

Biological and Community Health Determinants of Childhood Anemia: A Cross-Sectional Study in Primary Schools in Mosul, Iraq

Autor: Yousif Qasim Dawood, *College of nursing, University of Ninevah, Mosul, Iraq*
yousif.dawood@uoninevah.edu.iq

Abstract. Childhood anemia is a major global health issue, impairing growth, cognitive development, and immune function. Its prevalence is particularly concerning in post-conflict regions where healthcare infrastructure, nutrition, and sanitation are compromised. In Mosul, Iraq, years of conflict and displacement have heightened children's vulnerability to nutritional deficiencies and infections, yet localized epidemiological data remain scarce. Limited evidence exists on the combined biological and community health determinants of anemia in Iraqi primary school children, restricting effective intervention planning. This study aimed to determine the prevalence of anemia among school-aged children in Mosul and identify its key biological and socio-environmental determinants. Results: A cross-sectional study of 850 children aged 6–12 years revealed an overall anemia prevalence of 42.5%, with mild anemia as the most common form (65.1%). Logistic regression analysis identified low maternal education (OR = 2.34, $p < 0.001$), low household income (OR = 2.16, $p < 0.001$), infrequent red meat intake (<2 times/week, OR = 2.80, $p < 0.001$), stunting (OR = 3.50, $p < 0.001$), and a history of parasitic infection (OR = 2.10, $p = 0.003$) as significant predictors. This is among the first large-scale studies in Mosul to integrate both biological and community-level determinants of anemia, reflecting the multifactorial nature of the condition in post-conflict settings. The findings underscore the urgent need for multisectoral interventions, including nutritional supplementation, deworming, health education, and sanitation improvements, to combat childhood anemia and improve long-term child health outcomes in Mosul.

Highlights:

1. Childhood anemia prevalence in Mosul primary schools was 42.5%, classifying it as a severe public health problem.
2. Key determinants included low maternal education, low household income, infrequent red meat consumption, stunting, and parasitic infections.
3. Findings highlight the urgent need for multisectoral interventions combining nutrition, deworming, education, and sanitation improvements.

Keywords: Childhood anemia, Mosul, Biological determinants, Community health, Nutritional status

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Introduction

Iron Deficiency Anemia (IDA) is a global public health problem and affects approximately 1.62 billion of the world's population, where preschool and school-age children are considered as one of the most at risk groups [1]. Worldwide, anemia in children is considered a serious public health problem when prevalence exceeds 40% [2, 3]. The detrimental effects of childhood anemia are considerable and long-term, including poor cognitive and psychomotor development, low physical activity and deficient immune function, which increases the risk of infections [4].

The concept of biological and community health determinants of childhood anemia underscores the complex interaction between individual nutritional status, infections, and broader socio-environmental conditions [5]. On the biological level, inadequate dietary iron intake, poor absorption, and recurrent parasitic infections contribute directly to the development of anemia among children. At the same time, community health factors such as parental education, household income, sanitation, and access to clean water and healthcare services shape children's vulnerability to this condition. In many low- and middle-income settings, these determinants overlap and amplify each other, creating a cycle of poor nutrition and ill health that particularly affects school-age children [6]. Understanding childhood anemia through both biological and community health lenses is therefore essential, as it not only highlights the immediate nutritional needs of children but also emphasizes the importance of improving social and environmental conditions [7]. This dual perspective provides a foundation for comprehensive interventions that address the root causes of anemia, moving beyond clinical treatment to long-term, sustainable improvements in child health and development [8].

Mosul, the largest city in the Nineveh Governorate, Iraq, has been a site of protracted conflict, displacement and collapse of infrastructure. This long standing crisis resulted in a serious deterioration in the health and nutritional condition of its people, including children. [9]. Availability of healthy food, potable water, proper sanitation and health services had been greatly compromised. The city has been in a phase of recovery, with long term health ramifications of the conflict are simultaneously emerging [5, 10].

Previous studies in Iraq have highlighted anemia as a prevalent issue, but there is a scarcity of recent, localized data from post-conflict Mosul. Understanding the specific determinants in this unique context is crucial for designing effective and targeted public health interventions [11]. This study, therefore, aims to Determine the current prevalence of anemia among primary school children in Mosul also Identify the key biological determinants (dietary patterns, nutritional status, parasitic infections) associated with anemia and investigate the role of

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community and socio-demographic factors (parental education, household income, sanitation) as determinants of anemia.

Methods

2.1 Study Design

A descriptive cross-sectional study was conducted between October 2024 and February 2025. The setting comprised 10 government-run primary schools in Mosul. The schools were selected using a multi-stage random sampling method to ensure representation from different socio-economic areas of the city (both east and west banks of the Tigris River).

2.2 Study Population and Sampling

The selected primary schools were those that accepted children aged 6–12 years. Sample size was calculated using the formula for single proportion: $n = d^2 Z^2 P (1-P)$, where Z (standard normal deviate) is 1.96 for 95% CI, P (expected prevalence) was taken as 50% (0.5) because of paucity of recent data, and d (absolute precision) was 0.05. The estimated sample size was 384, and we decided to expand it to 850 to give us more power to test hypotheses and accommodate for non-response. From class rosters, students were systematically sampled from each school.

2.3 Data Collection

- **Questionnaire:** A pre-tested, structured questionnaire was administered to the parents or legal guardians to collect data on socio-demographics (parental education, occupation, household income), the child's dietary habits (frequency of consumption of iron-rich foods), and medical history (history of chronic diseases, parasitic infections).
- **Anthropometric Measurements:** Children's weight was measured to the nearest 0.1 kg with a validated digital scale and height to the nearest 0.1 cm with a stadiometer. WHO AnthroPlus software was used to obtain BMI-for-age and height-for-age Z-Scores to determine nutritional status (stunting and wasting).
- **Hemoglobin Measurement:** Capillary blood was collected via a sterile finger prick. Hemoglobin (Hb) concentration was measured on-site using a portable, battery-operated hemoglobinometer (HemoCue® Hb 301). Anemia was defined according to WHO criteria: Hb < 11.5 g/dL for children aged 5-11 years and Hb < 12.0 g/dL for children aged 12 years.

2.4 Ethical Issues

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Ethical approval was obtained from the Research Ethics Committee at the University of Mosul and the Nineveh Directorate of Education. Written informed consent was obtained from the parents or guardians of all participating children, and verbal assent was obtained from the children themselves. All anemic children were provided with counseling and referred to the nearest primary healthcare center for treatment and follow-up.

2.5 Statistical Analysis

The data were coded and analyzed with Statistical Package for the Social Sciences (SPSS) version 26.0. Summary statistics (percentages, frequencies, standard deviations and means) was used. Associations between categorical variables were analyzed using the chi-square (X²) test. Univariate analysis and multivariate logistic regression were used to determine independent predictors of anemia in OR (Odds Ratio) and 95% CI (confidence interval). P value < 0.05 was considered as significant.

Results

A total of 850 children participated in the study, of which 48.9% (n=416) were male and 51.1% (n=434) were female. The mean age of the participants was 9.2 ± 1.8 years.

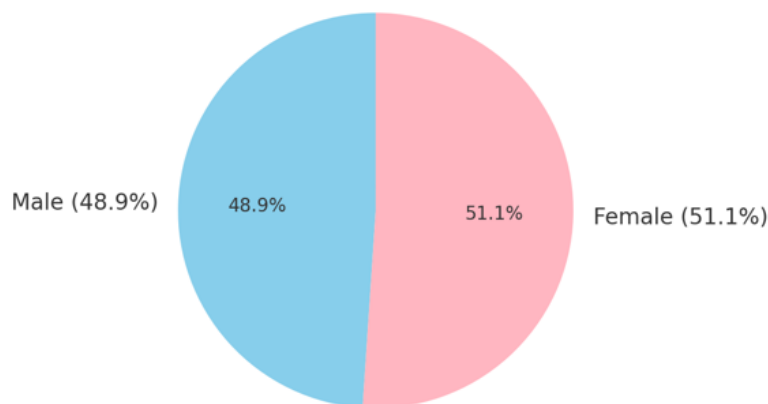


Figure 1. Total Participated Children Gender

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Table 1. Prevalence of Anemia

Category	Subcategory	Value
Overall Anemia Prevalence	Total Children with Anemia	361
	Percentage (%)	42.5%
Severity of Anemia	Mild Anemia	65.1%
	Moderate Anemia	30.5%
	Severe Anemia	4.4%
Prevalence by Gender	Females	44.0%
	Males	40.9%
	p-value	0.312

The findings of this study reveal that anemia is highly prevalent among primary school children, with 361 children affected, representing 42.5% of the study population. This proportion classifies anemia as a serious public health problem according to international standards. When examining severity, the majority of cases were classified as mild anemia (65.1%), followed by moderate anemia (30.5%), while severe anemia was relatively uncommon (4.4%).

Table 2. Association of Socio-demographic, Nutritional, and Health Factors with Anemia

Variable	Category	Anemic (%)	N	Non-Anemic (%)	N	p-value
Maternal Education	Illiterate/Primary	155 (60.1%)		103 (39.9%)		<0.001
	Secondary/Higher	206 (34.8%)		386 (65.2%)		
Household Income	Low (<500k IQD/month)	210 (55.7%)		167 (44.3%)		<0.001
	High (≥500k IQD/month)	151 (31.9%)		322 (68.1%)		
Red Meat Intake	<2 times/week	231 (51.1%)		221 (48.9%)		<0.001

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	≥2 times/week	130 (32.6%)	268 (67.4%)	
Nutritional Status	Stunted (HAZ < -2)	98 (68.1%)	46 (31.9%)	<0.001
	Not Stunted	263 (37.2%)	443 (62.8%)	
Parasitic Infection	History of infection	75 (57.7%)	55 (42.3%)	<0.001
	No history	286 (39.7%)	434 (60.3%)	

The results show that anemia was significantly more common among children of mothers with low education (60.1%) compared to those with higher education (34.8%, $p < 0.001$). Children from low-income households also had higher anemia prevalence (55.7%) than those from higher-income families (31.9%, $p < 0.001$). Red meat intake was strongly associated, with 51.1% of children consuming it less than twice weekly being anemic compared to 32.6% among those with higher intake ($p < 0.001$). Stunted children had markedly higher anemia prevalence (68.1%) compared to non-stunted children (37.2%, $p < 0.001$). A history of parasitic infection was also linked to anemia, with 57.7% of infected children affected compared to 39.7% of those without infection ($p < 0.001$).

Table 3. Logistic Regression Analysis of Predictors for Anemia

Predictor Variable	B	S.E.	Wald	df	Sig.	Odds Ratio (OR)	95% C.I. for OR
Low Maternal Education	0.85	0.21	16.3	1	<0.001	2.34	1.55 - 3.53
Low Household Income	0.77	0.20	14.9	1	<0.001	2.16	1.46 - 3.19
Infrequent Meat Intake	1.03	0.19	29.1	1	<0.001	2.80	1.93 - 4.07
Stunting (HAZ < -2)	1.25	0.24	27.5	1	<0.001	3.50	2.18 - 5.62
History of Parasites	0.74	0.25	8.8	1	0.003	2.10	1.29 - 3.42
Constant	-2.45	0.31	62.4	1	<0.001	0.08	

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B = regression coefficient, S.E. = standard error, Wald = Wald chi-square, df = degrees of freedom, Sig. = significance (p-value), OR = odds ratio, 95% C.I. for OR = 95% confidence interval for the odds ratio.

Children of mothers with low education had more than twice the likelihood of being anemic compared with those whose mothers had higher education (OR = 2.34, 95% CI: 1.55–3.53, $p < 0.001$). Low household income also doubled the odds of anemia (OR = 2.16, 95% CI: 1.46–3.19, $p < 0.001$). Infrequent meat intake (<2 times per week) emerged as a strong dietary risk factor, nearly tripling the risk (OR = 2.80, 95% CI: 1.93–4.07, $p < 0.001$). Stunted children had the highest risk, being 3.5 times more likely to be anemic than their non-stunted peers (OR = 3.50, 95% CI: 2.18–5.62, $p < 0.001$). Finally, a history of parasitic infection was also significant, with affected children having more than double the odds of anemia (OR = 2.10, 95% CI: 1.29–3.42, $p = 0.003$).

Discussion

This study reveals a **42.5% prevalence of anemia** among primary school children in Mosul, classifying it as a severe public health problem according to WHO thresholds. This rate is higher than pre-conflict national averages in Iraq and is comparable to findings from other post-conflict or resource-limited settings, underscoring the devastating impact of the recent crisis on child health [12, 13].

While stunting was associated with anemia, (OR=3.5), the fact undernutrition and micronutrient deficiencies coexist, reflecting phenomenon of "double burden of malnutrition" is evident. Stunting is a bio-marker of chronic malnutrition, which commonly caused by suboptimal diet lacking essential nutrients, such as iron that leads to anemia [14, 15]. This result is similar to some reports from Ethiopia and Yemen [16, 17].

The dietary habits of the children also appeared to be an important factor. Rarely ingestion of heme-iron rich foods as red meat was a powerful predicting factor for anemia (OR=2.8) [18]. This is probably related to poor socioeconomic status in which reduced income lowers the ability to consume expensive, nutrient dense foods. This economic limitation is also supported by the independent association between low household income and anemia [19, 20].

Furthermore, this study reinforces the crucial role of **maternal education**. Mothers with higher education levels are more likely to have better knowledge of child nutrition, hygiene, and healthcare-seeking behaviors, thereby protecting their children from anemia [21]. The link between anemia and a **history of parasitic infections** (OR=2.1), such as Giardia or

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helminths, is also well-established [22]. These infections can cause chronic intestinal blood loss and malabsorption of nutrients, directly contributing to iron deficiency. This points to underlying community-level issues like inadequate sanitation and contaminated water sources, which are prevalent in many recovering neighborhoods in Mosul.

The findings of this study must be viewed within its limitations. First, the cross-sectional design does not allow for the establishment of causality. Second, anemia was determined by hemoglobin levels alone, without measuring serum ferritin, which would have definitively diagnosed iron-deficiency anemia. Finally, dietary and health history data were based on parental recall, which may be subject to bias.

Conclusion

Childhood anemia is a crisis-level health issue in Mosul, driven by a complex interplay of chronic malnutrition, poor dietary quality, infectious diseases, and socio-economic deprivation. The recovery of Mosul cannot be complete while its children's health and future potential are compromised.

Addressing childhood anemia in Mosul requires a concerted effort from health authorities, educational bodies, non-governmental organizations, and the international community to ensure that the city's youngest generation can grow, learn, and thrive.

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