

Evaluation of Socioeconomic and Nutritional Status in Children with Iron-Related Disorders

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Abstract

Background: Iron deficiency (ID), iron deficiency anemia (IDA), and anemia of inflammation without iron deficiency are widespread nutritional and hematological disorders affecting children globally. This study aimed to assess the impact of socioeconomic status, dietary habits, and physical activity on iron-related disorders among children aged 2–10 years in Zakho City, Kurdistan Region, Iraq.

Methods: A cross-sectional study was conducted among 171 children, categorized into four groups based on clinical and biochemical criteria: control (n = 68), ID (n = 50), IDA (n = 31), and anemia of inflammation without iron deficiency (n = 22), defined as chronic inflammation that traps iron within storage sites, resulting in low hemoglobin. Data were collected using structured questionnaires and laboratory assessments, including serum iron and complete blood count (CBC).

Results: Statistically significant associations were found between iron-related disorders and several socioeconomic and nutritional factors ($p < 0.0001$). Children diagnosed with iron deficiency and anemia were more likely to come from households with low income and low parental educational levels, consume fewer daily meals, and have a reduced intake of iron-rich foods such as meat, vegetables, legumes, and fruits. Binary logistic regression analysis identified key predictors of iron-related disorders, including consumption of only one meal per day (OR = 5.73, 95% CI: 1.69–19.50), never consuming meat (OR = 28.8, 95% CI: 6.82–121.63), and spending less than 1 h per day on physical activity (OR = 18.13, 95% CI: 2.59–126.72). **Conclusions:** Socioeconomic status, dietary patterns, and physical activity levels significantly influence the risk of iron-related disorders in children. These findings highlight the need for targeted nutritional education and public health interventions to reduce childhood anemia and improve iron status in vulnerable populations.

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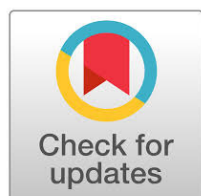
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1. Introduction

Iron is an essential trace element in the human body that participates in oxygen transport and tissue respiration, supports normal hematopoietic function, and maintains immune function [1,2]. ID is a common micronutrient deficiency [3]. The predominant source of iron in the body contained within the hemoglobin of erythrocytes [4].

The iron level in the body is influenced by various factors, including digestive system diseases, physiological status, chronic diseases, and diet [5]. Among these, diet is one of the main causes of ID, which can occur when iron intake is insufficient or when dietary factors interfere with absorption [6]. Iron deficiency has been documented in multiple regions, with the main causes stemming from dietary patterns combined with socioeconomic factors



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beyond biological mechanisms [7]. Other significant risk factors for IDA in low-income nations include diets high in iron absorption inhibitors and infrequent consumption of meat or animal protein [8]. In addition, socioeconomic conditions such as household income, parental education levels, and healthcare access strongly influence both nutritional status and the iron levels of children [9].

According to the World Health Organization (WHO), 280 million children worldwide suffer from anemia, with ID being one of its main causes [10]. Anemia is a condition in which the level of hemoglobin (Hb) in the blood is below normal [11]. Nearly 1.62 billion individuals worldwide are affected by anemia, with approximately 47% being preschool-aged children. South-East Asia and Africa have the highest prevalence rates [12,13]. In Zakho City, a study by Armishty et al. reported that the prevalence of anemia among children under five was 42.8% [14]. ID is defined as insufficient iron in the body that does not inhibit hemoglobin synthesis, whereas IDA is characterized by reduced hemoglobin levels resulting from iron deficiency [15]. Both ID and IDA contribute significantly to the global disease burden, threatening the health and lives of billions of people, and are considered among the five leading causes of disease burden worldwide [16]. The global prevalence of IDA and ID was 16.42% and 17.95%, respectively [17].

In spite of the well-documented global association between dietary patterns, socioeconomic status, and iron status, there is still a lack of specific data on how these factors interact among children in Zakho and similar local contexts. This research aims to assess the socioeconomic indicators and nutritional status of anemia of inflammation without iron deficiency, IDA, and ID in children in Zakho city, Kurdistan Region, Iraq. The investigation will provide important findings on the causes of child iron deficiency by examining dietary behaviors, household income, educational levels, and healthcare system availability. Based on these findings, targeted nutritional prevention programs can be developed to improve child nutrition while combating iron deficiency.

2. Materials and Methods

2.1. Study design and sampling

This study employed a cross-sectional design. A total of 171 children aged 2–10 years, residing in various regions of Zakho and visiting Zakho General Hospital, were enrolled during the data collection period (November 2024 to late February 2025). Participants were selected using a non-probability consecutive sampling method, whereby all children who met the inclusion criteria and attended the hospital during the study period were included. The participants were categorized into four distinct groups: the control group ($n = 68$; healthy children), the ID group ($n = 50$), the IDA group ($n = 31$), and the anemia of inflammation without iron deficiency group ($n = 22$), which

included children whose anemia was caused by inflammation that traps iron in storage sites.

2.2. Criteria for Inclusion and Exclusion

All children aged 2–10 years who attended Zakho General Hospital during the data collection period were invited to participate. Children who were receiving iron supplements, had undergone blood transfusions in recent months, had congenital diseases such as thalassemia or hemochromatosis, or girls who had reached the menstrual period were excluded from the study population.

2.3. Criteria for diagnosis and measurement

Data collection was preceded by a review of the questionnaire contents by the research supervisor to assess validity, clarity, and cultural suitability. A structured questionnaire was then developed to collect demographic data, including the child's name, age, gender, health and medical history, parental education level, household income, and diet and nutrition, including food consumption. Anthropometric measurements were also recorded: body weight in kilograms was assessed using a standard weighing scale, height in centimeters was measured with a standard tape measure, and body mass index (BMI) was calculated using the formula: $\text{body weight (kg)} / \text{squared height (m}^2\text{)}$. The study groups were diagnosed based on the following criteria and relevant literature [1]: the first group (control) included healthy children with hemoglobin (Hb) > 11.5 g/dL, serum iron > 55 $\mu\text{g/dL}$ for males and > 50 $\mu\text{g/dL}$ for females, and mean corpuscular volume (MCV) > 75 fL; the second group (iron deficiency) included children with insufficient iron but normal hemoglobin, defined as Hb > 11.5 g/dL, serum iron < 55 $\mu\text{g/dL}$ for males and < 50 $\mu\text{g/dL}$ for females, and MCV < 75 fL; the third group (iron deficiency anemia, IDA) included children with low iron levels leading to reduced red blood cells, low hemoglobin, and small, pale red blood cells, defined as Hb < 11.5 g/dL, serum iron < 55 $\mu\text{g/dL}$ for males and < 50 $\mu\text{g/dL}$ for females, and MCV < 75 fL; and the fourth group (anemia of inflammation without iron deficiency) included children with anemia caused by inflammation that traps iron in storage sites, resulting in low hemoglobin; this group was defined as Hb < 11.5 g/dL, serum iron > 55 $\mu\text{g/dL}$ for males and > 50 $\mu\text{g/dL}$ for females, and MCV < 75 fL.

2.4. Laboratory assessment

Approximately 3 mL of venous blood was collected from a forearm vein of each participant. One milliliter was placed in an EDTA tube for complete blood count (CBC) analysis using a hematology autoanalyzer (Medonic Coulter Counter, Sweden). The remaining 2 mL were transferred to a gel tube, allowed to clot at room temperature for 30 minutes, and then centrifuged at 5000 rpm for 10 minutes. The separated serum was stored in labelled Eppendorf

tubes at -74°C for subsequent analysis. Serum iron levels were measured using the COBAS 501 autoanalyzer (Roche) according to the manufacturer's instructions.

2.5. Statistical analysis

Data entry and analysis were performed using IBM Statistical Package for Social Sciences-26 version (SPSS-26). The Shapiro-Wilk normality test was employed to assess the normal distribution of continuous variables; non-normally distributed variables were presented as median (interquartile ranges). A p -value less than 0.05 indicated non-normal distribution. Categorical variables (e.g., gender, parental education, household income, dietary habits) were coded appropriately (e.g., 1, 2, 3, 4, etc.) and organized in separate sheets for analysis. These variables were summarized as frequencies and percentages (n (%)), and the Chi-square test was used to assess statistically significant differences in their distribution. For non-normally distributed continuous data, the Kruskal-Wallis test followed by pairwise comparisons was applied to detect differences among groups. Results were presented using subscripted letters, where different letters indicate statistically significant differences, and identical letters denote no significant difference between groups. Significant $p < 0.05$ is represented in bold. Finally, binary logistic regression analysis was conducted to identify factors associated with the presence of iron-related disorders. For each categorical variable, the lowest category in the Iron-Related Disorders group was used as the reference.

3. Results and Discussion

3.1. Results

Table 1 presents the comparisons of demographic and socioeconomic characteristics of the studied groups, showing that child age was statistically different between groups ($p = 0.009$) and was youngest in the IDA group (median age = 3.5 years). There were no significant differences between the groups in gender or parental age. Parent education ($p < 0.0001$) and household income ($p < 0.0001$) were highly statistically significant among the groups. Tertiary education was most prevalent in the control group (39.7%), while none of the children in the IDA and anemia of inflammation without iron deficiency groups had parents with tertiary education. Low-income households represented the majority of IDA (90.3%) and anemia of inflammation without iron deficiency (81.8%) children, whereas only 1.5% of the control group belonged to low-income households.

Table 2 presents the comparisons of dietary patterns, showing that one meal per day was consumed by 90.3% of patients with IDA and 81.8% of children with anemia of inflammation without iron deficiency, but only 4.4% in the control group ($p < 0.0001$). There was a considerable difference among the four groups in terms of non-healthy

snack consumption (chips, sugary beverages, candies, processed baked goods, and fast foods). In the control group, 60.3% of children had one snack and 27.9% had two snacks daily. In contrast, children in the IDA group showed a higher tendency for unhealthy snacking, with 54.8% consuming three snacks per day and 22.6% consuming more than three snacks per day. A similar pattern was observed in the ID group, where 32% of children had three snacks and 26% had more than three snacks per day. Among children with anemia of inflammation without iron deficiency, 27.3% had three snacks per day, and 18.2% had more than three. Overall, the frequency of non-healthy snacking was highest in the IDA group compared with the other groups ($p < 0.0001$). The frequency of consuming iron-rich foods, including meat and fish, was lower among the IDA, ID, and anemia of inflammation without iron deficiency groups compared with the control group. The proportion of children who never consumed meat or animal protein was 54.8% in the IDA group and 23.5% in the control group. The intake of fruits and vegetables was significantly lower in the two iron-deficient groups, with only 12.9% of IDA children consuming fruits daily, compared with 80.9% in the control group. The consumption of legumes, seeds, and nuts exhibited similar patterns in the IDA and anemia of inflammation without iron deficiency groups.

In Table 3, 74.2% of children with IDA engaged in less than one hour of physical activity per day, while 73.5% of the control group participated in physical activity for more than three hours daily. The highest percentage of sedentary behavior was observed among children with IDA (77.4%), compared with only 5.9% in the control group. The IDA group experienced the greatest health and nutritional deficits, as shown in Table 3, with the lowest median weight, height, hemoglobin level at 10.5 g/dL, and serum iron at 30.1 $\mu\text{g/dL}$. Complete blood count (CBC) indices further confirmed this pattern: the IDA group had the lowest MCH, MCHC, MCV, RBC, and hematocrit values, and the highest RDW compared with the other groups ($p < 0.0001$).

Table 4 presents the comparisons of children in the control and iron-related disorder (ID, IDA, and anemia of inflammation without iron deficiency) groups to investigate the general association between iron deficiencies and various risk factors. Children with iron-related disorders belonged to families with lower socioeconomic status and less educated parents, consumed fewer daily meals, and ate smaller amounts of iron-rich foods such as fruits, vegetables, legumes, and nuts.

Table 5 shows the results from a binary logistic regression, indicating that children with low socioeconomic status had increased risks of iron-related disorders. They also had higher risks associated with eating only one meal daily ($\text{OR} = 5.73$) and consuming multiple snacks each day ($\text{OR} = 29.61$ for three snacks), as well as never consuming meat ($\text{OR} = 28.8$) or vegetables. Children who spent less than one hour on physical activity ($\text{OR} = 18.13$) and those who spent more than three hours sedentary behavior ($\text{OR} = 80.29$) were at an increased risk of iron-related disorders.

Table (1): Comparison of demographic and socioeconomic characteristics among control, ID, IDA, and anemia of inflammation without iron deficiency groups.

Variable	Control (n=68)	ID (n=50)	IDA (n=31)	Anemia of inflammation without iron deficiency (n=22)	P-value
All	68 (39.8)	50 (29.2)	31 (18.1)	22 (12.9)	<0.0001
Child Age (years), median (interquartile range)	5.75 (5) ^a	6 (5.03) ^a	3.5 (3.8) ^b	5.5 (5.23) ^a	0.009
Child Gender, n (%)					0.329
Female	31 (45.6)	17 (34)	9 (29)	10 (45.5)	
Male	37 (54.4)	33 (66)	22 (71)	12 (54.5)	
Parent age (year), n (%)					0.354
20-30	26 (38.2)	11 (22)	7 (22.6)	5 (22.7)	
31-40	34 (50)	27 (54)	18 (58.1)	12 (54.6)	
41-50	8 (11.8)	12 (24)	6 (19.4)	5 (22.7)	
Parent education, n (%)					<0.0001
No formal education	1 (1.5)	2 (4)	8 (25.8)	6 (27.3)	
Primary education	4 (5.9)	19 (38)	14 (45.2)	15 (68.2)	
Secondary education	36 (52.9)	25 (50)	9 (29)	1 (4.5)	
Tertiary education	27 (39.7)	4 (8)	0 (0)	0 (0)	
Household income, n (%)					<0.0001
Low	1 (1.5)	27 (54)	28 (90.3)	18 (81.8)	
Medium	49 (72.1)	19 (38)	3 (9.7)	4 (18.2)	
High	18 (26.5)	4 (8)	0 (0)	0 (0)	

Note: Data are presented as frequencies and percentages (n (%)) for categorical variables, and statistical significance was tested using the Chi-square test. Non-normally distributed continuous variables are presented as median (interquartile range) and were analyzed using the Kruskal–Wallis test followed by pairwise comparisons. Different subscripted letters within the same row indicate statistically significant differences between groups ($p < 0.05$), while identical subscripted letters indicate no significant difference ($p > 0.05$). Statistically significant results are shown in bold.

Table 2. Comparison of dietary patterns among control, ID, IDA, and anemia of inflammation without iron deficiency groups.

Variable	Control (n=68)	ID (n=50)	IDA (n=31)	Anemia of inflammation without iron deficiency (n=22)	P-value
Meals/day, n (%)					<0.0001
1	3 (4.4)	12 (24)	28 (90.3)	18 (81.8)	
2	15 (22.1)	19 (38)	3 (9.7)	4 (18.2)	
3	40 (58.8)	14 (28)	0 (0)	0 (0)	
More than 3	10 (14.7)	5 (10)	0 (0)	0 (0)	
Snacks/day, n (%)					<0.0001
1	41 (60.3)	5 (10)	1 (3.2)	3 (13.6)	
2	19 (27.9)	16 (32)	6 (19.4)	9 (40.9)	
3	6 (8.8)	16 (32)	17 (54.8)	6 (27.3)	
More than 3	2 (2.9)	13 (26)	7 (22.6)	4 (18.2)	

(continues)

Table 2. Continued.

Variable	Control (n=68)	ID (n=50)	IDA (n=31)	Anemia of inflammation without iron deficiency (n=22)	P-value
Food Consumption, n (%)					
Meat, n (%)					<0.0001
Daily	16 (23.5)	5 (10)	0 (0)	0 (0)	
Weekly	27 (39.7)	12 (24)	2 (6.5)	5 (22.7)	
Monthly	16 (23.5)	9 (18)	6 (19.4)	7 (31.8)	
Rarely	5 (7.4)	11 (22)	6 (19.4)	4 (18.2)	
Never	4 (5.9)	13 (26)	17 (54.8)	6 (27.3)	
Fish, n (%)					<0.0001
Daily	8 (11.8)	6 (12)	0 (0)	0 (0)	
Weekly	24 (35.3)	4 (8)	3 (9.7)	4 (18.2)	
Monthly	23 (33.8)	19 (38)	8 (25.8)	6 (27.3)	
Rarely	9 (13.2)	7 (14)	7 (22.6)	4 (18.2)	
Never	4 (5.9)	14 (28)	13 (41.9)	8 (36.4)	
Dairy products, n (%)					0.903
Daily	50 (73.5)	40 (80)	25 (80.6)	15 (68.2)	
Weekly	8 (11.8)	3 (6)	1 (3.2)	2 (9.1)	
Rarely	5 (7.4)	4 (8)	2 (6.5)	3 (13.6)	
Never	5 (7.4)	3 (6)	3 (9.7)	2 (9.1)	
Fruits, n (%)					<0.0001
Daily	55 (80.9)	15 (30)	4 (12.9)	1 (4.5)	
Weekly	7 (10.3)	9 (18)	10 (32.3)	7 (31.8)	
Monthly	3 (4.4)	8 (16)	8 (25.8)	6 (27.3)	
Rarely	2 (2.9)	11 (22)	7 (22.6)	2 (9.1)	
Never	1 (1.5)	7 (14)	2 (6.5)	6 (27.3)	
Vegetables, n (%)					<0.0001
Daily	10 (14.7)	27 (54)	12 (38.7)	6 (27.3)	
Weekly	5 (7.4)	14 (28)	12 (38.7)	11 (50)	
Monthly	11 (16.2)	4 (8)	5 (16.1)	2 (4.5)	
Rarely	13 (19.1)	4 (8)	0 (0)	1 (4.5)	
Never	29 (42.6)	1 (2)	2 (6.5)	2 (4.5)	
Legumes, n (%)					<0.0001
Daily	11 (16.2)	5 (10)	0 (0)	0 (0)	
Weekly	38 (55.9)	17 (34)	5 (16.1)	5 (22.7)	
Monthly	6 (8.8)	4 (8)	5 (16.1)	0 (0)	
Rarely	7 (10.3)	7 (14)	7 (22.6)	3 (13.6)	
Never	6 (8.8)	17 (34)	14 (45.2)	14 (63.6)	
Nuts and seeds, n (%)					<0.0001
Daily	14 (20.6)	4 (8)	0 (0)	0 (0)	
Weekly	31 (45.6)	7 (14)	6 (19.4)	6 (27.3)	
Monthly	12 (17.6)	12 (24)	2 (6.5)	3 (13.6)	
Rarely	8 (11.8)	18 (36)	9 (29)	7 (31.8)	
Never	3 (4.4)	9 (18)	14 (45.2)	6 (27.3)	

(continues)

Table 2. Continued.

Variable	Control (n=68)	ID (n=50)	IDA (n=31)	Anemia of inflammation without iron deficiency (n=22)	P-value
Cereals and grains, n (%)					0.153
Daily	3 (4.4)	0 (0)	4 (12.9)	2 (9.1)	
Weekly	28 (41.2)	22 (44)	14 (45.2)	9 (40.9)	
Monthly	14 (20.6)	5 (10)	3 (9.7)	5 (22.7)	
Rarely	11 (16.2)	14 (28)	3 (9.7)	5 (22.7)	
Never	12 (17.6)	9 (18)	7 (22.6)	1 (4.5)	

Note: Data are presented as frequencies and percentages (n (%)) for categorical variables, and statistical significance was tested using the Chi-square test, and statistically significant results are shown in bold.

Table 3. Comparison of physical activity, anthropometric measurements, and clinical parameters among control, ID, IDA, and anemia of inflammation without iron deficiency groups.

Variable	Control (n=68)	ID (n=50)	IDA (n=31)	Anemia of inflammation without iron deficiency (n=22)	P-value
Physical activities/day, n (%)					<0.0001
Less than 1 hour	11 (16.2)	35 (70)	23 (74.2)	1 (4.5)	
1-2 hours	2 (2.9)	12 (24)	1 (3.2)	16 (72.7)	
2-3 hours	5 (7.4)	1 (2)	2 (6.5)	1 (4.5)	
More than 3 hours	50 (73.5)	2 (4)	5 (16.1)	4 (18.2)	
Sedentary activities/day, n (%)					<0.0001
Less than 1 hour	41 (60.3)	5 (10)	0 (0)	1 (4.5)	
1-2 hours	17 (25)	14 (28)	0 (0)	1 (4.5)	
2-3 hours	6 (8.8)	18 (36)	7 (22.6)	10 (45.5)	
More than 3 hours	4 (5.9)	13 (26)	24 (77.4)	10 (45.5)	
Child's Weight (Kg)	20.35 (11.7) ^a	17.8 (9.7) ^b	14 (6.2) ^{cd}	15.2 (5.3) ^{db}	<0.0001
Child's Height (cm), median (interquartile range)	119 (28) ^a	109 (21) ^b	92 (21) ^{cd}	102 (12) ^{db}	<0.0001
BMI (Kg/cm²), median (interquartile range)	15.35 (2) ^a	15.2 (2.2) ^a	16.5 (3.5) ^a	14.6 (4.2) ^a	0.506
Hemoglobin (g/dL), median (interquartile range)	13.1 (1.2) ^a	12.8 (1.1) ^{ba}	10.5 (1.4) ^{cd}	10.6 (1) ^d	<0.0001
Serum Iron (µg/dL), median (interquartile range)	90.5 (40.36) ^a	39.07 (14.25) ^{bc}	30.1 (15.27) ^c	55.54 (5.73) ^d	<0.0001
MCH (pg), median (interquartile range)	27.90 (2.18) ^a	26.50 (3.15) ^b	22.90 (5.20) ^c	25.80 (2.80) ^{cd}	<0.0001
MCHC (g/dL), median (interquartile range)	37.10 (1.40) ^a	36.70 (1.05) ^b	35.20 (2.20) ^c	37.10 (1.30) ^{abd}	<0.0001
RBC (10¹²/L), median (interquartile range)	4.83 (0.46) ^a	4.86 (0.47) ^{ab}	4.50 (0.61) ^c	4.28 (0.25) ^{cd}	<0.0001
MCV (fL), median (interquartile range)	77.10 (2.88) ^a	72.95 (9.33) ^b	63.80 (13.50) ^c	74.10 (7.28) ^{bd}	<0.0001
HCT (%), median (interquartile range)	36.30 (1.40) ^a	35.20 (4.40) ^b	29.10 (3.90) ^c	29.20 (1.20) ^{cd}	<0.0001
RDW (%), median (interquartile range)	12.20 (0.55) ^a	12.10 (1.43) ^{ab}	14.70 (4.30) ^c	13.10 (0.70) ^{cd}	<0.0001

Note: Data are presented as frequencies and percentages (n (%)) for categorical variables, and statistical significance was tested using the Chi-square test. Non-normally distributed continuous variables are presented as median (interquartile range) and were analyzed using the Kruskal-Wallis test followed by pairwise comparisons. Different subscripted letters within the same row indicate statistically significant differences between groups (p < 0.05), while identical subscripted letters indicate no significant difference (p > 0.05). Statistically significant results are shown in bold.

Table 4. Comparison of socio-demographic, dietary, and lifestyle factors between control children and those with iron-related disorders.

Variable	Control Group (n=68)	Iron-Related Disorders Group (n=103)	P- value
Child Age (years), median (interquartile range)	5.75 (5) ^a	5 (5) ^a	0.054
Child Gender, n (%)			0.163
Female	31 (45.6)	36 (35)	
Male	37 (54.4)	67 (65)	
Parent age (year), n (%)			0.042
20-30	26 (38.2)	23 (22.3)	
31-40	34 (50)	57 (55.3)	
41-50	8 (11.8)	23 (22.3)	
Parent education, n (%)			<0.0001
No formal education	1 (1.5)	16 (15.5)	
Primary education	4 (5.9)	48 (46.6)	
Secondary education	36 (52.9)	35 (34)	
Tertiary education	27 (39.7)	4 (3.9)	
Household income, n (%)			<0.0001
Low	1 (1.5)	73 (70.9)	
Medium	49 (72.1)	26 (25.2)	
High	18 (26.5)	4 (3.9)	
Meals/day, n (%)			<0.0001
1	3 (4.4)	31 (30.1)	
2	15 (22.1)	43 (41.7)	
3	40 (58.8)	24 (23.3)	
More than 3	10 (14.7)	5 (4.9)	
Snacks/day, n (%)			<0.0001
1	41 (60.3)	9 (8.7)	
2	19 (27.9)	31 (30.1)	
3	6 (8.8)	39 (37.9)	
More than 3	2 (2.9)	24 (23.3)	
Food Consumption, n (%)			
Meat, n (%)			<0.0001
Daily	16 (23.5)	5 (4.9)	
Weekly	27 (39.7)	19 (18.4)	
Monthly	16 (23.5)	22 (21.4)	
Rarely	5 (7.4)	21 (20.4)	
Never	4 (5.9)	36 (35)	
Fish, n (%)			<0.0001
Daily	8 (11.8)	6 (5.8)	
Weekly	24 (35.3)	11 (10.7)	
Monthly	23 (33.8)	33 (32)	
Rarely	9 (13.2)	18 (17.5)	
Never	4 (5.9)	35 (34)	

(continues)

Table 4. Continued.

Variable	Control Group (n=68)	Iron-Related Disorders Group (n=103)	P- value
Dairy products, n (%)			0.58
Daily	50 (73.5)	80 (77.7)	
Weekly	8 (11.8)	6 (5.8)	
Rarely	5 (7.4)	9 (8.7)	
Never	5 (7.4)	8 (7.8)	
Fruits, n (%)			<0.0001
Daily	55 (80.9)	20 (19.4)	
Weekly	7 (10.3)	26 (25.2)	
Monthly	3 (4.4)	22 (21.4)	
Rarely	2 (2.9)	20 (19.4)	
Never	1 (1.5)	15 (14.6)	
Vegetables, n (%)			<0.0001
Daily	10 (14.7)	45 (43.7)	
Weekly	5 (7.4)	37 (35.9)	
Monthly	11 (16.2)	11 (10.7)	
Rarely	13 (19.1)	5 (4.9)	
Never	29 (42.6)	5 (4.9)	
Legumes, n (%)			<0.0001
Daily	11 (16.2)	5 (4.9)	
Weekly	38 (55.9)	27 (26.2)	
Monthly	6 (8.8)	9 (8.7)	
Rarely	7 (10.3)	17 (16.5)	
Never	6 (8.8)	45 (43.7)	
Nuts and seeds, n (%)			<0.0001
Daily	14 (20.6)	4 (3.9)	
Weekly	31 (45.6)	19 (18.4)	
Monthly	12 (17.6)	17 (16.5)	
Rarely	8 (11.8)	34 (33)	
Never	3 (4.4)	29 (28.2)	
Cereals and grains, n (%)			0.651
Daily	3 (4.4)	6 (5.8)	
Weekly	28 (41.2)	45 (43.7)	
Monthly	14 (20.6)	13 (12.6)	
Rarely	11 (16.2)	22 (21.4)	
Never	12 (17.6)	17 (16.5)	
Physical activities/day, n (%)			<0.0001
Less than 1 hour	11 (16.2)	59 (57.3)	
1-2 hours	2 (2.9)	29 (28.2)	
2-3 hours	5 (7.4)	4 (3.9)	
More than 3 hours	50 (73.5)	11 (10.7)	

(continues)

Table 4. Continued.

Variable	Control Group (n=68)	Iron-Related Disorders Group (n=103)	P- value
Sedentary activities/day, n (%)			<0.0001
Less than 1 hour	41 (60.3)	6 (5.8)	
1-2 hours	17 (25)	15 (14.6)	
2-3 hours	6 (8.8)	35 (34)	
More than 3 hours	4 (5.9)	47 (45.6)	

Note: Data are presented as frequencies and percentages (n (%)) for categorical variables, and statistical significance was tested using the Chi-square test. Non-normally distributed continuous variables are presented as median (interquartile range) and were analyzed using the Kruskal–Wallis test followed by pairwise comparisons. Different subscripted letters within the same row indicate statistically significant differences between groups ($p < 0.05$), while identical subscripted letters indicate no significant difference ($p > 0.05$). Statistically significant results are shown in bold.

Table 5. Binary logistic regression of factors associated with iron-related disorders in children, with odds ratios and 95% confidence intervals.

Variable	OR	95% CI Lower	95% CI Upper	P-value
All	171			
Child Gender				
Female	Ref.			
Male	1.559	0.834	2.916	0.164
Parent age(year)				
20-30	Ref.			
31-40	1.895	.938	3.83	0.075
41-50	3.25	1.219	8.666	0.019
Parent education				
No formal education	81	18.738	350.15	<0.0001
Primary education	6.562	2.081	20.695	0.001
Secondary education	108	11.081	1052.594	<0.0001
Tertiary education	Ref.			
Household income				
Low	2.388	0.731	7.795	0.149
Medium	328.5	34.582	3120.435	<0.0001
High	Ref.			
Meals/day				
1	5.733	1.686	19.495	0.005
2	1.2	0.366	3.932	0.763
3	20.667	4.177	102.262	<0.0001
More than 3	Ref.			
Snacks/day				
1	Ref.			
2	7.433	2.962	18.653	<0.0001
3	29.611	9.641	90.951	<0.0001
More than 3	54.667	10.896	274.27	<0.0001

(continues)

Table 5. Continued.

Variable	OR	95% CI Lower	95% CI Upper	P-value
Food Consumption				
Meat				
Daily	Ref.			
Weekly	2.252	0.704	7.206	0.171
Monthly	4.4	1.335	14.506	0.015
Rarely	13.44	3.315	54.494	<0.0001
Never	28.8	6.819	121.634	<0.0001
Fish				
Daily	Ref.			
Weekly	0.611	0.17	2.19	0.450
Monthly	1.913	0.585	6.256	0.283
Rarely	2.667	0.707	10.052	0.147
Never	11.667	2.656	51.254	0.001
Dairy products				
Daily	2.133	0.699	6.512	0.183
Weekly	Ref.			
Rarely	2.4	0.524	10.992	0.259
Never	2.133	0.458	9.942	0.335
Fruits				
Daily	0.248	0.028	2.212	0.211
Weekly	0.489	0.046	5.159	0.552
Monthly	0.667	0.055	8.057	0.750
Rarely	0.024	0.003	0.196	<0.0001
Never	Ref.			
Vegetables				
Daily	42.92	11.334	162.525	<0.0001
Weekly	5.8	1.638	20.542	0.006
Monthly	2.231	0.549	9.061	0.262
Rarely	26.1	8.096	84.143	<0.0001
Never	Ref.			
Legumes				
Daily	Ref.			
Weekly	1.563	0.487	5.019	0.453
Monthly	3.3	0.753	14.468	0.113
Rarely	5.343	1.35	21.144	0.017
Never	16.5	4.245	64.134	<0.0001
Nuts and seeds				
Daily	Ref.			
Weekly	2.145	0.615	7.482	0.231
Monthly	4.958	1.306	18.832	0.019
Rarely	14.875	3.848	57.494	<0.0001
Never	33.833	6.648	172.194	<0.0001

(continues)

Table 5. Continued.

Variable	OR	95% CI Lower	95% CI Upper	P-value
Cereals and grains				
Daily	Ref.			
Weekly	0.804	0.186	3.474	0.770
Monthly	0.464	0.096	2.25	0.341
Rarely	1	0.209	4.776	1
Never	0.708	0.147	3.407	0.667
Physical activities/day				
Less than 1 hour	18.125	2.592	126.721	0.003
1-2 hours	6.705	1.551	28.982	0.011
2-3 hours	Ref.			
More than 3 hours	0.275	0.063	1.194	0.085
Sedentary activities/day				
Less than 1 hour	Ref.			
1-2 hours	6.029	2.002	18.163	0.001
2-3 hours	39.861	11.79	134.77	<0.0001
More than 3 hours	80.292	21.178	304.401	<0.0001

Note: Data were analyzed by binary logistic regression to assess the association between selected variables and iron-related disorders in children. OR (Odds Ratio) measures the association between exposure and outcome, 95% CI (Confidence Interval) indicates the range where the true OR is expected to lie, and Ref. (Reference Group) represents the baseline category for comparison. A p-value < 0.05 indicates statistical significance, and significant results are shown in bold.

3.2. Discussion

This study showed that socioeconomic status significantly affects the rates of ID and IDA among children in Zakho. Families with lower income and education levels exhibited an increased tendency for iron-related disorders in their children. Various factors can influence iron status in children, including socioeconomic status, demography, the type of milk consumed by infants, dietary intake, and gastrointestinal diseases [18,19,20,21]. Our study found that children with iron deficiency disorders were more likely to have parents with lower educational levels, which is consistent with previous research showing a link between low parental education and poor nutritional outcomes in children [22]. Lower parental education may contribute to limited nutritional knowledge and reduced awareness of iron-rich diets, thereby increasing the risk of iron deficiency and anemia in children. Promoting education and awareness among parents may therefore help reduce childhood iron deficiency disorders.

This study also found that children with ID and IDA had significantly poorer dietary patterns. In particular, most children in the IDA group consumed only one meal per day and rarely consumed iron-rich foods such as meat, fish, legumes, and green vegetables. These results are consistent with the findings of Cohen & Powers [23], Armishty et al. [14], and Fu et al. [16]. The study indicates that irregular meat consumption, together with excessive intake of iron absorption blockers, represents a major contributor to iron deficiency and anemia in children [8]. Previous

studies have shown that insufficient consumption of fruits and vegetables can lead to abnormal mineral absorption and nutritional deficiencies, and the findings of this study support this existing knowledge [24].

Our findings showed that children in both the IDA and anemia of inflammation without iron deficiency groups had a significantly higher frequency of non-healthy snacking, often consuming three or more snacks daily instead of balanced meals. These snacks, typically low in bioavailable iron and high in absorption inhibitors such as sugar, calcium, and phytates, may impair iron status and displace iron-rich foods [25,16]. This behavior likely contributes to anemia and underscores the importance of promoting healthier snacking habits in children.

This research showed that children with iron-related disorders were more inactive and spent more time in sedentary activities compared with the control participants. Most children with IDA engaged in less than one hour of physical activity per day, while spending more than three hours in sedentary activities. Similar patterns have been reported in previous studies [26,27,2]. The study found that insufficient physical activity is common among children with iron deficiency, likely due to fatigue and weakness caused by anemia.

The research data on anthropometry and clinical indicators provide established scientific evidence that iron deficiency adversely affects physical development. Children with IDA had the lowest median weight and height, along with the lowest hemoglobin and serum iron

levels. These findings are consistent with previous studies [28]. The IDA group also exhibited the lowest MCH, MCHC, MCV, RBC count, and hematocrit, and the highest RDW compared with the other groups, which aligns with earlier research [29]. The performance of these markers confirms an anemia diagnosis and reflects prolonged nutritional insufficiencies, which negatively affect growth and immune competence.

Statistical analysis using logistic regression indicates that low parental education, combined with low household income, infrequent meals, and inadequate food choices, serves as a primary predictive factor for iron-deficiency disorders. The study findings connect results from different regions by illustrating how nutritional risks and social factors contribute to anemia during childhood [30,31].

This study supports previous research on the multiple factors contributing to iron deficiency and anemia in children. The findings highlight the need for immediate implementation of targeted nutritional interventions and comprehensive public health education, combined with economic support, to address these health issues. Similar to worldwide trends, the Zakho population experiences deficits in dietary quality, limited financial resources, and inadequate health education programs, which must be addressed to improve child health outcomes.

To our knowledge, there is a lack of recent studies in the Kurdistan Region of Iraq that comprehensively assess the combined impact of socioeconomic status, dietary habits, and physical activity on iron deficiency, iron deficiency anemia, and anemia of inflammation in children. By including a distinct group for anemia of inflammation without iron deficiency and analyzing multiple interacting factors, this study addresses an important gap and provides new context-specific evidence to guide local interventions.

Future research should focus on evaluating the effectiveness of school-based nutrition programs, community health education, and targeted policy interventions aimed at improving food security and health literacy. The described methods have the potential to reduce the impact of iron deficiency in pediatric patients, particularly in low-resource settings such as Zakho and similar regions worldwide.

However, this study has several limitations. The dietary data were based on parent-reported questionnaires, which may be subject to recall bias. The study sample was also restricted to a single geographic area (Zakho City), which may limit the generalizability of the findings to other regions. Additionally, although complete blood count (CBC) parameters were assessed, serum ferritin was not measured due to laboratory constraints, limiting the comprehensive evaluation of iron status. Furthermore, other micronutrient deficiencies (e.g., folate, vitamin B12, zinc), which may contribute to anemia, should be considered in future research.

4. Conclusions

This study provides additional evidence supporting the multifactorial etiology of iron deficiency and anemia

among children in Zakho, highlighting the critical influence of dietary patterns, socioeconomic factors, and iron-related biomarkers. The results indicate that low parental education, limited household income, inadequate dietary diversity, and reduced physical activity were significant determinants of iron-related disorders in the study population, consistent with prior research in other settings. These findings underscore the urgent need to move beyond individual-level treatment toward comprehensive, community-based public health interventions. In particular, targeted nutrition education programs for caregivers, the introduction of school-based iron-fortified meal initiatives, and social policies aimed at poverty reduction and improved access to affordable, diverse, and iron-rich foods are strongly recommended. Such strategies are essential to effectively address the root causes of childhood iron deficiency and anemia and to improve health outcomes among vulnerable populations.

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Declarations

Informed Consent Statement

Informed consent was obtained from parents prior to participation.

Data Availability Statement

The data that support the findings of this study are not publicly available due to privacy and ethical restrictions. However, the data can be made available from the corresponding author upon reasonable request.

Ethical Approval

Ethical approval was obtained before data collection, by the Declaration of Helsinki, from the Bioethics Committee of the College of Medicine, University of Zakho (Reference Number: NOV2024/UOZE26; Date: 14/11/2024).

Author Contributions

LYM: Conceptualization; MKS: Data curation; MKS: Formal analysis; MKS: Funding acquisition; MKS: Investigation; MKS: Methodology; LYM: Project administration; MKS: Resources; MKS: Software; LYM: Supervision; LYM: Validation; LYM; Visualization; MKS: Writing-original draft; LYM: Writing-review & editing.

Conflict of Interest

The authors declare no conflict of interest with other previous studies.

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References

- [1] Kulik-Rechberger, B.; Dubel, Iron deficiency, iron deficiency anaemia and anaemia of inflammation – an overview. *Ann. Agric. Environ. Med.*, 31(1): 151–157, 2024. <https://doi.org/10.26444/aaem/171121>
- [2] Woźniak, D.; Podgórski, T.; Krzyżanowska-Jankowska, P.; Dobrzyńska, M.; Wichłacz-Trojanowska, N.; Przysławski, J.; et al., The influence of intensive nutritional education on the iron status in infants. *Nutrients*, 14(12): 2453, 2022. <https://doi.org/10.3390/nu14122453>
- [3] Georgieff, M.K.; Krebs, N.F.; Cusick, S.E., The benefits and risks of iron supplementation in pregnancy and childhood. *Annu. Rev. Nutr.*, 39(1): 121–146, 2019. <https://doi.org/10.1146/annurev-nutr-082018-124213>
- [4] Vogt, A.-C.S.; Arsiwala, T.; Mohsen, M.; Vogel, M.; Manolova, V.; Bachmann, M.F., On Iron Metabolism and Its Regulation. *Int. J. Mol. Sci.*, 22 (9): 4591, 2021. <https://doi.org/10.3390/ijms22094591>
- [5] Piskin, E.; Cianciosi, D.; Gulec, S.; Tomas, M.; Capanoglu, E., Iron Absorption: Factors, Limitations, and Improvement Methods. *ACS Omega*, 7 (24): 20441–20456, 2022. <https://doi.org/10.1021/acsomega.2c01833>
- [6] Kumar, A.; Sharma, E.; Marley, A.; Samaan, M.A.; Brookes, M.J., Iron deficiency anaemia: pathophysiology, assessment, practical management. *BMJ Open Gastroenterol.*, 9 (1): e000759, 2022. <https://doi.org/10.1136/bmjgast-2021-000759>
- [7] Safiri, S.; Amiri, F.; Karamzad, N.; Sullman, M.J.M.; Kolahi, A.-A.; Abdollahi, M., Burden and trends of dietary iron deficiency in the Middle East and North Africa region, 1990–2021. *Front. Nutr.*, 11: 1517478, 2025. <https://doi.org/10.3389/fnut.2024.1517478>
- [8] Mantadakis, E.; Chatzimichael, E.; Zikidou, P., Iron deficiency anemia in children residing in high and low-income countries: risk factors, prevention, diagnosis and therapy. *Mediterr. J. Hematol. Infect. Dis.*, 12 (1): e2020041, 2020. <https://doi.org/10.4084/MJHID.2020.041>
- [9] Amoadu, M.; Abraham, S.A.; Adams, A.K.; Akoto-Buabeng, W.; Obeng, P.; Hagan, J.E., Risk factors of malnutrition among in-school children and adolescents in developing countries: a scoping review. *Children*, 11 (4): 0476, 2024. <https://doi.org/10.3390/children11040476>
- [10] World Health Organization. WHO guidance helps detect iron deficiency and protect brain development. WHO, 2020. Available: <https://www.who.int/news/item/20-04-2020-who-guidance-helps-detect-iron-deficiency-and-protect-brain-development>
- [11] Yanti S, Sari YAP, Meilina A. Diet, Protein, Iron and Vitamin C Intake on Anemia Status of Adolescent Girls. *J Appl Nurs Health*, 6(1):177–183, 2024. <https://doi.org/10.55018/janh.v6i1.192>
- [12] Baranwal A, Baranwal A, Roy N. Association of Household Environment and Prevalence of Anemia Among Children Under-5 in India. *Front Public Health*, 2:196, 2014. <https://doi.org/10.3389/fpubh.2014.00196>
- [13] Chowdhury MRK, et al. Prevalence and risk factors of childhood anemia in Nepal: A multilevel analysis. *PLoS One*, 15(10):e0239409, 2020. <https://doi.org/10.1371/journal.pone.0239409>
- [14] Armishty F, et al. The Prevalence of Anemia and Associated Factors among Children under 5 years in Zakho City, Kurdistan Region, Iraq. *Passer J Basic Appl Sci*, 5(2):391–397, 2023. <https://doi.org/10.24271/psr.2023.390463.1287>
- [15] Aksu T, Unal S. Iron Deficiency Anemia in Infancy, Childhood, and Adolescence. *Turk Arch Pediatr*, 58:358–362, 2023. <https://doi.org/10.5152/TurkArchPediatr.2023.23049>
- [16] Fu J, Zeng C, Huang J, Guo J, Su Z, Luo S. Dietary patterns and association with iron deficiency among children and adolescents aged 9–17 years in rural Guangzhou, China: a cross-sectional study. *Front Nutr*. 2024 Sep;11:1443849. <https://doi.org/10.3389/fnut.2024.1443849>
- [17] Gedfie S, Getawa S, Melku M. Prevalence and Associated Factors of Iron Deficiency and Iron Deficiency Anemia Among Under-5 Children: A Systematic Review and Meta-Analysis. *Glob Pediatr Health*, 9:2333794X221110860, 2022. <https://doi.org/10.1177/2333794X221110860>
- [18] Flora R, Zulkarnain M, Fajar NA, Aguscik A, Febri F, Sitorus NL. Factors Associated with Iron Deficiency in Elementary School Children. *Open Access Maced J Med Sci*. 2022 Jan;10(E):97–100. <https://doi.org/10.3889/oamjms.2022.7800>
- [19] Subramaniam G, Girish M. Iron Deficiency Anemia in Children. *Indian J Pediatr*, 82(6):558–564, 2015. <https://doi.org/10.1007/s12098-014-1643-9>
- [20] van der Merwe LF, Eussen SR. Iron status of young children in Europe. *Am J Clin Nutr*, 106:1663S–1671S, 2017. <https://doi.org/10.3945/ajcn.117.156018>
- [21] Mantadakis E. Iron deficiency anemia in children residing in high and low-income countries: Risk factors, prevention, diagnosis and therapy. *Mediterr J Hematol Infect Dis*, 12(1):e2020041, 2020. <https://doi.org/10.4084/mjhid.2020.041>
- [22] Abdulhussein HM, Ahmed JT. Comparative Study of Children with/without Iron Deficiency Anemia Based on Parents' Knowledge, Attitude and Practice in Basra/Al-Madinah City. *Medico-Legal Update*, 21:2328, 2021. <https://doi.org/10.37506/mlu.v21i1.2328>
- [23] Cohen CT, Powers JM. Nutritional Strategies for Managing Iron Deficiency in Adolescents: Approaches to a Challenging but Common Problem. *Adv Nutr*, 15(5):100215, 2024. <https://doi.org/10.1016/j.advnut.2024.100215>
- [24] Kiani AK, Dhuli K, Donato K, Aquilanti B, Velluti V, Matera G, et al. Main nutritional deficiencies. *J Prev Med Hyg*. 2022 Jun;63(2 Suppl 3):E93–E101. <https://doi.org/10.15167/2421-4248/jpmh2022.63.2S3.2752>
- [25] Ma J, Huang J, Zeng C, Zhong X, Zhang W, Zhang B, Li Y. Dietary Patterns and Association with Anemia in Children Aged 9–16 Years in Guangzhou, China: A Cross-Sectional Study. *Nutrients*. 2023 Sep;15(19):4133. <https://doi.org/10.3390/nu15194133>
- [26] Hanifah L, Nasrulloh N, Sufyan DL. Sedentary Behavior and Lack of Physical Activity among Children in Indonesia. *Children (Basel)*. 2023 Jul;10(8):1283. <https://doi.org/10.3390/children10081283>
- [27] Haas JD, Brownlie T. Iron Deficiency and Reduced Work Capacity: A Critical Review of the Research to Determine a Causal Relationship. *J Nutr*, 131(2):676S–690S, 2001. <https://doi.org/10.1093/jn/131.2.676S>
- [28] Elhabashy SASM, Salah El Din RANT, Nouran Y. Iron Deficiency Anemia in Children and Adolescents with Type I Diabetes, Is it a Real Problem? *Med J Cairo Univ*, 89(9):1603–1619, 2021. <https://doi.org/10.21608/mjcu.2021.194977>
- [29] Moscheo C, Licciardello M, Samperi P, La Spina M, Di Cataldo A, Russo G. New Insights into Iron

- Deficiency Anemia in Children: A Practical Review. *Metabolites*, 12(4):289, 2022. <https://doi.org/10.3390/metabo12040289>
- [30] Chouraqui J-P. Dietary Approaches to Iron Deficiency Prevention in Childhood—A Critical Public Health Issue. *Nutrients*, 14(8):1604, 2022. <https://doi.org/10.3390/nu14081604>
- [31] Adokorach G, Oyet SM, Obai G, Muggaga C. Dietary quality, anaemia prevalence and their associated factors among rural school-going adolescents in Acholi sub-region of Uganda. *BMC Nutr*, 10(1):166, 2024. <https://doi.org/10.1186/s40795-024-00982-3>