Pediatr Pract Res 2024; 12(2): 38-45
DOI: 10.21765/pprjournal.1500065

ORIGINAL ARTICLE
ORİJİNAL ARAŞTIRMA

Evaluation of Anemia Distribution According to Erythrocyte Morphology in Hospitalized Children

Hastanede Yatırılarak Takip Edilen Çocuklarda Eritrosit Morfolojisine Göre Anemi Dağılımının Değerlendirilmesi

Sadiye Sert, Şerife Karaçal Say, Ebru Buldu

Department of Pediatrics, Konya Beyhekim Training and Research Hospital, Konya, Turkey

ABSTRACT

Aim: While the prevalence of anemia among hospitalized children varies in the literature, there is currently a lack of studies in our region that specifically examine the distribution of anemia based on erythrocyte morphology. Therefore, our aim was to compare the prevalence of anemia based on sex and age distribution among children undergoing hospitalization in our region and investigate the distribution of anemia according to erythrocyte morphology.

Material and Method: Children aged between 6 months and 18 years who were only hospitalized and followed up in the Department of Pediatrics at the Health Sciences University Konya Beyhekim Training and Research Hospital between January 2021 and March 2024 were retrospectively analyzed.

Results: Of the 1148 children hospitalized in the pediatric clinic, 876 (76.3%) had hemoglobin levels within the reference range for their age, while 272 (23.7%) were found to have anemia. A statistically significant difference was observed in the presence of anemia among age groups, with the 6 months-<2 years and 2-<6 years age groups differing significantly from the other age groups (p: 0.001).

Conclusion: Our study results indicated that mild anemia was the most common type of anemia detected in hospitalized children, with the highest frequency observed in the 6 months-<2 years age group, and microcytic anemia was the most common type based on erythrocyte morphology. Hemogram analysis, which is a simple and cost-effective method, can assist in classifying anemia based on erythrocyte morphology. This can facilitate further testing for the underlying etiology in patients diagnosed with anemia.

Keywords: Anemia, red cell morphology, hospitalized children, hemogram, prevalence

ÖZ

Amaç: Hastanede yatan çocuklar arasındaki anemi yaygınlığı literatürde değişmekle birlikte, bölgemizde eritrosit morfolojisine dayalı anemi dağılımını özellikle inceleyen çalışmaların eksikliği bulunmaktadır. Bu nedenle amacımız, bölgemizde hastaneye yatırılan çocuklar arasında cinsiyet ve yaş dağılımına göre anemi yaygınlığını karşılaştırmak ve eritrosit morfolojisine göre anemi dağılımını araştırmaktı.

Gereç ve Yöntem: Ocak 2021 ile Mart 2024 tarihleri arasında Sağlık Bilimleri Üniversitesi Konya Beyhekim Eğitim ve Araştırma Hastanesi Çocuk Hastalıkları Bölümü'nde yalnızca hastaneye yatırılan ve takip edilen 6 ay ile 18 yaş arasındaki çocuklar retrospektif olarak analiz edildi.

Bulgular: Pediatri kliniğinde yatırılan 1148 çocuktan, 876'sının (%76.3) yaşlarına göre referans aralıkta hemoglobin seviyelerine sahip olduğu, 272'sinde (%23.7) ise anemi olduğu belirlendi. Yaş grupları arasında anemi varlığında istatistiksel olarak anlamlı farklılık gözlendi, 6 ay-<2 yaş ve 2-<6 yaş aralığındaki grupların diğer yaş gruplarından önemli ölçüde farklı olduğu görüldü (p: 0.001).

Sonuç: Çalışmamızın sonuçları, hastanede yatırılan çocuklarda tespit edilen aneminin en yaygın türünün hafif anemi olduğunu gösterdi. En yüksek sıklığın 6 ay-<2 yaş grubunda olduğu ve eritrosit morfolojisine dayalı olarak mikrositik aneminin en yaygın tür olduğu belirlendi. Hemogram analizi, basit ve maliyet etkin bir yöntem olup, eritrosit morfolojisine dayalı anemi sınıflandırmasında yardımcı olabilir. Bu, anemi tanısı konmuş hastalarda temel etiyoloji için daha fazla test yapılmasını kolaylaştırabilir.

Anahtar Kelimeler: Anemi, kırmızı küre morfolojisi, hastanede yatan çocuklar, hemogram, prevalans

Corresponding Author: Sadiye Sert
Address: Department of Pediatrics, Konya Beyhekim Training and Research Hospital, Konya, Turkey
E-mail: sadiyesert@yahoo.com.tr

Başvuru Tarihi/Received: 12.06.2024
Kabul Tarihi/Accepted: 20.07.2024

INTRODUCTION

Childhood anemia, a persistent public health issue in developing nations, is characterized by a decrease in red blood cell mass or hemoglobin (Hb) concentration (1).

Anemia is known to be a potential cause of death in developing nations, especially in hospitalized children under five years old. In Tanzania, frequency rates of anemia have been reported to be approximately 77% (2,3).

The most frequent reason for childhood anemias is iron deficiency anemia, often preventable in the absence of additional medical history. Other nutritional deficiencies such as vitamin B12 and folate similarly fall among preventable causes of anemia. Childhood represents a period of rapid growth and development, where issues related to anemia can have lasting consequences, emphasizing the importance of preventive measures over treatment. Given the severe impact of childhood anemia, screening programs are recommended for monitoring and supporting its treatment, particularly in children under two years old, as anemia significantly affects growth, development, and cognitive functions, underscoring the crucial role of early diagnosis and treatment (4).

Hematological analyses, including complete blood count, are routinely conducted across various healthcare facilities in our country, facilitating the prompt diagnosis of anemia. Although the literature shows varying rates of anemia among hospitalized children, there is currently a lack of studies in our region that specifically examine the distribution of anemia based on erythrocyte morphology. Therefore, our aim was to compare the prevalence of anemia based on sex and age distribution among children undergoing hospitalization in our region and investigate the distribution of anemia according to erythrocyte morphology.

MATERIAL AND METHOD

Retrospective analysis was done on children between the ages of 6 months and 18 years who were hospitalized and monitored in the pediatric department at the Konya Beyhekim Training and Research Hospital between January 2021 and March 2024. Patient data were obtained from the hospital's records system. Individuals over 18 years of age and children under 6 months of age were excluded from the study. Those with known chronic illnesses were also not included.

To compare the distribution of anemia among different age groups, patients were divided into four groups based on age ranges: 6 month-<2 years, 2-<6 years, 6-12 years, and >12 years.

Hemogram analysis was performed utilizing the flow cytometric method on the Shenzhen Mindray Auto Haematology Analyzer BC-6800 (Shenzhen, China). Parameters including Hb, hematocrit, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and red cell distribution width (RDW) were evaluated based on established reference ranges for the study cohort. The diagnostic criteria for anemia were in accordance with the guidelines set forth by the World Health Organization (5). Specifically, anemia was defined as Hb levels falling below 11 g/dL for children aged 2.1-4.9 years, below 11.5 g/dL for children aged 5-11.9 years, below 12 g/dL for females aged 15 years and older, and below 13 g/dL for males aged 15 years and older.

Classification of anemia based on red cell morphology categorized individuals into microcytic if their MCV values were below the age- and sex-specific normal range, normocytic if MCV values were within the normal range, and macrocytic if MCV values were above the normal range. The Mentzer index was calculated as the ratio of MCV to red blood cell count. Anemia severity was stratified as mild for Hb levels between 10.0-10.9 g/dL, moderate for levels between 7.0-9.9 g/dL, and severe for levels ≤6.9 g/dL (5,6).

This study was approved by KTO-Karatay University Pharmaceutical and Non-Medical Device Research Ethics Committee (Date:09.05.2024, Decision No: 2024/030).

Statistical Analysis

Statistical Package for Social Sciences for Windows Version 16.0, or SPSS 23.0, was used to perform the statistical analysis of the data. Descriptive statistics were reported as mean±standard deviation (SD) for numerical variables that fit into a normal distribution, and as median (range) for variables that didn't. The presentation of categorical variables consisted of counts and percentages (%). For categorical variables, group comparisons were carried out using Fisher's exact test and the chi-square test. We evaluated the normality of numerical parameters by applying the Shapiro-Wilk and Kolmogorov-Smirnov tests. For variables with a normal distribution, the t-test and ANOVA variance analysis were used to examine differences between group means; for variables without a normal distribution, the Mann-Whitney U test and Kruskal-Wallis test were employed. The outcomes were deemed statistically significant. For p-values less than 0.05, the results were deemed statistically significant.

RESULTS

Among the patients, 622 (54.2%) were male and 526 (45.8%) were female. The age was 5.25±4.05 years (median age 4.4, minimum-maximum age 0.7-17.8), with males having an average age of 5.29±4.14 years and females 5.21±3.94 years. Regarding the age distribution by sex, there was no significant difference (p: 0.184). The distribution of demographic and laboratory characteristics of the patients by sex is presented in **Tables 1** and **2**. Of the patients, 876 (76.3%) had Hb levels within the reference range for their age, while 272 (23.7%) were found to have anemia. Among

those with anemia, 149 (54.8%) were male and 123 (45.2%) were female. There was no discernible variation in the frequency of anemia between the sexes (p: 0.428). When examining the severity of anemia based on Hb levels, 209 patients (18.2%) had mild anemia, 62 (5.4%) had moderate anemia, and 1 had severe anemia. There was no statistically significant difference in the level of anemia by sex (p: 0.152).

Table 1. Demographic and laboratory characteristics of the hospitalized children according to sex

Variable	Males	Females	Total	p
Year				0.623
2021	51 (56.0)	40 (44.0)	91 (7.9)	
2022	224 (54.8)	185 (45.2)	409 (35.6)	
2023	282 (54.8)	233 (45.2)	515 (44.9)	
2024	65 (48.9)	68 (51.1)	133 (11.6)	
Age groups				0.195
6 months-2 years	170 (58.8)	119 (41.2)	289 (25.1)	
2.0-6.0 years	240 (51.2)	229 (48.8)	469 (40.9)	
6.0-12.0 years	153 (53.3)	134 (46.7)	287 (25.0)	
>12.0 years	59 (57.3)	44 (42.7)	103 (9.0)	
Hemoglobin				0.438
Normal	473 (54.0)	403 (46.0)	876 (76.3)	
Anemia	149 (54.8)	123 (45.2)	272 (23.7)	
Anemia Status				0.152
Mild	108 (51.7)	101 (48.3)	209 (18.2)	
Moderate	41 (66.1)	21 (33.9)	62 (5.4)	
Severe	0 (0)	1 (100.0)	1 (0.1)	
MCV level				0.112
<80 fL	416 (57.5)	308 (42.5)	724 (63.1)	
81-100 fL	206 (48.6)	218 (51.4)	424 (36.9)	
RDW level				0.001
Normal	422[a] (51.1)	404[a] (48.9)	826 (71.9)	
Increased	200[b] (62.1)	122[b] (37.9)	322 (28.1)	
Platelet count				0.276
Normal	528 (54.9)	434 (45.1)	962 (83.8)	
Thrombocytosis	94 (50.5)	92 (49.5)	186 (16.2)	
Mentzer index				0.173
< 13	47 (66.2)	24 (33.8)	71 (6.2)	
>13	575 (53.4)	502 (46.6)	1077 (93.8)	
Total	622 (54.2)	526 (45.8)	1148 (100.0)	

Regarding age groups, 289 patients (25.1%) were aged 6 months-<2 years, 469 (40.9%) were aged 2-<6 years, 287 (25.0%) were aged 6-12 years, and 103 (9.0%) were aged >12 years. The distribution of demographic and laboratory characteristics of the patients by age groups is shown in **Tables 3** and **4**. When analyzing the distribution of anemia by age group, Upon examining the anemia distribution by age group, it was found that 131 patients (48.2%) belonged to the 6 months–<2 years age group, 108 patients (39.7%) to the 2-<6 years age group, 27 patients (9.9%) to the 6–12 years age group, and 6 patients (2.2%) to the age group exceeding 12 years. Anemia frequency varied among age groups in a statistically significant way, with the 6-month–2-year and 2-<6-year age groups significantly different from the other age groups (p: 0.001) (**Table 3**).

The Hb level of the patients was 12.33±1.45 g/dl (median; min-max: 12.3; 7.5-17). The Hb levels did not significantly differ between the sexes (p: 0.858) (**Table 2**). When examining Hb levels by age groups, the levels were 11.41±1.22 g/dl for 6 months-2 years, 12.14±1.04 g/dl for 2-6 years, 12.96±1.09 g/dl for 6-12 years, and 13.73±1.53 g/dl for those over 12 years old. Between the age groups, there was a significant difference in Hb levels (p: 0.001) (**Table 4**).

Patients' MCV levels were examined in the study, revealing that 724 patients (63.1%) had low MCV levels, while 424 patients (36.9%) had levels within the normal range. When comparing MCV levels by sex, there was no significant difference (p: 0.112). Of the patients with low MCV levels, 251 (34.7%) belonged to the age group of 6 months-< 2 years, 315 (43.5%) to the age group of 2 -<6 years, 132 (18.2%) to the age group of 6 to 12 years, and 26 (3.6%) to the age group of more than 12 years. A statistical analysis of the MCV level distribution by age group revealed a significant difference (p: 0.001) between the 6-months-<2 years and 2-<6 years age groups and the other age groups (p: 0.001) (**Table 3**).

Table 2. Comparison of hemogram results of the hospitalized children according to sex

Variable	Males		Females		Total		p
	Mean±SD	Median (min-max)	Mean±SD	Median (min-max)	Mean±SD	Median (min-max)	
WBC (10^3/µL)	9.53±4.25	8.67 (2.31-31.58)	9.4±4.55	8.35 (2.16-33.88)	9.47±4.39	8.51 (2.16-33.88)	0.855
Neutrophil (10^3/µL)	5.21±3.29	4.35 (0.55-23.67)	4.9±3.08	4.3 (0.29-18.73)	5.07±3.2	4.32 (0.29-23.67)	0.118
Lymphocyte (10^3/µL)	3.57±2.3	3.01 (0.38-15.13)	3.69±2.03	3.26 (0-17.97)	3.62±2.18	3.16 (0-17.97)	0.171
RBC (10^6/µL)	4.8±0.44	4.76 (3.62-6.87)	4.71±0.41	4.7 (3.47-6.22)	4.76±0.43	4.73 (3.47-6.87)	0.002
Hemoglobin (g/dL)	12.33±1.45	12.3 (7.5-17)	12.3±1.23	12.3 (6-15.8)	12.31±1.35	12.3 (6-17)	0.858
Htc (%)	36.77±3.92	36.5 (24.1-49.3)	36.81±3.43	36.8 (21.7-47.9)	36.79±3.7	36.7 (21.7-49.3)	0.540
MCV (fL)	76.95±6.77	77.75 (53.7-96.4)	78.48±6.16	79.25 (51.6-99)	77.65±6.54	78.6 (51.6-99)	0.001
MCH (pg)	25.86±2.67	26.2 (16.6-35.1)	26.33±2.49	26.6 (16.2-43.5)	26.07±2.6	26.4 (16.2-43.5)	0.003
MCHC (g/dL)	33.64±1.37	33.6 (27-37.8)	33.61±1.63	33.6 (27.5-56)	33.62±1.49	33.6 (27-56)	0.408
RDW (%)	14.34±1.6	13.95 (11.8-24)	13.98±1.36	13.7 (11.9-21.9)	14.18±1.51	13.8 (11.8-24)	0.001
PLT (103/µL)	342.44±123.39	325.5 (33-1168)	342.24±118.19	316 (74-950)	342.35±120.98	322 (33-1168)	0.939
MPV (fL)	9.06±1.03	8.9 (7-13.1)	9.09±1.01	8.95 (6.8-13.5)	9.07±1.02	8.9 (6.8-13.5)	0.562
PDW (fL)	15.33±1.27	15.6 (9.7-17.1)	15.2±1.44	15.6 (10-17.3)	15.27±1.35	15.6 (9.7-17.3)	0.294
PCT (%)	0.34±0.3	0.29 (0.03-3.54)	0.33±0.23	0.29 (0.09-2.73)	0.33±0.27	0.29 (0.03-3.54)	0.718

Table 3. Demographic and laboratory characteristics of the hospitalized children according to age groups

Variable	Age groups				p
	6 months-<2 years	2-<6 years	6-12 years	>12 years	
Year					0.513
2021	24 (26.4)	38 (41.8)	23 (25.2)	6 (6.6)	
2022	105 (25.7)	172 (42.1)	95 (23.2)	37 (9.0)	
2023	125 (24.3)	197 (38.3)	145 (28.2)	48 (9.3	
2024	35 (26.3)	62 (46.6)	24 (18.0)	12 (9.0)	
Hemoglobin					0.001
Normal	158^{a} (18.0)	361^{b} (41.2)	260^{b} (29.7)	97^{b} (11.1)	
Anemia	131^{a} (48.2)	108^{b} (39.7)	27^{c} (9.9)	6^{c} (2.2)	
Anemia status					0.001
Normal	158^{a} (18.0)	361^{b} (41.2)	260^{b} (29.7)	97^{b} (11.1)	
Mild	92^{a} (44.0)	89^{b} (42.6)	623^{c} (11.0)	5^{c} (2.4)	
Moderate	39^{a} (62.9)	19^{b} (30.6)	4^{b} (6.5)	0 (0)	
Severe	0^{a} (0)	0^{a} (0)	0 (0)	1^{a} (100.0)	
MCV (fL)					0.001
<80	251^{a} (34.7)	315^{b} (43.5)	132^{c} (18.2)	26^{c} (3.6)	
81-100	38^{a} (9.0)	154^{b} (36.3)	155^{c} (36.6)	77^{c} (18.2)	
RDW (%)					0.001
Normal	139^{a} (16.8)	351^{b} (42.5)	246^{c} (29.8)	90^{c} (10.9)	
Increased	150^{a} (46.6)	118^{b} (36.6)	41^{c} (12.7)	13^{c} (4.0)	
Platelet count					0.001
Normal	205^{a} (21.3)	396^{b} (41.2)	261^{bc} (27.1)	100^{c} (10.4)	
Thrombocytosis	84^{a} (45.2)	73^{b} (39.2)	26^{bc} (14.0)	3^{c} (1.6)	
Mentzer index					0.003
<13	31^{a} (43.7)	24^{b} (33.8)	11^{b} (15.5)	5^{ab} (7.0)	
>13	258^{a} (24.0)	445^{b} (41.3)	276^{b} (25.6)	98^{ab} (9.1)	
Total	289 (25.1)	469 (40.9)	287 (25.0)	103 (9.0)	

Table 4. Comparison of hemogram results of the hospitalized children by age groups

Variable	6 months-<2 years Mean±SD	2.0-<6.0 years Mean±SD	6.0-12.0 years Mean±SD	>12.0 years Mean±SD	p
RBC (106/µL)	4.70±0.43^{a}	4.69±0.39^{a}	4.83±0.43^{b}	4.92±0.47^{b}	0.001
Hemoglobin (g/dL)	11.41±1.22^{a}	12.14±1.04^{b}	12.96±1.09^{c}	13.73±1.53^{d}	0.001
MCV (fL)	73.82±6.63^{a}	77.48±5.71^{b}	79.81±5.30^{c}	83.12±6.54^{d}	0.001
MCH (pg)	24.44±2.63^{a}	26.10±2.30^{b}	26.97±2.06^{c}	27.98±2.57^{d}	0.001
MCHC (g/dL)	33.11±1.42^{a}	33.77±1.62^{b}	33.86±1.27^{b}	33.69±1.31^{b}	0.001
RDW (%)	15.09±1.81^{a}	14.08±1.38^{b}	13.61±0.91^{c}	13.62±1.20^{c}	0.001

The MCV level of the patients was 77.65±6.54 fL (51.6–99.0), with males having a mean MCV level of 76.95±6.77 fL (53.7-96.4) and females 78.48±6.16 fL (51.6-99). When the mean MCV levels were compared by sex, a significant difference was found (p: 0.001) (**Table 2**). When MCV levels were divided by age groups, all groups showed important differences (p: 0.001) (**Table 3**).

Of the patients diagnosed with anemia based on Hb levels, 223 (82.0%) had microcytic anemia while 49 (18.0%) had normocytic anemia. A significant difference was found in the MCV levels of patients diagnosed with anemia when compared statistically (p: 0.001). The distribution of demographic and laboratory findings of patients diagnosed with anemia based on their Hb levels is presented in **Table 5**. The distribution of anemia status among patients by age groups is illustrated in **Figure 1**.

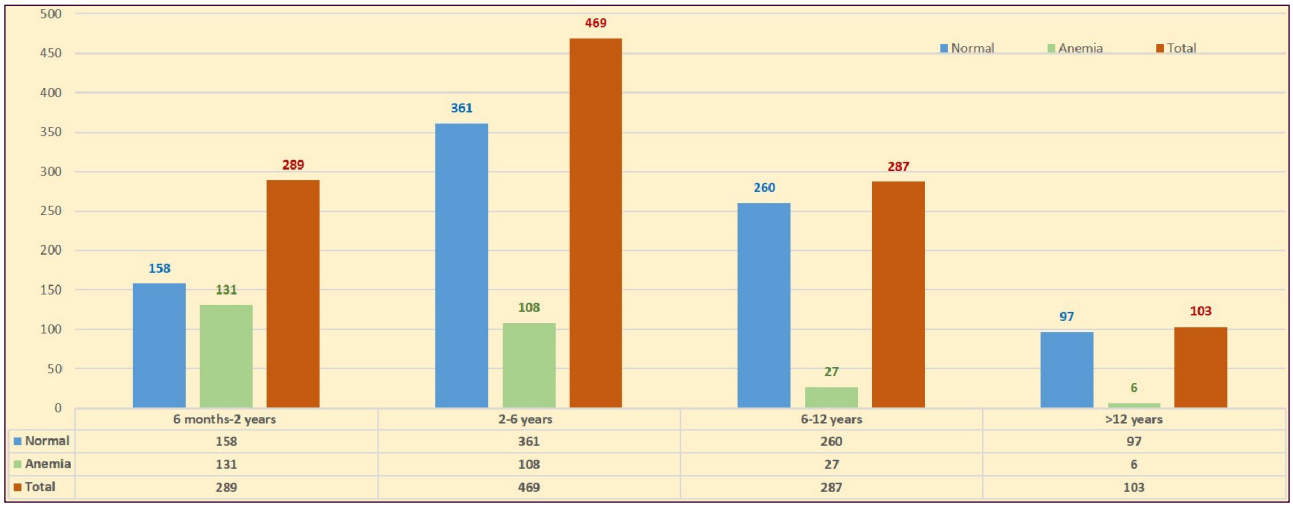

Figure 1. Distribution of anemia in hospitalized children according to age groups

Table 5. Comparison of demographic and laboratory findings of hospitalized children without and with anemia

Variable	Children without anemia n (%)	Children with anemia n (%)	p
Sex			0.821
Male	473 (54.0)	149 (54.8)	
Female	403 (46.0)	123 (45.2)	
Age groups			0.001
6 months-<2 years	158[a] (54.7)	131[b] (45.3)	
2.0-<6.0 years	361[a] (77.0)	108[b] (23.0)	
6.0-12.0 years	260[a] (90.6)	27[b] (9.4)	
>12.0 years	97[a] (94.2)	6[b] (5.8)	
Year			0.005
2021	80[a] (9.1)	11[b] (4.0)	
2022	322[a] (36.8)	87[a] (32.0)	
2023	381[a] (43.5)	134[a] (49.3)	
2024	93[a] (10.6)	40[a] (14.7)	
MCV level			0.001
<80 fL	501[a] (57.2)	223[b] (82.0)	
81-100 fL	375[a] (42.2)	49[b] (18.0)	
RDW level			0.005
Normal	713[a] (81.4)	113[b] (41.5)	
Increased	163[a] (18.6)	159[b] (58.5)	
Platelet count			0.001
Normal	751[a] (85.7)	211[b] (77.6)	
Thrombocytosis	125[a] (14.3)	61[b] (22.4)	
Mentzer index			0.001
<13	25[a] (35.2)	46[b] (64.8)	
>13	851[a] (79.0)	226[b] (21.0)	
Total	876 (76.3)	272 (23.7)	

Among the patients, 186 (16.2%) were diagnosed with thrombocytosis, while 962 (83.8%) had platelet counts within the normal range. Of those with thrombocytosis, 94 (50.5%) were male and 92 (49.5%) were female. When patients with thrombocytosis were analyzed by age groups, 84 (45.2%) were in the 6 months-<2 years age group, 73 (39.2%) were in the 2-<6 years age group, 26 (14.0%) were in the 6-12 years age group, and 3 (1.6%) were >12 years old. When the distribution of platelet counts among patients diagnosed with anemia was examined, 211 (77.6%) had platelet counts within normal ranges, while 61 (22.4%) had thrombocytosis. A significant difference was observed in the distribution of platelet counts among patients diagnosed with anemia (p: 0.001) (**Table 5**).

71 (6.2%) of the study's patients had a Mentzer index of less than 13 after being examined. There was no discernible difference in the Mentzer index when compared by sex (p: 0.173). There was a significant difference between the 6 months-2 years and 2-6 years age groups and other age groups in the distribution of patients with a Mentzer index <13 by age groups (p: 0.003) (**Table 3**).

DISCUSSION

Anemia in children is a major global public health concern, leading to substantial morbidity (7). The frequency of anemia varies according to age, sex, socioeconomic status, and geographic regions. In regions with low to moderate socioeconomic conditions, inadequate and unbalanced nutrition remains a primary cause of anemia. Clinical manifestations may or may not be present in anemic patients, and the diagnosis may be incidental during laboratory testing (8). Our study results demonstrated a frequency of anemia in nearly one out of every four children hospitalized in our region.

Childhood represents a period of rapid growth and development, during which both nutritional deficiencies and anemia-related issues can have lasting effects. Identifying deficiencies and determining at-risk children before clinical manifestations of nutritional deficiencies or anemia emerge is crucial for improving public health. To implement national health programs, it is essential to identify anemia and associated risk factors for anemia development across all age groups nationwide. In our country, interpretations are based on studies conducted

in different cities and age groups, as there is no nationwide frequency study encompassing all children. A hospital-based study in India in 2014 reported an anemia frequency of approximately 73% among hospitalized children aged 6 months to 12 years (9). Another study in India in 2017 found a general anemia frequency of 32.21% among hospitalized children aged 2-12 years (10). A study conducted in Pakistan in 2021 revealed that 63.7% of hospitalized children aged 1-5 years had anemia (11). In our study, 23.7% of the 1148 children hospitalized in the pediatric clinic were diagnosed with anemia. Anemia was more prevalent in the 6 months-2 years age group (48.2%) and the 2-6 years age group (39.7%). The rapid growth and development during these periods contribute to the increased frequency of anemia. Additionally, during and after the school years, we found a decline in the prevalence of anemia in our study.

According to a 2016 meta-analysis, Middle and Western Sub-Saharan Africa had the highest anemia frequencies, at 45% and 43%, respectively. While Chile, Venezuela, Canada, and Ukraine had anemia rates exceeding 14%, they were globally reported to have the lowest levels of anemia (12). Studies from different regions of our country have reported varying rates of anemia frequency. These epidemiological studies included different age groups in different regions. The reported frequency of anemia in various studies conducted in different cities in our country ranged from 3.5% to 45.6%. For instance, a study in Manisa including children aged 0-14 years reported a frequency of 44%, while in Tokat, the frequency was as high as 43.7% among elementary school children (15,16). In a study conducted in Konya in 2013, the frequency of anemia among hospitalized children was found to be 3.29% (17). This variation may be attributed to factors such as the level of development in the country or region, sample size, age groups, and whether the children were hospital admissions or part of school screenings.

Childhood encompasses periods of rapid growth and development, such as infancy and puberty, during which there is a heightened need for various nutritional factors, particularly iron (18). Our study also highlighted the period of 6 months-2 years as one with a high frequency of anemia, characterized by external dependency on nutrition, unbalanced and irregular dietary issues, frequent infections, and rapid growth. It is natural for the frequency of anemia to be higher in this age group compared to others. Our study also observed a significantly high frequency of anemia in the pre-school period, which decreased during the school years.

Children under the age of five are particularly at risk due to the rapid growth and development during this period. In a study by Stevens et al. in 2011, it was found that 43% of children under the age of five were anemic worldwide (19). This issue suggests that globally, 273 million children under the age of 5 are anemic. In Africa, Southeast Asia, and the Eastern Mediterranean countries, the frequency of anemia was found to be 67.6%, 65.5%, and 46.7%, respectively (20). The frequency of anemia is much lower in developed countries like Europe (22%) and America (29%). In India, the frequency of anemia was reported as 74.35% in the 6-35 months age group, 78% in Nepal in the 6-59 months age group, and 73.7% in Kazakhstan in the 0-23 months age group (21). In a study by Akkermans et al. involving patients from the Netherlands, Germany, and the UK, 18.9% of children aged 1-3 years were found to be anemic (22). It is estimated that 20% of children in America have anemia (23).

In our country, a study by Karagün et al. in Sivas found an anemia frequency of 5.9% in children aged 1-15 years (24). In a study by Güngör et al. in Samsun involving children aged 7-14 years, the frequency of anemia was 9.4% (25). In Zonguldak, a study in 2017 including 392 children aged 6-14 years found an anemia frequency of 13.5% (26). In a study conducted in Amasya in 2018 involving 213 patients aged 1-17 years, an anemia frequency of 29.6% was reported (27). Although anemia rates varied by region, overall, high rates of anemia were found in children under the age of five, similar to our study findings.

The World Health Organization reported an anemia frequency of 25.4% in school-age children, including this age group. In the same publication, the frequency of anemia in school-age children in Europe was reported as 9.3% (28). In a study by Gür et al. in our country, the frequency of anemia in children aged 6-16 years was reported as 27.6%, with a prevalence of 26.2% in the 6-10 year age group (29). In Samsun, Güngör et al. found a prevalence of 9.4% in children aged 7-14 years (25). In our study, we found a lower frequency of anemia in children during the school-age period.

Anemia frequency varies in different studies in terms of sex distribution. Zuffo et al. observed a higher frequency of anemia in males in daycares and nurseries in Brazil (30). However, Gür et al. did not find a difference in terms of sex in their study (29). In our study, 12.9% of males and 10.7% of females were anemic. We found a significantly higher frequency of anemia, especially in the 6 months-<2 years age group compared to other age groups.

A Hb level of less than 7 g/dl in children under 5 years old and less than 8 g/dl in other age groups is considered severe anemia. Severe anemia can lead to high-output heart failure and death. A cross-sectional study in Pakistan in 2022 involving children aged 1 month to 12 years found anemia in 43.1% of children, with 26.7% having mild anemia and 45.5% having moderate anemia (31). Similarly, in our study, we found a high rate of mild anemia and a low rate of severe anemia.

Reactive thrombocytosis is frequently described in children with iron deficiency. However, the mechanism of development is not well understood. Due to the homologous structure of thrombopoietin and erythropoietin (EPO), it has been thought that EPO increases thrombopoiesis, but this has not been proven (32). In our study, thrombocytosis was found in 22.4% of anemic patients. Other etiological diagnostic tests were not performed in hospitalized patients, as the aim of the study was not focused on this aspect. It should also be noted that thrombocytosis is an acute-phase reactant.

Thalassemia is a disease that affects 1-4% of the global population (33). It is more commonly observed in regions such as the Mediterranean, Sub-Saharan Africa, the Middle East, and India (34). Given the high frequency of thalassemia in our region, it should be considered as a differential diagnosis for microcytic anemia in our province. In our study, we found that 16.9% of our anemic patients had a Mentzer index <13, while 83.1% had a Mentzer index >13. Therefore, the Mentzer index can be easily applied in the differential diagnosis of microcytic anemia.

Limitations of Our Study

The goal of this study was to find out how common anemia is among hospitalized patients, with a focus on erythrocyte morphology. Notably, biochemical markers including B12 vitamin, folate, and ferritin levels were not assessed in the current analysis, owing to its retrospective nature. As a result, it's possible that the results of this study cannot be applied to a larger pediatric population. There is a need for comprehensive studies aimed at investigating anemia in both inpatient and outpatient populations. These studies should include the analysis of vitamin B12, folate, and ferritin levels, as these parameters are essential for a thorough understanding of the pathophysiology and potential causes of anemia. Nevertheless, the substantial sample size of the study cohort represents a notable strength of the investigation.

CONCLUSION

Our study results indicated that mild anemia was the most common type of anemia detected in hospitalized children, with the highest frequency observed in the 6 months-<2 years age group, and microcytic anemia was the most common type based on erythrocyte morphology. Hemogram analysis, which is a simple and cost-effective method, can assist in classifying anemia based on erythrocyte morphology. This can facilitate further testing for the underlying etiology in patients diagnosed with anemia.

ETHICAL DECLARATIONS

Ethics Committee Approval: This study was approved by KTO-Karatay University Pharmaceutical and Non-Medical Device Research Ethics Committee (Date:09.05.2024, Decision No: 2024/030).

Informed Consent: Because the study was designed retrospectively, no written informed consent form was obtained from patients.

Referee Evaluation Process: Externally peer-reviewed.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declared that this study has received no financial support.

Author Contributions: All of the authors declare that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

REFERENCES

1. D'Souza AM. A General Pediatrician's Approach to Anemia in Childhood. Pediatr Ann. 2020;49(1):10-6.
2. Mghanga FP, Genge CM, Yeyeye L, et al. Magnitude, Severity, and Morphological Types of Anemia in Hospitalized Children Under the Age of Five in Southern Tanzania. Cureus 2017;9(7): e1499.
3. Simbauranga RH, Kamugisha E, Hokororo A, et al. Prevalence and factors associated with severe anaemia amongst under-five children hospitalised at Bugando Medical Centre, Mwanza, Tanzania. BMC Hematol. 2015;12:13.
4. Dos Santos RF, Gonzalez ES, de Albuquerque EC, et al. Prevalence of anemia in under five-year-old children in a children's hospital in Recife, Brazil. Rev Bras Hematol Hemoter. 2011;33(2):100-4.
5. World Health Organization (WHO). Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. World Health Organization, Geneva, Switzerland, 2011.
6. Vaswani ND, Lekhwani S, Swami M. Clinical profile and etiology of severe anemia in hospitalized children aged 6 months to 5 years. IP Int J Med Paediatr Oncol 2020;6:68-71
7. WHO. The global prevalence of anaemia in 2011. Geneva:World Health Organization; 2015;
8. Yazıcı S, Çelik T, Seyrek K. Anemia Prevalance Among Children. İzmir Dr. Behçet Uz Çocuk Hast Derg 2012;2:6-9.
9. Saba F, Poornima S, Balaji PA, Varne SR, Jayashree K. Anemia among hospitalized children at a multispecialty hospital, bangalore (karnataka), India. J Family Med Prim Care. 2014;3(1):48-53.
10. Ritu S, Ashok D, Vithal TP, Shivani R, Rajaram N. A hospital based study on anemia prevalence in children of an Indian Island. Int J Pediatr. 2017;5(12):6245-52.
11. Khan L, Zafar F, Iqbal M. Anemia among Hospitalized Children-A Study Based on Occurrence, Morphology and Associated Factors. Pakistan Journal of Medicine and Dentistry. 2021;10(3): 30-5.
12. Kassebaum NJ, Fleming TD, Flaxman A, Phillips DE, Steiner C, Barber RM, et al. The Global Burden of Anemia. Hematol Oncol Clin North Am. 2016;30(2):247–308.
13. Yavuz T, Korkut S, Yavuz O, Kocabay K. Batı-Karadeniz Bölgesinde Adölesanlarda Anemi ve Demir Eksikliği Anemisi Prevalansı. Turkiye Klinikleri J Pediatr. 2004;13(2):71-5.
14. Çıkım G. Adolescent Iron Deficiency Anemia Incidence in Kahramanmaras. Int J Basic Clin Stud (IJBCS) 2019;8(2):17-23.
15. Revanlı M, Tosun SY, Tanyeli F. Manisa İlinde Çocuk Döneminde Demir Eksikliği Anemisinin araştırılması. İzmir Ataturk Eğitim Hastanesi Tıp Derg 2002:40:59-62.
16. Şapçı H, Koçoğlu G, Sümer H. Tokat'ın Almus ilçesinde ilkokul çocuklarında anemi sıklığı ve bunu etkileyen faktörler üzerine bir araştırma. Cumhuriyet Universitesi Tip Fakultesi Derg 1999;21:141-4.
17. Akin F, Solak ES, Kilicaslan C, Böke SB, Arslan Ş. Iron Deficiency

Anemia among Hospitalized Children in Konya, Turkey. Anemia, 2013;2013:514801.

18. Vatandaş N, Atay G, Tarcan A, Kanra S, Özbek N. Iron prophylaxis and anemia during the first year of life. Çocuk Sağlığı ve Hastalıkları Derg 2007;50:12-5.
19. Stevens GA, Finucane MM, De-Regil LM, et al. Global, regional, and national trends in haemoglobin concentration and prevalence of total and severe anaemia in children and pregnant and non pregnant women for 1995–2011: a systematic analysis of population-representative data. Lancet Glob Health 2013;1: e16–25.
20. Benoist B, McLean E, Egli I, Cogswell, M. Worldwide prevalence of anemia 1993-2005: WHO Global Database on Anemia. Geneva: World Health Organization, 2008.
21. Hall A, Bobrow E, Brooker S, et al. Anemia in school children in eight countries in Africa and Asia. Public Health Nutr 2001;4:749-56.
22. Akkermans MD, Eussen SR, van der Horst-Graat JM, van Elburg RM, van Goudoever JB, Brus F. A micronutrient-fortified young-child formula improves the iron and vitamin D status of healthy young European children: a randomized, double-blind controlled trial. Am J Clin Nutr. 2017;105(2):391-9.
23. Irwin JJ, Kirchner JT. Anemia in children. Am Fam Physician. 2001; 64(8):1379-86.
24. Karagün BŞ, Korkmaz Ö, Gürsu AH, et al. Sivas ilinde hastaneye başvuran 1-15 yaş grubu çocuklar arasında anemi prevalansı. Güncel Pediatri. 2014;2:67-72.
25. Güngör O, Albayrak D. Samsun ilinde 7-14 yaş arasındaki çocuklarda demir eksikliği ve demir eksikliği anemisi sıklığı. İzmir Dr. Behçet Uz Çocuk Hast Derg 2018;8(2):122-6.
26. Kefeli M, Örnek Z, Kardeş H. Okul çağındaki çocuklarda vitamin B 12 , folat ve demir eksikliği prevalansının değerlendirilmesi The evaluation of vitamin B 12 , folate and iron deficiency prevalence in school-age children. Ege Tıp Derg. 2021;60(3):244-51.
27. Celep G, Durmaz H. Çocuklarda Demir Eksikliği ve Demir Eksikliği Anemisi: Tek Merkez Deneyimi. IGUSABDER 2021;13:16–29.
28. World Health Organization. Worldwide prevalence of Anemia 1993- 2005.WHO Global Database on Anemia, Geneva, 2008.
29. Gür E, Yıldız I, Celkan T. Prevalence of anemia and the risk factors among school children in Istanbul. J Trop Pediatr 2005;51:346-50.
30. Zuffo CR, Osório MM, Taconeli CA, Schmidt ST, da Silva BH, Almeida CC. Prevalence and risk factors of anemia in children. J Pediatr (Rio J). 2016;92(4):353-60.
31. Hajrah S, Butt MHA, Faheem F, Kaleem N, Khan AU. Frequency of Anemia in Hospitalized Children Ages 0-12 Years and Associated Factors: A Cross-Sectional Study. Pak J Public Health. 2022;12(4):172-8.
32. Dan K. Thrombocytosis in iron deficiency anemia. Intern Med. 2005;44:1025-6.
33. Weatherall DJ. The inherited diseases of hemoglobin are an emerging global health burden. Blood. 2010;115(22):4331-6.
34. Taher AT, Weatherall DJ, Cappellini MD. Thalassaemia. Lancet. 2018;391(10116):155-67.