ORIGINAL RESEARCH

To investigate anemia in the pediatric population and analyze the associated hematological parameters

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ABSTRACT

Aim: This study aimed to investigate the prevalence, types, and severity of anemia in the pediatric population and analyze the associated hematological parameters to identify risk factors for anemia in children aged 1 to 12 years. **Materials and Methods:** A cross-sectional study was conducted at the pediatric outpatient and inpatient departments of a tertiary care hospital over six months, involving 100 children aged 1 to 12 years. Data collection included demographic information, clinical assessment, and laboratory investigations, focusing on complete blood count (CBC) parameters. Anemia was classified into microcytic, normocytic, or macrocytic types based on mean corpuscular volume (MCV) and categorized by severity into mild, moderate, or severe anemia. Statistical analysis was performed using descriptive statistics, chi-square tests, t-tests, and logistic regression to determine significant predictors of anemia. **Results:** The study revealed that 60% of the children were diagnosed with anemia, with microcytic anemia being the most prevalent type (58.3%), followed by normocytic (30%) and macrocytic anemia (11.7%). Moderate anemia was the most common severity level (46.7%), while severe anemia affected 20% of the anemic children. Anemic children had significantly lower mean hemoglobin levels (9.5 ± 1.2 g/dL) compared to non-anemic children (12.8 ± 1.1 g/dL) and lower hematocrit levels (30.2 ± 3.5% vs. 37.8 ± 3.0%). Logistic regression identified underweight status and prolonged symptom duration as significant predictors of anemia. **Conclusion:** The high prevalence of microcytic anemia in the pediatric population underscores the need for focused nutritional interventions to address iron deficiency. Early detection and management of moderate and severe anemia are crucial to prevent long-term health complications in children. Nutritional status and prolonged symptoms were identified as key risk factors for developing anemia, emphasizing the importance of targeted strategies in pediatric healthcare.

Keywords: Anemia, Pediatric population, Microcytic anemia, Hematological parameters, Risk factors.

INTRODUCTION

Anemia is one of the most prevalent hematological disorders affecting the pediatric population worldwide, characterized by a reduction in the number of red blood cells (RBCs) or hemoglobin concentration below the normal levels for age, gender, and altitude. It represents a significant public health concern, particularly in developing countries, where nutritional deficiencies, infectious diseases, and socioeconomic factors contribute to its high prevalence. Anemia in children can lead to a range of complications, including impaired cognitive development, delayed growth, decreased physical endurance, and a weakened immune response, all of which can have long-term consequences on a child's overall health and quality of life.[1]The diagnosis of anemia in the pediatric population involves a comprehensive analysis of hematological parameters that include hemoglobin levels, hematocrit, red blood cell indices such as mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC), as well as red cell distribution width (RDW). These parameters help determine not only the presence of anemia but also its type and severity. Understanding the type of anemia is essential in identifying its underlying cause, as different types of anemia have distinct etiological factors. For instance, microcytic anemia is often associated with iron deficiency, while macrocytic anemia may be linked to vitamin B12 or folate deficiency.The most common types of anemia in children include microcytic, normocytic, and macrocytic anemia. Microcytic anemia, typically resulting from iron deficiency, is the most prevalent

form in pediatric cases. Iron is a crucial component of hemoglobin, the protein in red blood cells that binds and carries oxygen throughout the body. In children, iron deficiency can occur due to inadequate dietary intake, poor absorption, or increased demand during periods of rapid growth. Normocytic anemia, which involves red blood cells of normal size but reduced in number, may be caused by chronic diseases, infections, or acute blood loss. Macrocytic anemia, characterized by larger-than-normal red blood cells, is often related to deficiencies in vitamin B12 or folate, substances necessary for proper red blood cell formation.[2]In pediatric populations, anemia can also be influenced by genetic factors, infectious diseases, and inflammatory conditions. Sickle cell anemia and thalassemia are examples of genetic conditions that can lead to chronic anemia in children. Infections such as malaria, parasitic infestations, and chronic inflammatory diseases can cause anemia of inflammation or anemia of chronic disease. These types of anemia are often more challenging to treat, as they are associated with underlying pathologies that need to be addressed in conjunction with the anemia itself.The severity of anemia in children is usually classified as mild, moderate, or severe, based on the hemoglobin concentration levels. Mild anemia may present with subtle symptoms like fatigue and pallor, which are often overlooked or attributed to other causes. Moderate anemia typically shows more pronounced symptoms, including irritability, shortness of breath, dizziness, and a noticeable decrease in physical activity levels. Severe anemia is a medical emergency that requires immediate intervention, as it can lead to serious complications such as heart failure, growth retardation, and impaired cognitive function. Identifying the severity of anemia is crucial for initiating timely treatment and preventing long-term health effects.[3]Pediatricanemia is a multifactorial condition influenced by dietary habits, socioeconomic status, access to healthcare, and environmental factors. Nutritional deficiencies, particularly iron, vitamin B12, and folate, play a significant role in the development of anemia among children. Socioeconomic factors such as poverty, lack of education, and limited access to nutritious food contribute to the persistence of anemia in low-income populations. In many regions, children from lower socioeconomic backgrounds are more likely to suffer from malnutrition, which directly affects their hemoglobin levels and overall health.Screening and early diagnosis of anemia in children are vital for reducing its prevalence and associated morbidity. Routine blood tests and clinical evaluations help in detecting anemia at an early stage, allowing for prompt treatment and intervention. Public health strategies aimed at improving child nutrition, fortifying staple foods with iron and other essential vitamins, and increasing awareness about the importance of a balanced diet are crucial steps in addressing the root causes of anemia. In addition, providing affordable and accessible healthcare services plays a significant role in managing and preventing anemia in vulnerable populations.[4]Treatment of pediatricanemia depends on the underlying cause and the severity of the condition. Iron supplementation is the standard treatment for iron deficiency anemia, and it is often accompanied by dietary modifications to enhance iron intake and absorption. In cases of vitamin B12 or folate deficiency, oral supplements or injections may be prescribed to restore normal levels. For children with anemia caused by chronic diseases or genetic conditions, treatment focuses on managing the primary disease and improving the child's overall health status. Regular monitoring of hematological parameters is essential to evaluate the effectiveness of the treatment and to adjust therapeutic strategies as needed.[5]Prevention of anemia in the pediatric population requires a multi-pronged approach that includes improving dietary practices, enhancing maternal nutrition during pregnancy, and implementing deworming and vaccination programs to reduce the risk of infections. Educating parents and caregivers about the importance of providing iron-rich foods, such as lean meats, beans, fortified cereals, and leafy green vegetables, is also crucial in preventing iron deficiency anemia. In areas with high rates of malnutrition and poverty, community-based nutrition programs and initiatives can make a significant impact in reducing the incidence of anemia among children.

MATERIALS AND METHODS

This study utilized a cross-sectional design to investigate the hematological findings of anemia in the pediatric population. The primary objective was to assess the prevalence and types of anemia in children aged 1 to 12 years by analyzinghematological parameters. The study was conducted at the pediatric outpatient and inpatient departments of a tertiary care hospital over a period of six months.A total of 100 pediatric patients aged 1 to 12 years were enrolled in this study. The sample size was calculated to provide sufficient statistical power to detect significant differences in hematological parameters among anemic and non-anemic children.

Inclusion Criteria

- Children aged 1 to 12 years.
- Diagnosed with anemia based on clinical symptoms and laboratory findings.
- Consent obtained from parents or legal guardians for participation in the study.
- No prior history of chronic hematological disorders.

Exclusion Criteria

- Children with known inherited blood disorders (e.g., sickle cell anemia, thalassemia).
- Recent history of blood transfusion in the last three months.

- Presence of severe acute infection or any other medical condition affecting hematological parameters.
- Inability of parents or guardians to provide informed consent for participation.

Data Collection

Data collection for this study was conducted using a structured data collection form designed to gather detailed and relevant information about each participant. The form was organized into several sections to ensure a comprehensive assessment. Demographic information was collected, including the age, gender, weight, and nutritional status of the child, to establish baseline characteristics and understand potential risk factors for anemia. The clinical assessment focused on documenting specific symptoms of anemia, such as pallor, fatigue, and shortness of breath, along with the duration of these symptoms and any significant findings observed during physical examination. Lastly, laboratory investigations were conducted, where the complete blood count (CBC) was performed, including measurements of red blood cell count (RBC), hemoglobin (Hb) level, hematocrit (Hct), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and red cell distribution width (RDW). These laboratory parameters were crucial for diagnosing and classifying the type and severity of anemia in each child.

Laboratory Analysis

The laboratory analysis involved a multi-step process starting with blood sample collection through venipuncture, carried out under strict aseptic conditions to ensure the integrity and accuracy of the samples. This step was vital for obtaining reliable data for further analysis. The collected blood samples underwent hematological analysis using an automated hematologyanalyzer. The complete blood count (CBC) results were crucial in defining anemia, which was diagnosed based on the hemoglobin level falling below the age-specific reference range, such as Hb < 11 g/dL for children aged 1 to 5 years and Hb < 11.5 g/dL for children aged 6 to 12 years. The analysis further involved the classification of anemia based on the mean corpuscular volume (MCV), categorizing it into microcytic (MCV < 80 fL), normocytic (MCV 80-100 fL), or macrocytic (MCV > 100 fL) anemia. The severity of anemia was classified as mild, moderate, or severe, depending on the hemoglobin levels, which helped in determining the extent of the condition in the pediatric population.

Statistical Analysis

For the analysis of the collected data, the Statistical Package for the Social Sciences (SPSS) software, version 21.0, was used. Descriptive statistics were employed to summarize the demographic and hematological data, presenting them in terms of frequencies, percentages, means, and standard deviations, which provided a clear overview of the study's findings. Inferential statistics were then applied to explore the relationships and differences within the data. Chi-square tests were used to assess associations between categorical variables such as age, gender, and type of anemia, while independent t-tests were conducted to compare mean hemoglobin levels and other hematological parameters between anemic and non-anemic groups. Logistic regression analysis was also performed to identify independent predictors of anemia in the pediatric population, allowing for a more detailed understanding of the risk factors involved. Statistical significance was determined with a p-value of <0.05, indicating that any results with this value were considered statistically significant and unlikely to have occurred by chance.

RESULTS

Table 1: Demographic Profile of Study Participants

The demographic profile of the study participants revealed that the age distribution was fairly balanced among the three age groups. Children aged 1-3 years constituted 30% of the population, those aged 4-7 years made up the largest group at 40%, and children aged 8-12 years also comprised 30% of the total participants. Gender distribution showed a slight predominance of males, with 55% of the participants being male and 45% female. Nutritional status was also assessed, and 60% of the children were classified as having normal nutritional status, while 40% were found to be underweight. These findings suggest that the study included a diverse population in terms of age and nutritional status, with a slight male predominance.

Table 2: Prevalence of Anemia in Pediatric Population

The prevalence of anemia in the pediatric population was notably high, with 60% of the participants diagnosed with anemia, while 40% were classified as non-anemic. This high prevalence indicates that anemia is a significant health issue among the pediatric population in the study setting. The fact that over half of the children exhibited low hemoglobin levels highlights the need for further investigation into the underlying causes of anemia in this age group.

Table 3: Types of Anemia in Pediatric Population

Among the 60 children diagnosed with anemia, the most common type was microcytic anemia, affecting 58.3% of the anemic cases. Normocytic anemia accounted for 30% of the cases, while macrocytic anemia was present in 11.7% of the children. The predominance of microcytic anemia suggests that iron deficiency could be a major contributing factor, as this type of anemia is often associated with low iron levels. Normocytic anemia, while less common, could indicate chronic disease or other underlying

conditions. Macrocytic anemia, being the least common, may be linked to deficiencies in vitamin B12 or folate.

Table 4: Severity of Anemia in Pediatric Population

The severity of anemia among the pediatric patients was categorized into mild, moderate, and severe based on hemoglobin levels. The largest proportion of children, 46.7%, had moderate anemia, followed by 33.3% with mild anemia. Severe anemia was observed in 20% of the anemic children. This distribution indicates that while moderate anemia is the most prevalent, a significant number of children suffer from severe anemia, which can have serious implications for their overall health and development. The presence of severe anemia in 20% of the cases underscores the need for targeted interventions to prevent and manage anemia in this population.

Table 5: Laboratory Parameters of Anemic and Non-Anemic Children

Laboratory analysis showed significant differences in hematological parameters between anemic and non-anemic children. The mean hemoglobin level in anemic children was 9.5 ± 1.2 g/dL, significantly lower than the mean of 12.8 ± 1.1 g/dL in non-anemic children, with a p-value of <0.001. Hematocrit levels also showed a marked difference, with anemic children having a mean of 30.2 ± 3.5% compared to 37.8 ± 3.0% in non-anemic children, which was statistically significant ($p < 0.001$). Mean Corpuscular Volume (MCV) was lower in anemic children at 72.4 ± 8.2 fL, compared to 86.5 ± 7.3 fL in non-anemic children, with a p-value of <0.05. Red Cell Distribution Width (RDW) was higher in anemic children (16.8 ± 2.3%) compared to non-anemic children (13.5 ± 1.7%), also significant at a p-value of <0.05. These findings demonstrate that anemic children not only have lower hemoglobin levels but also exhibit significant changes in other hematological parameters, indicating a more complex alteration in their blood profile.

Table 6: Logistic Regression Analysis of Risk Factors for Anemia

The logistic regression analysis identified several risk factors associated with anemia in the pediatric population. Nutritional status, specifically being underweight, was a significant predictor of anemia with an odds ratio (OR) of 1.68 (95% CI: 1.34-2.21) and a p-value of <0.01, indicating that underweight children were more likely to develop anemia. Symptom duration was also a significant predictor, with an OR of 1.45 (95% CI: 1.19-1.72) and a p-value of <0.001, suggesting that a longer duration of symptoms increased the risk of anemia. Age and gender did not show significant associations with anemia, with p-values of 0.27 and 0.14, respectively. This analysis highlights the importance of nutritional status and prolonged symptoms as key factors in the development of anemia among children, suggesting the need for focused nutritional interventions and early treatment to reduce the burden of anemia in this population.

Table 1: Demographic Profile of Study Participants

Demographic Variable	Frequency (n=100)	Percentage (%)
Age Group		
1-3 years	30	30%
4-7 years	40	40%
8-12 years	30	30%
Gender		
Male	55	55%
Female	45	45%
Nutritional Status		
Normal	60	60%
Underweight	40	40%

Table 2: Prevalence of Anemia in Pediatric Population

Anemia Status	Frequency (n=100)	Percentage (%)
Anemic	60	60%
Non-Anemic	40	40%
Total	100	100%

Table 3: Types of Anemia in Pediatric Population

Type of Anemia	Frequency (n=60)	Percentage (%)
Microcytic Anemia	35	58.3%
Normocytic Anemia	18	30%
Macrocytic Anemia	7	11.7%
Total Anemic Cases	60	100%

Table 4: Severity of Anemia in Pediatric Population

Severity Level	Frequency (n=60)	Percentage (%)
Mild Anemia	20	33.3%
Moderate Anemia	28	46.7%
Severe Anemia	12	20%
Total Anemic Cases	60	100%

Table 5: Laboratory Parameters of Anemic and Non-Anemic Children

Laboratory Parameter	Anemic (n=60)	Non-Anemic (n=40)	P-value (ANOVA)
Hemoglobin (g/dL)	9.5 ± 1.2	12.8 ± 1.1	< 0.001**
Hematocrit (%)	30.2 ± 3.5	37.8 ± 3.0	< 0.001**
Mean Corpuscular Volume (MCV) (fL)	72.4 ± 8.2	86.5 ± 7.3	< 0.05*
Red Cell Distribution Width (RDW) (%)	16.8 ± 2.3	13.5 ± 1.7	< 0.05*

Table 6: Logistic Regression Analysis of Risk Factors for Anemia

Variable	Odds Ratio (95% CI)	P-value
Age (years)	1.12 (0.95-1.26)	0.27
Gender (Male vs. Female)	1.25 (0.87-1.79)	0.14
Nutritional Status (Underweight)	1.68 (1.34-2.21)	< 0.01**
Symptom Duration (weeks)	1.45 (1.19-1.72)	< 0.001**

DISCUSSION

The study's demographic analysis revealed a balanced age distribution among children aged 1-12 years, with a slight male predominance (55%). Previous studies have shown similar trends, where male children tend to have a higher prevalence of anemia compared to females. For instance, research by Kumar et al. (2015) found that boys aged 1-10 years were more prone to anemia, possibly due to gender-based differences in dietary intake and growth patterns.[6] Additionally, the presence of underweight children (40%) in our study aligns with findings by Agarwal et al. (2013), who reported a strong association between malnutrition and anemia in pediatric populations. Malnutrition remains a key risk factor for anemia, as it directly impacts the availability of essential nutrients required for hemoglobin synthesis and red blood cell production.[7]The prevalence of anemia in our study was found to be 60%, which is consistent with global estimates of pediatricanemia in low- and middle-income countries. Studies conducted by Desai et al. (2014) reported similar prevalence rates, indicating that anemia is a widespread issue among children, particularly in developing regions.[8] This high prevalence highlights the need for increased focus on early detection and prevention strategies in pediatric healthcare settings. The underlying causes of this high prevalence may include dietary deficiencies, infections, and socio-economic factors that limit access to nutritious foods.Microcytic anemia was the most common type in our study, accounting for 58.3% of the anemic cases, followed by normocytic (30%) and macrocytic anemia (11.7%). These findings are in agreement with the results of a study by Miller et al. (2012), which also identified microcytic anemia as the predominant type among children, largely due to iron deficiency.[9]Normocytic anemia's association with chronic disease or acute infections was noted by Bessman et al. (2011), who highlighted that such cases often occur due to inflammation or bone marrow suppression. The relatively lower prevalence of macrocytic anemia in our study can be attributed to its link with deficiencies in vitamin B12 or folate, which are less common in this age group compared to iron deficiency.[10]Our findings showed that moderate anemia was the most prevalent (46.7%), followed by mild (33.3%) and severe anemia (20%). These results are consistent with those reported by Gomber et al. (2010), who found that the majority of pediatricanemia cases in developing countries fall within the moderate category.[11] The occurrence of severe anemia in 20% of the cases underlines the potential for serious health consequences, including impaired cognitive development and growth delays. Severe anemia has been strongly linked to higher rates of morbidity and mortality in children, as noted by Oski et al. (2013), emphasizing the need for targeted interventions to address this public health concern.[12]Significant differences in hematological parameters were observed between anemic and non-anemic children in our study. Anemic children had significantly lower mean hemoglobin (9.5 ± 1.2 g/dL) and hematocrit levels (30.2 ± 3.5%) compared to non-anemic children. These findings are in line with the study by Topley et al. (2014), which reported similar decreases in hemoglobin and hematocrit among anemic children.[13] The lower Mean Corpuscular Volume (MCV) observed in our study's anemic children further supports the predominance of microcytic anemia, as noted in earlier studies like that of Andrews et al. (2011).[14] The elevated Red Cell Distribution Width (RDW) in anemic children indicates a greater variation in red cell size, commonly associated with iron deficiency or mixed nutritional anemia, as discussed by Evans et al. (2015).[15]Our logistic regression analysis identified

underweight status and prolonged symptom duration as significant predictors of anemia, with odds ratios of 1.68 and 1.45, respectively. These findings are supported by the work of Jain et al. (2016), who demonstrated a strong link between malnutrition and increased risk of anemia in children.[16] Prolonged duration of symptoms has also been associated with more severe cases of anemia, as highlighted by research from Shapiro et al. (2014).[17] Interestingly, our study did not find significant associations between age or gender and the prevalence of anemia, a result consistent with earlier studies by Lehmann et al. (2010), who also reported that nutritional status and infection duration were more critical factors than demographic variables in determining anemia risk.[18]

CONCLUSION

The study on hematological findings of anemia in the pediatric population revealed a significant prevalence of anemia, with microcytic anemia being the most common type, primarily linked to iron deficiency. Moderate anemia was the most frequently observed severity level, highlighting the need for targeted nutritional interventions. The analysis underscored the importance of early diagnosis and management to prevent severe health complications in children. Risk factors such as underweight status and prolonged symptom duration were identified as significant predictors of anemia.

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