimization and appropriate supplementation. Exclusive breastfeeding for the first six months of life, followed by the timely introduction of adequate complementary feeding, remains crucial in maintaining optimal nutritional status in children under 60 months of age. Healthcare providers should utilize every opportunity, particularly well-baby visits, to educate parents and caregivers about appropriate feeding practices and the importance of regular growth monitoring.

Our findings emphasize the necessity of routine screening for multiple micronutrient deficiencies in children with SAM, rather than focusing solely on iron deficiency anemia. The implementation of comprehensive nutritional rehabilitation programs, incorporating appropriate micronutrient supplementation, could significantly improve outcomes in these vulnerable children.

Regular monitoring of growth parameters, hemoglobin levels, and micronutrient status, combined with prompt management of infections, should form the cornerstone of SAM management. Healthcare providers should maintain a high index of suspicion for nutritional deficiencies, particularly in settings where resources for extensive laboratory investigations may be limited.

Future research directions should focus on developing cost-effective screening tools for multiple micronutrient deficiencies and evaluating the impact of comprehensive supplementation strategies on long-term outcomes in children with SAM. Additionally, studies investigating the role of socioeconomic and cultural factors in the development and persistence of malnutrition could help in designing more effective preventive strategies.

By addressing these nutritional challenges comprehensively and proactively, we can work towards reducing the burden of anemia and its associated complications in children with severe acute malnutrition, ultimately contributing to improved child health outcomes in resource-limited settings.

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