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Micronutrient Profiles in Severe Acute Malnutrition: Analyzing Vitamin B12, Zinc, Copper, Selenium, Manganese, Molybdenum, and Cobalt Levels

Ubedullah Bahalkani[1*], Mumtaz Ali Bharo[2], Kamran Ali[1], BakhtiarAhmed Bhanbhro[3], Asif Ali Khuhro[3] and Faiza Kamran Ali[4]

[1]Department of Paediatrics, Khairpur Medical College, KhairpurMirs, Pakistan
[2]Department of Paediatrics, Ghulam Muhammad Mahar Medical College, Sukkur, Pakistan
[3]Department of Paediatrics, Pir Ahmed Shah Jillani, Institute of Medical Science, Gambat, Pakistan
[4]Department of Gynecology, Rural Health Center, Atta Muhammad Hami, Khairpur, Pakistan

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***Corresponding Author:**
Kamran Ali
Department of Paediatrics, Khairpur Medical College, KhairpurMirs, Pakistan
ga.shahani@gmail.com

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ABSTRACT

Severe Acute Malnutrition (SAM) is a critical public health issue affecting millions of people globally. **Objective:** To evaluate the status of micronutrients and their relationship with malnutrition severity. **Methods:** A cross-sectional study was conducted over six months from November 2023 to April 2024 at Pead's Department Of Khairpur Medical College, KhairpurMirs. The study included 384 participants diagnosed with SAM. Micronutrient levels were assessed using quantitative colorimetry. Statistical analyses were descriptive, independent t-tests, Pearson and Spearman correlation analyses to evaluate micronutrient deficiencies. **Results:** The mean age of the children was 24.5 months, with a male predominance of 54.7%. Micronutrient levels showed significant variation between children with mild and severe malnutrition: p = 0.03), zinc (62.7 vs. 55.8 µg/dl, p = 0.01), vitamin B12 (312.4 vs. 278.6 pg/ml, p = 0.02), copper (97.3 vs. 89.2 µg/dl, p = 0.03), and selenium (45.7 vs. 40.2 µg/l, p < 0.05). Positive correlations between micronutrient levels and anthropometric variables were found by correlation analysis. Logistic regression indicated that deficiencies in Vitamin B12 (OR: 1.45, p = 0.02), Zinc (OR: 1.62, p = 0.01), and Copper (OR: 1.35, p = 0.03) were significant predictors of severe malnutrition. **Conclusions:** The findings emphasized that the need for targeted nutritional interventions addressing Vitamin B12, Zinc, and Copper deficiencies to improve health outcomes in malnourished children. Further research was essential to evaluate the impact of supplementation strategies on growth and recovery.

INTRODUCTION

Severe acute malnutrition (SAM) is a leading cause of childhood mortality, mostly due to Gram-negative infections. It has been found that micronutrient deficiencies, including Vitamin B12, Zinc, Copper, Selenium, Manganese, Molybdenum and Cobalt are important in the etiology and treatment of SAM. Nutrients play an essential role in various metabolic functions, quality of immunological response and also for the growth in children [1]. In fact, Stand's report found that more than 40% of all the children under five worldwide went anemia. The most common type of anemia is due to micronutrient deficiencies, such as iron, folate and vitamin B12-based deficiencies. In SAM, anemia is rife with iron deficiency as the most prevalent stimulant [2]. Childhood is a critical stage for growth and development, which in turn are influenced by numerous factors including dietary intake. Among these parameters, micronutrients are one of the critical requirements that are necessary for various biological functions Vitamins and Minerals: These are micronutrients needed for the enzyme and protein productions that assist metabolic process, as well as immunological function, health proliferation [3, 4].

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Sufficient intake of all essential micronutrients in the diets of children is crucial for normal growth, cognitive development and avoidance of deficiency related diseases. Micronutrients are not just required for growth also function as regulators of numerous biochemical pathways that operate in physiological and developmental reactions[5]. Vitamin B12 deficiencies, as well as low levels of Zinc, Copper and Selenium have been associated with growth retardation, developmental delay and an increased susceptibility to infections [6]. Micronutrients are important indicators of nutritional status in children, especially those affected by Severe Acute Malnutrition (SAM)[7]. SAM is associated with dramatic weight loss and nutritional deficiencies that can cause significant health consequences. Assessment of micronutrient status among this vulnerable group could shed light on their nutritional requirements and mitigate specific therapeutic strategies which are conducive to achieve better health outcome [8]. Vitamin B12 deficiency is a long-known problem, especially in exclusively breast-fed newborn infants of mother's low in this vital mineral. Babies need adequate amount of vitamin B12 for healthy growth and development, particularly in the initial phase of life from feeding is their only source of nutrients. Babies born to vitamin B12-deficient mothers are also at risk for a deficiency, as the breast milk of these women may not provide enough of this crucial nutrient[9]. This situation is so common in deprived communities of mother nourishing or with very strict food restrictions, e.g. strict vegetarians and vegans. In infants, deficiency can lead to a wide range of impairments such as sensory neuropathy, myelopathy, motor disturbances or paraplegia failure to thrive and developmental delays which may be irreversible thus making routine monitoring for Vitamin B12 in maternal postpartum Prescription in critically ill children an everyday emergency. Given the importance of vitamin B12 for normal growth and development, the nutritional status of mums and babies should be monitored and intervened on as appropriate, particularly in high-risk groups. Early recognition and treatment of vitamin B12 inadequacy will be beneficial for breastfeeding infants[10].

To evaluate the status of micronutrients and their relationship with malnutrition severity.

METHODS

A cross-sectional study was carried out from November 2023 to April 2024 at Pead's department of Khairpur medical college, Khairpur Mirs after getting approval with IRB reference number KMC/RERC/84. The formula for estimating a proportion in a population was n=Z2·P·(1–P) / d2, where Z=1.96Z = 1.96Z=1.96 (for a 95% confidence interval), prevalence (P=50%) and d=0.05 (5% margin of error), n=0.9604/ 0.0025=384.16. The sample size was N=384 participants. Children who meet the inclusion criteria for Severe Acute Malnutrition (SAM), including bilateral nutritional edema or a Mid-Upper Arm Circumference (MUAC) of less than 115 mm, aged between six months and five years. Signed consent in writing from parents or legal guardians was obtained. Children with chronic infections, congenital disorders, metabolic conditions, kidney diseases, or liver diseases were excluded from this study. A digital scale was used to measure weight, recording it to the nearest 100 grams. A stadiometer was used to measure height (for children over two years), and an infant meter was used to measure the length of the child. A non-stretchable tape was used to measure the Mid-Arm Circumference (MAC) of the left arm, midway between the olecranon and acromion processes. Using WHO tables, the weight for height and length was determined. Head Circumference (HC), Chest Circumference (CC), Mid-Arm Circumference (MAC), and length/height measurements were recorded to the nearest 0.5 cm, mm, and cm, respectively. 3 ml of venous blood were drawn. Hemagglutinin-treated blood was used for the hemogram, and serum from plain tubes was used to assess micronutrients and Vitamin B12. WHO criteria were used to define anemia, vitamin B12 level below 203 pg/ml was taken as deficient and that above 911 pg/ml were taken as high range. Zinc and copper were considered deficient, if levels were < 65 µg/dl and < 63.5 µg/dl. Other micronutrients were considered deficient if, selenium (< 60 µg/dl and manganese < 7.10 µg/dl, molybdenum < 0.70 µg/dl and cobalt<1.0 µg/dl. Samples were sent in a cold chain to the testing facility (Arogyam Centre, Navi Mumbai) after being kept at -80°C. A chemiluminescent immunoassay was used to assess Vitamin B12 (Advia Centaur XP, Siemens). Colorimetric techniques (Elico, Hyderabad) were utilized to assess serum copper and zinc, while Thermo Fisher's ICP-MS was employed to analyze other micronutrients[11]. With SPSS version 26.0, data analysis was done. Descriptive statistics were used to collect clinical and demographic information. For continuous variables, means and standard deviations were computed. The micronutrient levels in children with mild and severe forms of malnutrition were compared using independent t-tests. A Pearson or Spearman correlation analysis was used to look at the relationships between anthropometric markers and micronutrient levels. The predictive value of micronutrient deficiencies for the severity of malnutrition was ascertained by the application of logistic regression analysis.

RESULTS

Severe Acute Malnutrition (SAM) was identified in 384 of the study's participants. Given that the children's mean age was 24.5 ± 6.3 months, it was clear that the majority of the sample's participants were young children the majority

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being two years old. Out of the total number of children, 210 (54.7%) were male and 174 (45.3%) were female. As the gender differences were not particularly noticeable, this suggests a slight male predominance in the research population. The children's mean weight was 6.8 ± 2.1 kg, which was considerably less than what was normal for youngsters of this age, indicating that the participants were malnourished. The average Mid-Upper Arm Circumference (MUAC) was 113.5 ± 12.7 mm, while the average height was 65.4 ± 5.2 cm (Table 1).

Table 1: Descriptive Statistics of Demographic and Clinical Features (n=384)

Variables	Mean ± SD/N (%)
Age (Months)	24.5 ± 6.3
Age (Months)	24.5 ± 6.3
Gender	
Male	210 (54.7%)
Female	174 (45.3%)
Weight (Kg)	6.8 ± 2.1
Height (cm)	65.4 ± 5.2
MUAC (mm)	113.5 ± 12.7
Degree of Malnutrition	
Mild	160 (41.7%)
Severe	224 (58.3%)

The children who suffered from severe malnutrition had considerably lower levels of vitamin B12 (278.6 ± 52.3 pg/ml) than the children who suffered from moderate malnutrition (312.4 ± 56.7 pg/ml). A p-value of 0.02 indicated a serious deficit in the severe cases. With a p-value of 0.01 zinc levels were similarly substantially lower in the severe malnutrition group (55.8 ± 10.1 µg/dl) than in the mild malnutrition group (62.7 ± 11.3 µg/dl). A p-value of 0.03 indicated a significant decrease in copper levels between severely malnourished children (89.2 ± 15.5 µg/dl) and mildly malnourished children (97.3 ± 14.9 µg/dl). The severe malnutrition group had considerably lower selenium levels (40.2 ± 7.6 µg/l) than the moderate group (45.7 ± 8.5 µg/l) (p-value = 0.04). Manganese levels were similar in both groups (p = 0.15), with mean values of 9.8 ± 2.3 µg/l for severe malnutrition and 10.4 ± 2.7 µg/l for mild malnutrition. Molybdenum levels were not significantly different (p = 0.09), with mean values of 4.2 ± 1.2 µg/l for severe and 4.7 ± 1.1 µg/l for mild deficiency. Children with severe malnutrition had significantly lower cobalt levels (0.54 ± 0.3 µg/l) than those with mild malnutrition (0.65 ± 0.2 µg/l) (p-value = 0.04), see Table 2.

Table 2: Comparison of Micronutrient Levels between Mild and Severe Malnutrition (Independent t-test)

Micronutrient	Standard Values	Mild Malnutrition (Mean ± SD)	Severe Malnutrition (Mean ± SD)	p-value
Vitamin B12 (pg/mL)	< 200-900 pg/mL	312.4 ± 56.7	278.6 ± 52.3	0.02*
Zinc (µg/dL)	< 70-120 µg/dL	62.7 ± 11.3	55.8 ± 10.1	0.01*
Copper (µg/dL)	< 70-140 µg/dL	97.3 ± 14.9	89.2 ± 15.5	0.03*
Selenium (µg/L)	<70-150 µg/L	45.7 ± 8.5	40.2 ± 7.6	0.04*
Manganese (µg/L)	< 4-15 µg/L	10.4 ± 2.7	9.8 ± 2.3	0.15
Molybdenum (µg/L)	0.2-1.5 µg/L	4.7 ± 1.1	4.2 ± 1.2	0.09
Cobalt (µg/L)	0.2-1.0 µg/L	0.65 ± 0.2	0.54 ± 0.3	0.04*

*Significant at p < 0.05

The statistical analysis revealed significant positive relationships between micronutrient levels and anthropometric indicators, with vitamin B12, zinc, and copper having the highest associations. Zinc showed the strongest correlation values with weight (r = 0.35, p < 0.05), height (r = 0.32, p < 0.05), and MUAC (r = 0.33, p < 0.05), demonstrating a substantial link with growth indices. Vitamin B12 had a significant connection with weight (r = 0.31, p < 0.05), height (r = 0.27, p < 0.05), and MUAC (r = 0.29, p < 0.05). Copper had moderate but statistically significant relationships with weight (r = 0.28, p < 0.05), height (r = 0.25, p < 0.05), and MUAC (r = 0.21, p < 0.05). Selenium, Manganese, Molybdenum, and Cobalt had lesser correlations that did not achieve statistical significance, with R-values ranging from 0.09 to 0.22 and p > 0.05, showing a less meaningful relationship with the anthropometric markers. Thus, zinc, vitamin B12, and copper were more important in determining the growth and nutritional condition of children with severe acute malnutrition see Table 3.

Table 3: Correlation between Micronutrient Levels and Anthropometric Markers (Pearson or Spearman Correlation)

Micronutrient	Weight (Kg) (R-Value)	Height (cm) (R-Value)	MUAC (mm) (R-Value)
Vitamin B12 (pg/mL)	0.31*	0.27*	0.29*
Zinc (µg/dL)	0.35*	0.32*	0.33*
Copper (µg/dL)	0.28*	0.25*	0.21*
Selenium (µg/L)	0.22	0.20	0.18
Manganese (µg/L)	0.15	0.14	0.12
Molybdenum (µg/L)	0.10	0.12	0.09
Cobalt (µg/L)	0.20	0.17	0.15

*Significant at p < 0.05

Significant predictors included Vitamin B12 deficiency (OR: 1.45 [95% CI: 1.12 - 1.89], P = 0.02), with children who were deficient in vitamin B12 having 45% increased odds of malnutrition. Zinc deficiency was also strongly associated with severe malnutrition, OR 1.62, 95% (CI): 1.23 -2.14 p =0.01, suggesting a relative risk of +62%. The deficiency of copper also showed highly significant association with (OR = 1.35, 95% CI: 1.05 - 1.74, p = 0.03) where risk of severe malnutrition was increased for a person consuming diet

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deficient in Copper by appxiciently factor of 35%. Positive association was also seen with selenium deficiency, but it did not reach statistical significance (OR = 1.28; 95% CI: 0.98–1.67; p = 0.08). No significant association was observed for Severe Malnutrition with Manganese deficiency (OR = 1.10; 95% CI: 0.85 -1.42; p = 0.27) and Molybdenum deficiency (OR = 1.20; 95% CI: 0.94-1.54, p = 0.15). Cobalt deficiency had a borderline significant association, with an OR of 1.32 (95% CI: 1.00-1.74; p = 0.05), suggesting the potential for increased likelihood of implant revision due to aseptic loosening see Table 4.

Table 4: Logistic Regression for Predictive Value of Micronutrient Deficiencies for Severe Malnutrition

Variables	Odds Ratio (OR)	95% Confidence Interval (CI)	p-Value
Vitamin B12 Deficiency	1.45	1.12-1.89	0.02*
Zinc Deficiency	1.62	1.23-2.14	0.01*
Copper Deficiency	1.35	1.05-1.74	0.03*
Selenium Deficiency	1.28	0.98-1.67	0.08
Manganese Deficiency	1.10	0.85-1.42	0.27
Molybdenum Deficiency	1.20	0.94-1.54	0.15
Cobalt Deficiency	1.32	1.00-1.74	0.05*

*Significant at $p < 0.05$

DISCUSSION

Developmental delays were linked to deficiency in vital micronutrients in children with Severe Acute Malnutrition (SAM), namely in zinc, copper, selenium, manganese, molybdenum, and cobalt. These data indicate clear biologically plausible associations between a subset of the vitamins and severity of malnutrition, as has been supported by previous research [12]. There were slightly more males (54.7%) and the average age was 24.5 months according to patient demographics. The present outcomes associate with other previous literature on childhood undernutrition among children of similar age groups as rapid growth and development pose particular risks to the young ones. The proportion of medical data linked with children with severe malnutrition (58.3%) was in accordance with available information from other countries, further emphasizing the ongoing public health challenge posed by SAM in kids from this age group [13]. According to these results to showed significant differences between mild and severe malnourished children in mean values of Vitamin B12, Zinc, Copper and Selenium [14]. Previous research demonstrates that malnourished children consistently show low levels of the micronutrients, suggesting that deficiencies in these nutrients exacerbate malnutrition and associated morbidities. Previous research by Arfi *et al.*, in 2022 stressed the importance of zinc in immune function and growth, with zinc deficiency associated with morbidities including malnutrition in children [15]. In the present study to reveals that of correlations between vitamin B12, Zinc and Copper levels with anthropometric parameters (Weight, Height and MUAC) means being positively associated [16]. In the current study to found that, the study variables; vitamin B12, zinc and copper deficiencies were significant predictors for cases of severe malnutrition [17, 18]. Vitamin B12 deficiency indicate a meaningful risk that was why even more nursing research was needed in Pakistan to investigate this phenomenon as has been identified and found a significant association of Vitamin B12 deficiency with severe malnutrition among young children [19]. Zinc deficiency, with an OR of 1.62 highlights the critical role plays in normal immune function and overall childhood growth. Kurmi *et al.*, 2023 have previously shown that zinc supplementation could protect from malnutrition and reduced disease manifestation in immunocompromised, destitute populations [20].

CONCLUSIONS

The objective was to ascertain the frequency of nutritional deficiencies and their correlation with the demographics, socioeconomic status, and severity of childhood malnutrition. The marked unadjusted relationships noted for Vitamin B12, Zinc, Copper illustrate specific candidates for targeted nutrition interventions to correct these deficiencies among children with SAM.

Authors Contribution

Conceptualization: UB
Methodology: MAB, BAB, KA
Formal analysis: MAB, FKA
Writing, review and editing: AAK, FKA

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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