CLINICAL STUDY

Clinicoepidemiological Profile and Micronutrient Deficiencies in Children with Severe Acute Malnutrition

RAM SINGH YADAV*, KUSUM DEVPURA†, DHAN RAJ BAGRI‡

ABSTRACT

Introduction: Malnutrition is widely prevalent in developing countries and is considered a common denominator in infant and under-5 mortalities. Most child deaths are associated with inappropriate feeding practices and specific micronutrient deficiencies during the first year of life. There is a lack of data about severe acute malnutrition (SAM) and specific micronutrient deficiencies in India; hence, the present study was conducted to study the iron profile, including folic acid, and vitamin B12 levels and their correlation with the clinicoepidemiological profile of children with SAM. **Materials and methods:** This hospital-based cross-sectional study included 95 children with SAM, aged 6 months to 5 years. A predesigned structured proforma was used to collect information. Data concerning clinical examination and history given by the mother and a reliable attendant was collected. The quantitative data were expressed as mean and standard deviation and qualitative data as percentage and proportion. The difference in proportion was analyzed by the Chi-square test and the difference in means was analyzed by ANOVA. P-value <0.05 was taken as significant. All calculations were done by Microsoft Excel, Primer. SPSS Software [version 21] was used for doing statistical analysis. **Results:** In the present study, a total of 95 SAM patients were included with mean age 19.74 months and an F:M ratio of 1.2:1. Weight-for-height was found to be the most reliable criterion to identify children with SAM (78.95%). Edema was present in 18 (18.95%) patients. Around 68.42% of patients had mid-upper arm circumference (MUAC) <11.5 cm; 25.26% of children were found completely immunized, remaining 74.74% were either partially immunized or unimmunized. According to the Kuppuswamy scale for the socioeconomic class, more than two-thirds of the parents belonged to the upper-lower class. About 44.21% of children received exclusive breastfeeding till 6 months of age, while complementary feeding was started in only 25.26% of children at 6 months of age. Anemia was present in 93 children with a prevalence of 97.89%. Of these, 30 patients had vitamin B12 deficiency anemia, 20 patients had iron deficiency anemia, and 6 patients had folate deficiency anemia. **Conclusions:** Severe acute malnutrition is an important preventable and treatable cause of morbidity and mortality in children below 5 years of age in India. Although malnutrition is highly prevalent in Indian children, there are very limited data that use biochemical indexes to characterize the epidemiology of micronutrient deficiencies in children with SAM. A detailed understanding of micronutrient deficiencies and clinical and epidemiological profile of children may help in micronutrient supplementation and fortification programs and targeting the basic causes of pediatric mortalities.

Keywords: Severe acute malnutrition, NFHS-5, iron, folic acid, vitamin B12, wasting, stunting

Childhood undernutrition is an underlying cause of an estimated 45% of all deaths among under-5 children[1]. India has an under-5 mortality rate (U5MR) of 41.9 per 1,000 live births. According to the National Family Health Survey (NFHS-5) 2019-21, 35.5% of children under 5 years are stunted (Below –2 standard deviations [SD], based on the World Health Organization [WHO] standard, height-for-age); 19.3% of children under 5 years are wasted (< –2SD, WHO standard, weight-for-height), 7.7% of children under 5 years are severely wasted (< –3SD, WHO standard; weight-for-height), 32.1% of children under 5 years are underweight (< –2SD, based on the WHO standard, weight-for-age); and 3.4% of children under 5 years

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are overweight (> +2SD, based on the WHO standard, weight-for-height)[2].

It is estimated that 1 in every 3 malnourished children live in India. Malnutrition in children is widely prevalent in developing countries and has been responsible for 60% of the 10.9 million deaths annually among children less than 5 years. Over two-thirds of these deaths, often associated with inappropriate feeding practices, occurred during the first year of life[1]. The infant mortality rate of India is 35.2 per 1,000 live births. As per NFHS-5, in India, 63.7% of children below 6 months of age are exclusively breastfed and 45.9% of children aged 6 to 8 months are receiving solid or semi-solid food and breastmilk[2]. As per NFHS-5, 67.1% of children of age 6 to 59 months in India are anemic. Only 11.1% of breastfeeding and 12.7% of nonbreastfeeding (total 11.3%) children aged 6 to 23 months are receiving an adequate diet[2].

Dietary sources of vitamin B12 are almost exclusively from animal foods. As far as anemia in malnutrition or severe acute malnutrition (SAM) is concerned much emphasis is laid on supplementation of iron and folic acid and not on vitamin B12[3]. Moreover, supplementation of only folic acid in children deficient in both vitamin B12 and folic acid can worsen the neurological status of the child[4]. There is a lack of data about SAM and specific micronutrient deficiencies in India; hence, the present study was aimed to study the iron profile, folic acid, and vitamin B12 levels, and their correlation with the clinicoepidemiological profile of children with SAM.

MATERIALS AND METHODS

This hospital-based cross-sectional study was conducted at the Malnutrition Treatment Center (MNTC), Dept. of Pediatric Medicine of a tertiary care center; children with SAM, aged 6 months to 5 years were included in the study after receiving the requisite clearance from Institutional Ethics Committee. Exclusion criteria were children who were already on hematinics before admission, those aged below 6 months and above 5 years, and refusal for consent. At 95% confidence level and 5% absolute allowable error assuming 94% prevalence of anemia among SAM cases, the required sample size was 91 cases, which was further rounded off to 95 cases of SAM.

A predesigned structured proforma was used to collect information. Basic demographic data, child's profile (address, age, sex, birth spacing, and birth order); education, occupation, and religion of parents; socio-economic details of their parents (family income, caste), breastfeeding (immediate breastfeeding, exclusive breastfeeding, duration of feeding) and introduction of complementary food and child feeding status were collected from all patients. Weight was measured in kilograms using an electronic weighing scale. Mid-upper arm circumference (MUAC) was measured in centimeters using a simple measuring tape. These anthropometric measurements were compared to the WHO reference standards to determine the nutritional status of the child.

Two milliliters of the peripheral venous blood sample was taken with aseptic precautions, in an EDTA vial for determination of complete blood count, 2 mL in the plain vial for C-reactive protein (CRP), and 3 mL in another plain vial for serum iron profile, folic acid, and vitamin B12 estimation. Serum iron profile, folic acid, and vitamin B12 were estimated by using the electrochemiluminescence (ECL) method using VIT B12 600, FOL III 618, and FERRITIN 381 ELECSYS kits for COBASe411 analyzer, Roche diagnostics GmBH Germany distributed by Roche diagnostics GmBH, Sandhofer Strasse 116 Mannheim.

Iron deficiency was defined as ferritin concentration <12 ng/mL, or if the CRP was >5 mg/L, iron deficiency was defined as ferritin concentration <30 ng/mL.[5] Vitamin B12 deficiency was defined as serum or plasma total vitamin B12 concentrations <148 pmol/L, and vitamin B12 insufficiency was defined as vitamin B12 concentrations <221 pmol/L, unless otherwise specified. Folate deficiency was defined as a serum folate concentration <10 nmol/L[6]. Biochemical evidence of inflammation was defined as a CRP concentration >5 mg/L. CRP was measured to evaluate whether systemic inflammation could account for an abnormal ferritin concentration[7].

Data were collected concerning clinical examination and history given by mother and reliable attendant. The quantitative data were expressed as mean and SD and qualitative data as percentage and proportion. The difference in proportion was analyzed by the Chi-square test and the difference in means was analyzed by ANOVA. P-value <0.05 was taken as significant. All calculations were done by Microsoft Excel, Primer. SPSS Software [version 21] was used for doing statistical analysis.

RESULTS

The baseline characteristics of the study participants are depicted in Figure 1. Out of 95 SAM patients, 39 (41.05%) were between 6 to 12 months, 39 (41.05%) between

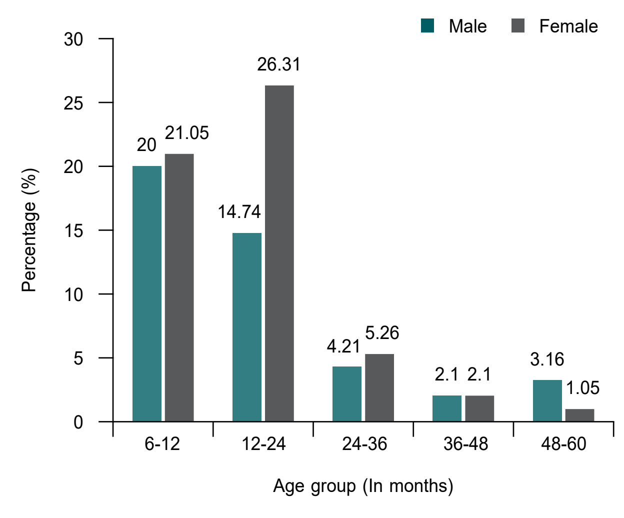

Figure 1. Baseline characteristics of study participants.

Table 1. Weight-for-Height of Study Participants

Age group (In months)	Weight/Height			Total
	<1SD	<2SD	<3SD	
6-12	3 (3.16)	3 (3.16)	32 (33.68)	39 (41.05)
12-24	2 (2.10)	7 (7.37)	30 (31.58)	39 (41.05)
24-36	0 (0.00)	0 (0.00)	9 (9.47)	9 (9.47)
36-48	1 (1.05)	1 (1.05)	2 (2.10)	4 (4.21)
48-60	0 (0.00)	2 (2.10)	2 (2.10)	4 (4.21)
Total	**7 (7.37)**	**13 (13.68)**	**75 (78.95)**	**95 (100.00)**

12 to 24 months, 9 (9.47%) between 24 to 36 months, 4 (4.21%) between 36 to 48 months, and 4 (4.21%) were between 48 to 60 months age group. The mean age of the participants was 19.74 months. Fifty-three (55.79%) were female and 42 (44.21%) were male with a sex ratio (F:M) of 1.2:1.

Out of 95 SAM children, 75 (78.95%) had weight-for-height <3SD, 13 (13.68%) patients had weight-for-height <2SD, and 7 (7.37%) patients had weight-for-height <1SD. Gender-based evaluations concerning weight-for-height suggested that out of 75 having weight-for-height <3SD, 33 (34.74%) were male and 42 (44.21%) were female (Table 1).

Eighteen participants (18.95%) had edema and 77 (81.05%) had no edema. Distribution according to sex and edema shows that out of the 18 patients with edema, 5 were male, and 13 were female. The Chi-square value was 1.679, degree of freedom was 1, and p-value was >0.05, hence not significant.

Out of the 95 study subjects, 68.42% (65) patients had MUAC <11.5 cm, and 31.58% (30) of patients had MUAC >11.5 cm. Twenty-nine patients were male and 36 were female out of the 65 (68.42%) having MUAC <11.5 cm. Thirteen patients were male and 17 were female out of the 30 (31.58%) having MUAC >11.5 cm. The Chi-square value was 0.01, the degree of freedom was 1, and the p-value was >0.05, hence not significant.

Out of 95, 42 (44.21%) children were exclusive breastfeeding, 40 (42.11%) were still predominantly breastfed and 13 (13.68%) were given complementary food besides milk. Out of 95, 24 (25.26%) were completely immunized, 61 (64.21%) were incompletely immunized and 10 (10.52%) were unimmunized.

Out of 95, 93 (97.89%) were anemic, 42 (44.21%) had severe anemia, 39 (41.05%) had moderate anemia, and 8 (8.42%) had mild anemia. Micronutrient deficiency was found in 56 (58.94%). Serum vitamin B12 deficiency was found in 30 (31.58%) patients, serum folate deficiency in 6 (6.32%) patients, and serum iron deficiency in 20 (21.05%) patients. The severity of anemia in study participants is depicted in Table 2.

Mean ± SD of age and severity of anemia analysis suggested 18.00 ± 0.00 for normal hemoglobin (Hb) (n = 2), 30.75 ± 17.17 for anemia (n = 4), 11.00 ± 3.32 for mild anemia (n = 8), 16.82 ± 10.86 for moderate anemia (n = 39), 15.40 ± 7.79 for severe anemia (n = 42).

Gender-wise evaluation suggested that out of the 42 (44.21%) severely anemic children, 20 (47.62%) were male and 22 (52.38%) were female, and out of 39 (41.05%) moderately anemic children, 18 (46.15%) were male and 21 (53.85%) were female. The study of birth order of study subjects showed higher prevalence of severe anemia (42) in the third birth order followed by second birth order, which was 20 and 13, respectively. Moderate anemia (39) was more in the second birth order followed by the fourth birth order, which was 15 and 8, respectively.

Table 3 describes the relationship of the severity of Hb level with weight-for-height of study participants; 34 (35.79%) participants with severe anemia had weight-for-height <3SD. The severity of Hb level analysis concerning feeding history of study subjects suggested that out of 42 exclusive breastfeeding children, 24 had severe anemia, 15 had moderate anemia, and 2 had mild anemia. Mean ± SD of serum iron according to severity of Hb level was 89.00 ± 13.00 for normal Hb (n = 2), 77.50 ± 6.10 for anemic (n = 4), 80.00 ± 29.95 for mildly anemic (n = 8), 110.00 ± 35.94 for moderate anemic (n = 39), 112.12 ± 37.57 for severe anemic (n = 42) patients.

Table 2. Severity of Anemia in Study Participants

Age group (In months)	Normal	Anemic (<11 g/dL)	Mild anemic (10-10.9 g/dL)	Moderate anemic (7-9.9 g/dL)	Severe anemic (<7 g/dL)	Total
6-12	0 (0.00)	0 (0.00)	5 (12.82)	16 (41.02)	18 (46.15)	39
12-24	2 (5.12)	2 (5.12)	3 (7.69)	16 (41.02)	16 (41.02)	39
24-36	0 (0.00)	1 (11.11)	0 (0.00)	3 (33.33)	5 (55.55)	9
36-48	0 (0.00)	0 (0.00)	0 (0.00)	1 (25)	3 (75)	4
48-60	0 (0.00)	1 (25)	0 (0.00)	3 (75)	0 (0.00)	4
Total	**2 (2.10)**	**4 (4.21)**	**8 (8.42)**	**39 (41.05)**	**42 (44.21)**	**95 (100)**

Table 3. Relationship of Severity of Hb Level with Weight-for-Height of Study Participants

Hb	Weight-for-Height			Total
	<1SD	<2SD	<3SD	
Normal	0 (0.00)	0 (0.00)	2 (2.10)	2 (2.10)
Anemic	0 (0.00)	1 (1.05)	3 (3.16)	4 (4.21)
Mildly anemic	2 (2.10)	0 (0.00)	6 (6.32)	8 (8.42)
Moderate anemic	3 (3.33)	6 (6.31)	30 (31.58)	39 (41.05)
Severe anemic	2 (2.10)	6 (6.31)	34 (35.79)	42 (44.21)
Total	**6 (6.31)**	**32 (33.68)**	**57 (60.0)**	**95 (100.00)**

Table 4. Relationship Between Severity of Hb Level as per Vitamin B12 of Study Subjects

Hb	Vitamin B12		Total
	Abnormal	Normal	
Normal	1 (1.05)	1 (1.05)	2 (2.10)
Anemic	4 (4.21)	0 (0.00)	4 (4.21)
Mildly anemic	0 (0.00)	8 (8.42)	8 (8.42)
Moderate anemic	15 (15.79)	24 (25.26)	39 (41.05)
Severe anemic	10 (10.53)	32 (33.68)	42 (44.21)
Total	**30 (31.58)**	**65 (68.42)**	**95 (100.00)**

Out of 95, 20 patients had abnormal iron. Out of 20, 11 (11.58%) patients had MUAC <11.5 cm and 9 (9.47%) patients had MUAC of >11.5 cm. The Chi-square value was 2.110, the degree of freedom was 1, and the p-value was >0.05; hence, not significant.

Analysis of severity of Hb level and serum iron of study subjects suggested that out of 20 children with abnormal serum iron, 10 were severely anemic, 8 were moderately anemic, and 2 were mildly anemic. Distribution according to age and serum iron shows that 20 patients had abnormal iron. Out of 20, 9 patients were in the 6 to 12 months age group and 6 patients were in the 12 to 24 months age group.

Distribution according to sex and serum iron shows that 20 patients had abnormal iron. Out of 20, 9 patients were male and 11 were female. The Chi-square value was 0.01, the degree of freedom was 1, and the p-value was >0.05; hence, not significant. Distribution according to serum iron and feeding history shows that 20 children had abnormal iron. Out of 20, 6 were exclusive breastfeeding, 12 were still predominantly breastfed, and 2 were given complementary food besides milk.

Analysis of severity of Hb level and total iron-binding capacity (TIBC) of study subjects suggested that out of 8 children with abnormal serum TIBC, 3 were severely anemic, 3 were moderately anemic, and 2 were mildly anemic. According to severity of Hb level, the mean ± SD of TIBC was 359.00 ± 9.00 for normal Hb (n = 2), 346.75 ± 34.23 for anemic (n = 4), 362.50 ± 53.84 for mildly anemic (n = 8), 307.31 ± 58.37 for moderately anemic (n = 39), 315.50 ± 59.26 for severely anemic (n = 42) patients (Table 4).

Out of 30 children with abnormal serum vitamin B12, 10 were severely anemic, 15 were moderate anemic, 4 were anemic, and 1 was normal (Table 4).

Analysis of severity of Hb level and serum ferritin of study subjects suggested that out of 52 children with abnormal ferritin, 25 were severely anemic, 25 were moderate anemic, and 2 were mildly anemic. Mean ± SD of serum ferritin according to severity of Hb level was 77.46 ± 47.55 for normal Hb (n = 2), 40.18 ± 17.33 for anemic (n = 4), 64.85 ± 45.56 for mildly anemic (n = 8), 192.04 ± 137.95 for moderate anemic (n = 39), 217.10 ± 187.41 for severe anemic (n = 42) patients.

The relationship between severity of Hb level as per vitamin B12 of study subjects depicted mean ± SD of vitamin B12 of 193.5 ± 7.65 for normal Hb (n = 2), 346.48 ± 258.61 for anemic (n = 4), 323.34 ± 74.71 for mildly anemic (n = 8), 295.29 ± 158.23 for moderately anemic (n = 39), 266.26 ± 106.56 for severely anemic (n = 42) patients. Out of 95, 30 (30.58%) patients had abnormal vitamin B12 levels. Out of 30, 10 (10.53%) were in 6 to 12 months age group and 15 (15.79%) were in 12 to 24 months age group, 3 (3.33%) were in 24 to 36 months age group and 2 (2.1%) were in 48 to 60 months age group. Out of 30, 14 were male and 16 were female; Chi-square value was 0.011, degree of freedom was 1 and p value was >0.05, hence not significant.

Out of 30, 13 (13.68%) were exclusively breastfeeding, 10 (10.53%) were still predominantly breastfed, and 7 (7.37%) were given complementary feeds besides milk; Chi-square value was 3.779, degree of freedom was 2, and p-value was >0.05; hence, not significant.

Out of 30, 19 (20%) patients had MUAC <11.5 cm and 11 (11.58%) patients had MUAC >11.5 cm. The Chi-square value was 0.530, degree of freedom was 1, and p-value was >0.05; hence, not significant. Out of 95, 6 (6.31%) children had abnormal serum folate. Out of 6, 2 (2.10%) were severely anemic, 2 were moderately anemic, and 2 were mildly anemic.

Out of 6 children with abnormal folate, 2 were in the 6 to 12 months age group, 3 were in the 12 to 24 months age group, and 1 was in the 24 to 36 months age group. Out of 6, 2 were male and 4 were female; Chi-square value was 0.017, degree of freedom was 1, and p-value was >0.05; hence, not significant. Out of 6, 2 were exclusive breastfeeding, 3 were still predominantly breastfed, and 1 was given complementary feeds besides milk. Out of 6, 5 had MUAC <11.5 cm and 1 patient had MUAC >11.5 cm. The Chi-square value was 0.128, degree of freedom was 1, and p-value was >0.05; hence, not significant.

The distribution of micronutrient deficiency in the groups based on severity of anemia depicted that in the normal Hb (n = 2) group, 1 child had vitamin B12 deficiency. In anemic group (n = 4), all 4 were vitamin B12 deficient. In mildly anemic (n = 8) group, 2 patients had serum iron deficiency and 2 patients had folate_deficiency; rest 4 were normal. In moderately anemic group (n = 39), 8 patients had serum iron deficiency, 2 patients had folate deficiency, and 15 patients had vitamin B12 deficiency. In severe anemic (n = 42) group, 10 patients had serum iron deficiency, 10 patients had vitamin B12 deficiency, and 2 patients had folate deficiency. Out of 56 SAM patients with micronutrient deficiencies, 30 (31.58%) had serum vitamin B12 deficiency, 20 (21.05%) had serum iron deficiency, and 6 (6.31%) had serum folate deficiency (Table 5).

Table 5. Prevalence of Hematopoietic Factor Deficiency in Relation to Severity of Anemia

	Iron	Folate	Vitamin B12
Normal (n = 2)	0 (0.00)	0 (0.00)	1 (3.33)
Anemic (n = 4)	0 (0.00)	0 (0.00)	4 (13.33)
Mildly anemic (n = 8)	2 (10)	2 (33.33)	0 (0.00)
Moderate anemic (n = 39)	8 (40)	2 (33.33)	15 (50)
Severe anemic (n = 42)	10 (50)	2 (33.33)	10 (33.33)
Total	**20 (21.05)**	**6 (6.31)**	**30 (31.58)**

DISCUSSION

Most of the data on SAM from developing countries is retrospective and descriptive type. The present study was a hospital-based cross-sectional study. Most of the studies were related to infectious comorbidities, while only a few studies were related to micronutrient deficiencies in severely malnourished children.

The present study was undertaken to collect data on demography and micronutrient deficiencies in our area.

The mean age of the study population was 19.74 months. In our study, 39% of the patients were in the age group 6 to 12 months. Another study also found that 50% of SAM patients belonged to the age group 6 to 12 months[8]. The high proportion of SAM patients in the early age group in this region could be due to maternal malnutrition and delayed introduction of complementary feeding[9]. Fifty-three (55.79%) of the patients were female with an F:M ratio was 1.2:1. Various studies have found that males are nearly equally vulnerable to develop SAM as females.

In our study, we found a preponderance of females over males. This may be due to ignorance about the health check-ups and nutrition of female children; however, no definite causal relationship was found for female preponderance.

In our study, 75 (78.95%) children had weight-for-height < –3SD, 40 (42.10%) children had visible severe wasting, 65 (68.42%) had MUAC <11.5 cm, while 18 (18.95%) had bilateral pitting edema of nutritional origin. So, weight-for-height < –3SD appears to be the most reliable criteria to identify children with SAM, while bilateral pitting edema appears to be least reliable. Another study also found similar results that 75.8% of cases had their weight for height < –3SD, 24.03% cases had severe visible wasting, and 27% had bilateral pitting edema[10].

In our study, 24 (25.26%) children were found completely immunized, 61 (64.21%) were partially immunized, and 10 (10.52%) were unimmunized. In another study, 42.3% of children were completely immunized and 52% had partial immunization, while 5.7% of children had no immunization[10]. According to NFHS-5, the percentage of children aged 12 to 23 months who have received all basic vaccinations increased from 44% in 2005-06 to 76.4% in 2019-21. Between 2005-06 and 2019-21, this percentage increased more in rural areas (from 39% to 76.8%) than in urban areas (from 58% to 75.5%). The proportion of children who received no vaccinations remained low in both surveys (5%-6%). In Rajasthan, the percentage of children aged 12 to 23 months who have received all basic vaccinations increased from 26.5% in 2005-06 to 54.8% in 2015-16 and 80.4% in 2019-21[2,11]. This shows less coverage of immunization in our study area, which is likely due to ignorance and unawareness about immunization.

According to modified Kuppuswamy socioeconomic scale, 74 (77.89%) children in our study belonged to the upper-lower class, 18 (18.95%) belonged to the lower-middle class, while 3 (3.16%) children belonged to the upper-middle class.

In another Indian study, around 75% of families belonged to lower socioeconomic status, which was similar to our study[10]. In another study, 69.4% of children belonged to the lower social class, 19.4% to the middle class while 5.6% was of the upper class, which also correlates with the results of our study[12].

In the present study, 42 (44.21%) children were found to receive exclusive breastfeeding till 6 months of age. In a study by Kumar et al, 6% of babies were found exclusive breastfeeding[10]. The rate of exclusive breastfeeding was more in our study, but weaning does not start at recommended age, which is a predisposing factor for malnutrition. As per NFHS-5, in India, 63.7% of children under age 6 months are exclusively breastfed. About 45.9% of children of age 6 to 8 months are receiving solid or semi-solid food and breast milk. Only 11.1% of breastfeeding children aged 6 to 23 months are receiving an adequate diet and 12.7% of nonbreastfeeding children aged 6 to 23 months are receiving an adequate diet. Total children age 6 to 23 months receiving an adequate diet are 11.3 %[2].

The overlapping nature of protein-energy malnutrition and micronutrient deficiencies is well understood and it is seen that lack of one micronutrient is typically associated with deficiency of others[13].

In the present study, 93 (97.89%) children had anemia. Out of these 8 (8.42%), children had mild anemia, 39 (41.05%) had moderate anemia, while 42 (44.21%) children had severe anemia. The high incidence of anemia in these children could be due to nutritional factors as well as incidental worm infestations. The high prevalence of anemia was also reported by other studies[10,14]. As per NFHS-5, 67.1% of children of age 6 to 59 months in India are anemic[2].

In our study, 56 (58.94%) patients had micronutrient deficiencies. This could be due to chronic disease, worm infestation, and protein-energy malnutrition. In the earlier studies on hematopoietic micronutrient levels in anemic children, iron deficiency was found to be the commonest, whereas in our study on SAM patients serum vitamin B12 deficiency was more common (31.58%) compared to iron (21.05%) and folate (6.32%) deficiency[14,15]. In the study by Yaikhomba et al, serum vitamin B12 deficiency (34%) was more common than iron and folate deficiencies (6% each) in SAM patients, similar to this study[8].

This could be due to routine iron and folic acid supplementation to the pregnant and lactating mothers, whereas higher vitamin B12 deficiency rate could be due to low maternal vitamin B12 levels in a predominantly vegetarian community where no vitamin B12 supplementation is routinely given. Vitamin B12 deficiency is well recognized in exclusively breastfed infants of vitamin B12-deficient mothers[16]. Concentrations of vitamin B12 in breast milk reflect maternal vitamin B12 stores[17], and maternal vitamin B12 stores are depleted in up to one-third of rural Indian women[18].

A study in rural Karnataka also found that the concentration of ferritin and vitamin B12 was decreased in toddlers who continued to receive breast milk[19]. Folate concentration in breast milk is generally high and independent of maternal stores, thus prolonged breastfeeding in most of our patients might protect from folate deficiency[20]. Other studies also found that 58% and 14.4% of the SAM patients were deficient in vitamin B12[10].

CONCLUSIONS

Severe acute malnutrition is an important preventable and treatable cause of morbidity and mortality in children below 5 years of age in India.

Although malnutrition is highly prevalent in Indian children, there are very limited data that use biochemical indexes to characterize the epidemiology of micronutrient deficiencies in children with SAM in rural communities where the burden is highest.

A detailed understanding of how micronutrient concentrations relate to factors such as child feeding practices, maternal health and nutrition, and broader factors such as maternal education and family wealth and food security, together with a detailed model of how these factors are related, would enable improved targeting of resources, including micronutrient supplementation and fortification programs within rural populations where the majority of India's population lives.

Malnutrition is predicted by recurrent hospitalizations, taking an unbalanced diet, lack or incomplete immunization, and lower socioeconomic status. Immunization coverage is not enough in our area, as shown in this study that most children were either partially immunized or unimmunized. So, awareness about immunization needs to be increased. Strengthening of the infant feeding practices needs to be done by promoting exclusive breastfeeding for the first 6 months of life, followed by appropriate complementary feeding with continued breastfeeding. Under-5 children should be screened for protein-energy malnutrition at the community level for early diagnosis and prompt management as a way of reducing the high mortality associated with admitted severe cases. Nearly all SAM patients have micronutrient deficiencies (Iron, folic acid, and vitamin B12). So, micronutrient supplement (Iron, folic acid, and vitamin B12) needs to be given to all SAM patients.

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