The Prevalence of Anemia and its Associated Risk Factors among Malnourished Children under Five Years Age attending to Al-wahdah University Teaching Hospital in Thamar, Yemen

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ABSTRACT

Background: Anemia is a major public health concern, particularly among malnourished children in low-resource settings. Despite this burden, limited data are available from Yemen. This study aimed to determine the prevalence of anemia and identify its associated risk factors among malnourished children under five years of age attending Al-Wahdah University Teaching Hospital in Thamar, Yemen.

Subjects and Methods: A cross-sectional study was conducted among 278 malnourished children under five years. Sociodemographic, clinical, and feeding information were collected using a structured questionnaire. Blood samples were analyzed for hemoglobin and red cell indices. Anemia was defined according to the WHO criteria (Hb < 11 g/dL). Logistic regression analysis was used to identify the factors associated with anemia.

Results: The overall prevalence of anemia was 52.9% (95% CI: 47 -59%). Mild anemia was the most common (50.3%), followed by moderate (46.3%) and severe (3.4%) anemia. Microcytic anemia predominated (85%), with normocytic anemia accounting for the remaining 15%. Multivariate logistic regression showed that male sex (AOR = 2.35, 95% CI: 1.43–3.87, P = 0.001) and presence of edema (AOR = 3.57, 95% CI: 1.85–6.91, P = 0.001) were significantly associated with anemia.

Conclusion: Anemia is highly prevalent among malnourished children under-five children in Thamar, Yemen, with microcytic anemia as the dominant type. Male sex and edema were independent predictors of anemia. Targeted nutritional and clinical interventions are urgently needed to address this challenge.

ARTICLE INFO

1. INTRODUCTION

Protein-energy malnutrition (PEM) arises from the inadequate intake of protein, calories, and essential micronutrients in varying proportions [1]. It is a significant public health concern in developing nations, particularly affecting children under the age of five [2, 3]. Globally, in 2022, 149 million (22.3%) children under 5 years of age were estimated to be stunted, and 45 million (6.7%) were estimated to be wasted [4].

Undernutrition encompasses underweight (weight-for-age Z-score (WAZ) < -2), stunting (height-for-age Z-score (HAZ) < -2), and wasting (weight-for-height Z-score (WHZ) < -2). Children suffering from these forms of malnutrition are likely to experience growth retardation, developmental delays, immune dysfunction, and impaired cognitive development [5]. PEM leads to systemic physiological disruption, affecting multiple organs

and systems. Within the hematopoietic system, PEM alters the production of all blood cell lines [6]. Previous studies have documented various hematological disturbances, such as anemia, changes in reticulocyte counts, leukocytosis, and modifications in the bone marrow microenvironment [3, 5, 7–9].

Animal models have shown that PEM leads to hematopoietic dysfunction due to impaired bone marrow stroma and altered cell cycling of hematopoietic progenitors, with a higher proportion of cells arrested in the G0/G1 phase [10]. Additionally, PEM impairs the production of granulocyte-macrophage colony-stimulating factor and macrophage colony-stimulating factor, leading to a compromised immune response and hindered hematopoiesis [11]. It also adversely affects lymphohematopoietic organs, such as the bone marrow, spleen, and thymus, contributing to anemia, leukopenia, immune suppression, and increased infection risk [5, 12].

Anemia, commonly observed in PEM, stems from decreased red blood cell (RBC) production, which is attributed to the reduced availability of protein and energy necessary for erythropoiesis [13, 14]. Moreover, reduced erythropoietin production and RBC synthesis in response to decreased lean body mass further contribute to anemia [5]. In most developing countries with low and intermediate incomes, the prevalence of anemia among children aged 6–59 months exceeded 40% according to new demographic and health survey report cycles from 2005 to 2018, classifying it as a serious public health concern [15]. Alarmingly, the prevalence of anemia in this population has reached 97% [16]. In the Eastern Mediterranean Region, the prevalence of anemia in children under five years of age varied from 11.9 to 79.5%; Yemen had the highest estimate, while Jordan had the lowest [17].

Data from Yemen's Ministry of Public Health and Population indicate a notable increase in the prevalence of anemia among children under five, even though the rate had previously dropped from 54% in 2005 to 40% in 2011 [18]. Recent evidence highlights the high burden of anemia among malnourished children under the age of five in Yemen. Al-Haddad et al. [18] reported that 54% of under-five children with malnutrition in Sana'a were anemic, with a mean hemoglobin (Hb) concentration of 10.4 mg/dL. Similarly, Saleh et al. documented a substantially higher prevalence, with 81.4% of malnourished under-five children affected by anemia [19].

Children who are stunted, underweight, or wasted exhibit a significantly higher risk of anemia than well-nourished peers [20]. Evidence indicates that severely malnourished anemic children are 2.62 times more likely to die than their nonanemic counterparts [21]. Anemia is a leading contributor to pediatric illnesses, hospitalization, and death [22]. Furthermore, it negatively impacts cognitive abilities and physical development [23]. The contributing factors to anemia in these children include deficiencies in iron, folate, vitamin A, and protein; hemolysis from disrupted antioxidant mechanisms in erythrocytes; infections; and parasitic infestations [5]. This study aimed to determine the prevalence of anemia and identify its associated risk factors among malnourished children under five years of age attending Al-Wahdah University Teaching Hospital in Thamar, Yemen.

2. SUBJECTS AND METHODS

This cross-sectional study was conducted to determine the prevalence and risk factors of anemia among under-five-year-old children with malnutrition who attended Al-Wahdah University Teaching Hospital in Thamar, Yemen. The study included all children under the age of five years who were diagnosed with malnutrition and attended the hospital prior to receiving treatment. Malnutrition severity was classified using z-scores, Mid-Upper Arm Circumference (MUAC), and the presence of edema. Children older than five years, those who had received blood transfusions, hematinic (iron, folate, or vitamin B12), or had chronic illnesses were excluded from the study.

Anemia was defined in accordance with altitude-adjusted Hb thresholds, whereby a concentration of less than 11 g/dl in children < five years of age was considered indicative of the condition. In line with established classification criteria, anemia severity was categorized as follows: mild anemia for Hb levels between 10.0 and 10.9 g/dl, moderate anemia for Hb levels ranging from 7.0 to 9.9 g/dl, and severe anemia for Hb concentrations below 7.0 g/dl [5]. Data were collected using a pre-designed standardized questionnaire that included socio-demographic details, associated risk factors, and other relevant clinical information. Malnutrition among children was diagnosed based on the World Health Organization (WHO) criteria includes Z-score Measurement, MUAC and Edema Assessment. These three criteria were collectively considered to determine and classify the severity of malnutrition as severe acute malnutrition (SAM), moderate acute malnutrition (MAM), or no malnutrition.

A total of 2 ml of whole blood was collected aseptically from each child via venipuncture and placed in an EDTA tube for complete blood count (CBC) and smear preparation. We performed CBC using Sysmex XP-300 and DW-3680 hematology analyzers, and thick and thin blood smears were prepared manually and stained with Giemsa stain. Informed consent was obtained from the parents or legal guardians of all the participating children. Participants were assured that participation was voluntary and that they could withdraw from the study at any time without providing a reason.

Table 1. Socio-Demographic Characteristic of Study Participants

Variable	Number (n)	Percentage (%)
Gender		
Male	130	46.8
Female	148	53.2
Age interval		
1-11 m	196	70.5
12-23 m	69	24.8
24-47 m	11	4.0
48-59 m	2	0.7
Birth order		
First	46	16.5
Second	100	36.0
More than second	132	47.5
Housing		
Urban	43	15.5
Rural	235	84.5
Father job		
Farmer	245	88.1
Others	33	11.9
Mother job		
House wife	276	99.3
Others	2	0.7
Pregnancy interval		
One year	226	81.3
More than two years	52	18.7

2.1. STATISTICAL ANALYSIS

All data were coded, entered into a computer, and analyzed using the Statistical Package for Social Sciences (SPSS) version 26. Results were presented as percentages, and tables and appropriate statistical tests were applied to assess the relationships between variables.

3. RESULTS

Socio-Demographic Characteristics

A total of 278 under-five children were included in the study. More than half of the participants were female (53.2%), and the majority (70.5%) were infants aged 1–11 months. Nearly half of the children (47.5%) were third-born or later. Most of the participants resided in rural areas (84.5%), and their fathers were predominantly farmers (88.1%), while almost all their mothers were housewives (99.3%). Regarding pregnancy interval, four out of five children (81.3%) were born within one year of the previous birth. The detailed socio-demographic characteristics are shown in Table 1.

Clinical and Feeding Characteristics

Most study participants reported recent episodes of illness. Diarrhea (71.6%) and fever (79.5%) were the most common symptoms in the two weeks prior to data collection, followed by vomiting (60.8%) and cough (45.7%). Edema was observed in about one-fifth of the children (21.6%), while a smaller proportion had abdominal bloating (31.7%) or cramps (5.0%).

Regarding feeding practices, nearly two-thirds of the children (64.4%) were given artificial milk, and most caregivers (62.2%) reported sterilizing the milk before use. The detailed clinical and feeding characteristics are presented in Table 2.

The hematological profile of the participants indicated reduced Hb levels, with a mean of 10.8 ± 1.7 g/dl. Red blood cell indices showed a Mean Corpuscular Volume (MCV) of 72.4 ± 7.8 fl, Mean Corpuscular Hemoglobin (MCH) of 24.5 ± 3.5 pg, and Mean Corpuscular Hemoglobin Concentration (MCHC) of 32.1 ± 3.5 g/dl. The mean reticulocyte count was $1.8 \pm 0.8\%$. Total white blood cells (WBCs) count averaged $13.1 \pm 5.3 \times$

Table 2. Clinical and Feeding Characteristic of Study participants

Variable	Number (n)	Percentage (%)
Diarrhea		
Yes	199	71.6
No	79	28.4
Fever		
Yes	221	79.5
No	57	20.5
Edema		
Yes	60	21.6
No	218	78.4
Vomiting		
Yes	169	60.8
No	109	39.2
Cough		
Yes	127	45.7
No	151	54.3
Cramps		
Yes	14	5
No	264	95
Abdominal bloating		
Yes	88	31.7
No	190	68.3
Artificial milk		
Yes	179	64.4
No	99	35.6
Sterilization of milk		
Yes	173	62.2
No	105	37.8

10^9/L, with median neutrophil and lymphocyte counts of 5.4 (3.9-8.4) $\times$ 10^9/L and 4.8 (3.1-6.9) $\times$ 10^9/L, respectively. Platelet counts were generally elevated, with a mean of 450.4 $\pm$ 220.3 $\times$ 10^9/L. The detailed hematological parameters are summarized in Table 3.

The overall prevalence of anemia among the study participants was 52.9% (95% CI: 47 -59). Regarding morphological classification, microcytic anemia was predominant (85%), followed by normocytic anemia (15%), with no cases of macrocytic anemia detected, as shown in Figure 1.

The mean Hb levels differed significantly across several variables. Female children had a higher mean Hb (11.1 $\pm$ 1.5 g/dl) than males (10.6 $\pm$ 2.0 g/dl; p = 0.018). Children with edema had markedly lower mean Hb levels (9.8 $\pm$ 2.2 g/dl) than those without edema (11.1 $\pm$ 1.5 g/dl; P=0.001). Similarly, children with a history of cough (10.6 $\pm$ 1.7 g/dl; P=0.034) had significantly lower Hb levels than their counterparts. The full results are presented in Table 4.

Risk factors associated with anemia

Bivariate and multivariate logistic regression analyses were performed to determine the risk factors associated with anemia among undernourished children under five years of age. In the adjusted model, male children had significantly higher odds of being anemic compared to females (AOR = 2.35, 95% CI: 1.43–3.87, P=0.001). Likewise, children with edema were more likely to develop anemia than those without edema (AOR = 3.57, 95% CI: 1.85–6.91, P= 0.001). The detailed findings are summarized in Table 5.
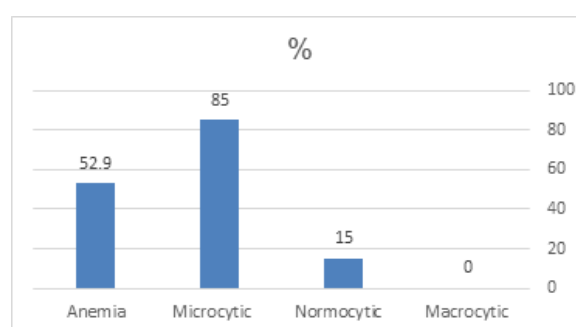
4. DISCUSSION

Anemia emerged as the most prevalent hematological abnormality, affecting 52.9% of our study participants (95% CI: (47-59%). Similar rates have been reported in Ethiopia (53.4%) [5], Sri Lanka (55.5%) [24] and Bangladesh (56.5%) [25], suggesting a consistent burden of anemia among undernourished populations in low-resource settings. However, the current study result was lower than the findings reported in India (84%, 90%, 91%, and 95%) [7, 26–28] and Brazil (88%) [29]. Conversely, it was higher than that of a study conducted in Ethiopia, which reported a prevalence of 41.43% [14].

Regarding the morphological classification of anemia, microcytic anemia was the predominant type, affecting 85% of the anemic participants, with normocytic anemia accounting for the remaining 15%. This finding is consistent with studies conducted in Ethiopia (73.1%) [5] and India (55%) [27], which also identified microcytic anemia as the most common form of anemia among undernourished children [5, 26]. Conversely, Dwivedi et al. [20]

Table 3. Hematological Parameters of Study Participants

Hematological Parameters	(Mean± SD)
Hb (g/dl)	10.8±1.7
MCV (fl)	72.4±7.8
MCH (pg)	24.5±3.5
MCHC (g/dl)	32.1±3.5
Reticulocyte %	1.8±0.8
WBCs count ($\times10^9$/L)	13.1±5.3
Neutrophil count ($\times10^9$/L), Median (IQR)	5.4 (3.9-8.4)
Lymphocyte count ($\times10^9$/L), Median (IQR)	4.8 (3.1-6.9)
Platelet counts ($\times10^9$/L)	450.4±220.3

*Data shown as mean ± standard deviation and Median (IQR; Interquartile Range); **Hb;** Hemoglobin, **MCV**; Mean corpuscular Volume, **MCH**; Mean corpuscular Hemoglobin, **MCHC**, Mean corpuscular Hemoglobin Concentration, **WBCs**; White Blood Cells **SD**; standard deviation.*

Figure 1. Hematological abnormalities among undernourished under-five children.

reported macrocytic anemia as the most prevalent type of anemia in children with SAM.

Anemiaisclassified asaseriouspublic healthissue bytheWHO if itsmagnitude isgreater than 40%. As a result, the current study's anemia magnitude suggests that anemia is a serious public health issue among the study area's undernourished under-five children [30]. The persistence of anemia in these children may be attributed to low consumption of iron-rich foods, poor dietary diversity, and impaired nutrient absorption due to gastrointestinal mucosal alterations, all of which are exacerbated by chronic undernutrition [31]. Furthermore, the interaction between chronic dietary inadequacy and infections, which are common in this age group, amplifies the risk of anemia through systemic inflammation and reduced erythropoietin production [32]. The observed differences could be explained by variations in sociodemographic factors, sample size, and study design. Additionally, the high prevalence of parasitic infections and infrequent consumption of vegetables and fruits may have contributed to the elevated rate of anemia observed in this study.

In this study, sex was significantly associated with anemia, with male children having more than twofold increased odds of anemia compared to their female coun-

terparts (AOR = 2.35; 95% CI: 1.43–3.87; P= 0.001). This finding aligns with that of Getawa et al. [5], who reported that male children were at a higher risk of anemia (AOR = 1.9; 95% CI: 1.10–3.61). The presence of edema was also strongly associated with anemia, with edematous children having more than threefold higher odds of anemia than those without edema (AOR = 3.57; 95% CI: 1.85–6.91; P= 0.001). This result is in line with the findings of Getawa et al. [5], who also reported a significant association between edema and anemia (AOR = 5.3; 95% CI: 1.21–23.5).

5. CONCLUSION AND RECOMMENDATIONS

This study demonstrates that anemia is a severe public health problem among malnourished children under five years in Thamar, Yemen, affecting more than half of the study population. Most cases were mild, with microcytic anemia being the most common form. Boys and children presenting with edema had significantly higher risks of developing anemia. These findings highlight the urgent need for integrated interventions, including routine anemia screening, iron supplementation, and comprehensive nutritional support, particularly in high-risk groups. Strengthening maternal and child health programs and

Table 4. Mean Hb Levels According to Socio-demographic and clinical Characteristics of study populatio

Variable		Hb (mean ±SD)	P. value
Gender	Male	10.6±2.0	0.018*
	Female	11.1±1.5	
Age group	1-11 months	10.8±1.7	0.117
	12-23 months	11.1±1.5	
	24-47 months	10.4±3.1	
	48-<60 months	2.6±1.9	
Residence	Rural	10.9±1.8	0.128
	Urban	10.5±1.6	
Father's job	Farmer	10.9±1.7	0.651
	Others	10.7±1.7	
Mother's job	Housewife	10.9±1.7	0.378
	Others	9.7±0.9	
Birth order	First	10.8±1.6	0.230
	Second	10.6±2.0	
	Third and more	11..0±1.6	
Diarrhea	Yes	10.9±1.7	0.453
	No	10.7±1.8	
Fever	Yes	10.7±1.8	0.256
	No	11.0±1.3	
Edema	Yes	9.8±2.2	0.001*
	No	11.1±1.5	
Vomiting	Yes	10.8±1.7	0.905
	No	10.9±1.7	
Cough	Yes	10.6±1.7	0.034*
	No	11.1±1.7	
Abdominal bloating	Yes	10.7±1.8	0.280
	No	10.9±1.7	
Cramps	Yes	10.2±2.4	0.178
	No	10.8±1.7	
Pregnancy interval	One year	10.7±1.6	0.177
	More than one year	11.1±2.0	
Type of delivery	Caesarian	10.6±1.3	0.338
	Natural	10.8±1.8	
Artificial milk	Yes	10.8±1.7	0.678
	No	10.7±1.8	
Sterilization milk	Yes	10.8±1.7	0.946
	No	10.8±1.8	

Data shown as mean ± standard deviation; P<0.05 is statistically significant

Table 5. Logistic Regression Analysis of Factors Associated with Anemia among Undernourished Children under Five Years of Age

Factor	Df	Bivariate analysis OR (95% CI)	P. value	Multivariate analysis AOR (95% CI)	P. value
Gender Male Female	1	2.18(1.35-3.53) Ref	0.002 -	2.35(1.43-3.87) Ref	0.001* -
Edema Yes No	1	3.30(1.74-6.29) Ref	0.001 -	3.57(1.85-6.91) Ref	0.001* -

P<0.05 is statistically significant; df, degrees of freedom; OR, odd ratio; AOR, adjusted odd ratio; CI, confidence interval.

addressing early signs of malnutrition are essential to reduce the burden of anemia and improve child health outcomes in this context.

6. CONFLICT OF INTEREST

The authors declare no conflict of interest.

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