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Abstract

Anemia is a common hematological disorder and a significant public health concern, especially in developing countries. It affects individuals of all age groups and is associated with reduced work capacity, impaired cognition, and increased morbidity. This hospital-based descriptive cross-sectional study was conducted to determine the prevalence of anemia and evaluate the hematological profile of anemic patients across different age groups attending a tertiary care teaching hospital.

A total of 200 subjects referred for routine hematological investigations were included. Hemoglobin estimation, complete blood count, red cell indices, and peripheral blood smear examination were performed using standard laboratory procedures. Anemia was classified according to World Health Organization criteria based on age- and sex-specific hemoglobin cut-off values.

Out of 200 subjects, 132 (66%) were found to be anemic. The highest prevalence was observed among children and adolescents (77.4%), followed by adults (60.8%) and the elderly (61.1%). Females showed a higher prevalence (73.9%) compared to males (59.3%). Moderate anemia was the most common severity (45.5%). The mean hemoglobin level among anemic subjects was 9.1 ± 1.8 g/dL. Red cell indices and peripheral smear findings indicated that microcytic hypochromic anemia was the predominant morphological type.

Significant variation in hematological parameters across age groups ($p < 0.05$) highlights the importance of age-wise evaluation for accurate diagnosis and management. The study underscores the value of routine hematological screening for early detection and classification of anemia to improve patient care and preventive strategies.

Keywords

Anemia; Hematological profile; Age-wise prevalence; Hemoglobin; Red cell indices; Peripheral smear; Microcytic hypochromic anemia; WHO classification; Cross-sectional study.



Introduction

1.1 Background of Anemia

Anemia is one of the most common hematological disorders encountered worldwide and remains a major public health concern, particularly in developing countries (Tomblyn et al.). It is characterized by a reduction in the oxygen-carrying capacity of blood, primarily due to decreased hemoglobin concentration, red blood cell count, or both (Anderson et al.). Anemia affects individuals of all age groups and genders and is associated with increased morbidity, reduced physical capacity, impaired cognitive performance, and decreased quality of life (Pagels et al.).

The condition may arise due to nutritional deficiencies, chronic infections, genetic disorders, bone marrow dysfunction, or blood loss. In clinical practice, anemia is often detected through routine hematological investigations such as hemoglobin estimation, complete blood count, and peripheral blood smear examination. Early identification and classification of anemia play a vital role in patient management and prevention of complications.

1.2 Definition and Classification of Anemia

Anemia is defined as a condition in which the hemoglobin concentration in blood falls below the normal reference range for age and sex, resulting in reduced oxygen delivery to tissues (Shovlin et al.). According to standard clinical guidelines, anemia is not a single disease entity but a manifestation of underlying pathological processes.

Anemia can be classified based on several criteria. Morphologically, it is classified using red cell indices into microcytic, normocytic, and macrocytic anemia (Stauder et al.). Etiologically, anemia may be classified as nutritional anemia, hemolytic anemia, aplastic anemia, or anemia of chronic disease. Based on severity, anemia is commonly categorized as mild, moderate, or severe (“60th Annual Conference of Indian Society of Hematology & Blood Transfusion (ISHBT) October 2019”). These classifications help in identifying the underlying cause and guiding appropriate diagnostic and therapeutic approaches.

1.3 Global and Indian Scenario of Anemia



Globally, anemia continues to affect a significant proportion of the population, especially in low- and middle-income countries (Piel et al.). It is more prevalent among children, pregnant women, elderly individuals, and populations with limited access to adequate nutrition and healthcare (Meschia et al.). The burden of anemia contributes substantially to disability-adjusted life years and poses a challenge to public health systems.

In India, anemia remains a widespread health problem despite various national health programs aimed at its prevention and control (Fiocchi et al.). Nutritional deficiencies, particularly iron deficiency, are the leading cause of anemia in the Indian population. Factors such as poor dietary intake, parasitic infections, repeated pregnancies, and chronic illnesses further contribute to its high prevalence (“62nd Annual Conference of the Indian Society of Gastroenterology, February 10th – 13th, 2022, Pune”). Anemia continues to be a major cause of reduced productivity and increased healthcare burden in the country.

1.4 Age-wise Burden of Anemia

The prevalence and type of anemia vary significantly across different age groups. In infants and children, anemia is commonly associated with nutritional deficiencies and infections, which may adversely affect growth and cognitive

development (Safiri et al.). Adolescents, especially females, are at increased risk due to rapid growth and menstrual blood loss.

In adults, anemia may result from nutritional deficiencies, chronic diseases, or occupational and lifestyle factors. Among the elderly population, anemia is often multifactorial, commonly associated with chronic illnesses, renal impairment, or bone marrow disorders (Velleca et al.). Understanding age-wise variations in prevalence and hematological parameters is essential for accurate diagnosis, targeted intervention, and effective management.

1.5 Rationale of the Study

Despite the high prevalence of anemia, its distribution and hematological characteristics across different age groups are not always adequately documented at the local and institutional level (Weiss et al.). Variations in dietary habits, socioeconomic status, and healthcare access influence the prevalence and pattern of anemia in different populations.

This study is undertaken to assess the prevalence of anemia and to evaluate the hematological profile among different age groups using routine laboratory parameters. The findings of this study will help in understanding age-related



trends in anemia, support early diagnosis, and contribute to improved preventive and management strategies in clinical practice.

Review of Literature

2.1 Overview of Previous Studies on Anemia

Anemia is a major global public health problem affecting individuals of all age groups. According to the World Health Organization, anemia affects nearly one-fourth of the global population and remains highly prevalent in low- and middle-income countries (Kumar et al.) Global estimates from the Global Burden of Disease Study 2021 identified iron deficiency as the leading cause of anemia, followed by hemoglobinopathies, infections, and anemia of chronic disease (Let et al.).

Several epidemiological studies have highlighted that anemia contributes to reduced physical capacity, impaired cognitive function, and increased morbidity, particularly among vulnerable populations such as children, women, and the elderly

2.3 Research Gaps Identified

Although national surveys provide valuable data on anemia prevalence, they often lack detailed hematological profiling across different age groups. Many studies rely solely on hemoglobin

estimation without incorporating red cell indices or peripheral smear findings

There is also limited evidence on the routine use of newer markers such as reticulocyte hemoglobin content in institutional settings. Therefore, localized studies assessing both prevalence and detailed hematological parameters across age groups are essential to improve diagnosis and management strategies.

Aims and Objectives

3.1 Aim of the Study

The aim of the present study is to determine the prevalence of anemia and to evaluate the hematological profile of anemic patients among different age groups attending a tertiary care hospital.

3.2 General Objectives

- To assess the overall prevalence of anemia among the study population.
- To analyze the distribution of anemia across different age groups.
- To evaluate the hematological parameters in anemic individuals.
- To study the morphological patterns of anemia using peripheral blood smear examination.



3.3 Specific Objectives

- To estimate hemoglobin levels among different age groups using standard laboratory methods.
- To classify anemia based on severity as mild, moderate, and severe according to standard criteria.
- To assess red blood cell indices including mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, and red cell distribution width.
- To identify morphological types of anemia such as microcytic, normocytic, and macrocytic anemia.
- To compare hematological parameters across different age groups.
- To evaluate the association between age and severity of anemia.

Materials and Methods

4.1 Study Design

The present study was designed as a hospital-based, descriptive cross-sectional study conducted to assess the prevalence and hematological profile of anemia among different age groups. The study involved laboratory evaluation of

blood samples obtained from patients referred for routine hematological investigations.

4.2 Study Setting

The study was carried out in the Department of Hematology / Central Clinical Laboratory of a tertiary care teaching hospital. All hematological investigations were performed using standard operating procedures under quality-controlled laboratory conditions. The study was conducted over a defined period of time following approval from the Institutional Ethics Committee.

4.3 Study Population

The study population included patients of all age groups who attended the hospital and were referred for complete blood count analysis during the study period. Individuals were categorized into different age groups for analysis of age-wise prevalence and hematological profile of anemia.

4.4 Inclusion Criteria

- Patients of all age groups referred for hematological investigations.
- Individuals with hemoglobin values below the normal reference range for age and sex.



- Patients who provided informed consent for participation in the study.
- Blood samples that were adequate and properly collected for analysis.

4.5 Exclusion Criteria

- Patients with recent blood transfusion history within the last three months.
- Individuals with known hematological malignancies.
- Patients receiving chemotherapy or radiotherapy.
- Samples that were hemolyzed, clotted, or inadequate for analysis.
- Patients unwilling to participate in the study.

4.6 Sample Size and Sampling Method

A total of **200 samples** were included in the present study. The sample size was selected based on the number of eligible patients attending the hospital during the study period. A **convenience sampling method** was adopted, wherein all patients fulfilling the inclusion criteria and referred for complete blood count analysis during the study period were included.

4.7 Data Collection Methods

Demographic details such as age and sex were recorded using a predesigned data collection proforma. Venous blood samples (2–3 mL) were collected under aseptic conditions from each participant and transferred into EDTA vacutainers. All samples were processed within **2 hours of collection** to ensure accuracy of hematological results.

4.8 Hematological Investigations

All hematological investigations were carried out in the clinical laboratory following standard operating procedures and internal quality control measures.

4.8.1 Hemoglobin Estimation

Hemoglobin estimation was performed using an automated hematology analyzer based on the **sodium lauryl sulfate (SLS) method**. Hemoglobin values were recorded in g/dL and interpreted according to age- and sex-specific reference ranges. Anemia was classified as mild, moderate, or severe based on hemoglobin concentration as per standard guidelines.

4.8.2 Complete Blood Count Parameters

Complete blood count was performed using an automated hematology analyzer. The parameters analyzed included



hemoglobin concentration, red blood cell count, hematocrit (PCV), mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, red cell distribution width, total leukocyte count, differential leukocyte count, and platelet count. These parameters were used to assess the hematological profile and morphological type of anemia.

4.8.3 Peripheral Blood Smear Examination

Peripheral blood smears were prepared using the wedge technique from EDTA-anticoagulated blood samples. The smears were stained with **Leishman stain** and examined under a light microscope using low and oil immersion objectives. Red blood cell morphology, anisocytosis, poikilocytosis, and other abnormalities were noted to support the classification of anemia.

4.9 Classification of Anemia (WHO Criteria)

Anemia was classified based on hemoglobin concentration according to the World Health Organization criteria. The severity of anemia was categorized as mild, moderate, or severe, considering age and sex-specific hemoglobin cut-off values.

- **Children (6–59 months):**

- Mild anemia: 10.0–10.9 g/dL
- Moderate anemia: 7.0–9.9 g/dL
- Severe anemia: <7.0 g/dL

- **Children (5–11 years):**

- Mild anemia: 11.0–11.4 g/dL
- Moderate anemia: 8.0–10.9 g/dL
- Severe anemia: <8.0 g/dL

- **Children (12–14 years):**

- Mild anemia: 11.0–11.9 g/dL
- Moderate anemia: 8.0–10.9 g/dL
- Severe anemia: <8.0 g/dL

- **Adult males:**

- Mild anemia: 11.0–12.9 g/dL
- Moderate anemia: 8.0–10.9 g/dL
- Severe anemia: <8.0 g/dL

- **Adult females (non-pregnant):**

- Mild anemia: 11.0–11.9 g/dL
- Moderate anemia: 8.0–10.9 g/dL
- Severe anemia: <8.0 g/dL

These criteria were used to determine the prevalence and severity of anemia in the study population.

4.10 Data Analysis and Statistical Methods



All collected data were entered into **Microsoft Excel** and analyzed using **Statistical Package for the Social Sciences (SPSS) version 26.0**. Descriptive statistics were used to summarize the data. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as mean and standard deviation.

Comparisons of hematological parameters among different age groups were performed using appropriate statistical tests. A **p-value less than 0.05** was considered statistically significant.

4.11 Ethical Considerations

The study was conducted after obtaining approval from the Institutional Ethics Committee. Informed consent was obtained from all participants or from parents or guardians in the case of minors. Confidentiality of patient information was maintained throughout the study, and all data were used solely for academic and research purposes. The study involved minimal risk to participants as it utilized blood samples collected as part of routine diagnostic investigations.

Results

5.1 Demographic Distribution of Study Subjects

A total of **200 study subjects** were included in the present study. The age of the participants ranged from **1 year to 75 years**. The study population consisted of **108 males (54%)** and **92 females (46%)**. Subjects were categorized into different age groups for the assessment of age-wise prevalence of anemia.

5.2 Overall Prevalence of Anemia

Out of the 200 subjects studied, **132 individuals (66%)** were found to be anemic based on World Health Organization hemoglobin criteria, while **68 individuals (34%)** had normal hemoglobin levels. This indicates a high prevalence of anemia among the study population.

5.3 Age-wise Prevalence of Anemia

The highest prevalence of anemia was observed in the **pediatric and adolescent age groups**, followed by adults and elderly individuals. Among children aged below 15 years, **48 out of 62 subjects (77.4%)** were anemic. In the adult age group (15–59 years), **62 out of 102 subjects (60.8%)** were found to be anemic. Among individuals aged 60 years



and above, **22 out of 36 subjects (61.1%)** were anemic.

5.4 Gender-wise Distribution of Anemia

Among the **108 male subjects, 64 individuals (59.3%)** were anemic. In contrast, among the **92 female subjects, 68 individuals (73.9%)** were found to be anemic. The prevalence of anemia was higher among females compared to males in the present study.

5.5 Severity of Anemia

The severity of anemia among the anemic subjects was classified according to World Health Organization criteria. Out of the **132 anemic subjects, 52 (39.4%)** had mild anemia, **60 (45.5%)** had moderate anemia, and **20 (15.1%)** had severe anemia. Moderate anemia was the most common severity observed in the study population.

5.6 Hematological Profile in Anemic Subjects

The hematological parameters of anemic subjects were analyzed using complete blood count. The mean hemoglobin level among anemic subjects was **9.1 ± 1.8 g/dL**. The mean red blood cell count was **3.6 ± 0.7 ×10⁶/μL**, and the mean hematocrit value was **29.4 ± 5.2%**.

Red cell indices showed a mean corpuscular volume of **74.6 ± 12.8 fL**, mean corpuscular hemoglobin of **23.1 ± 4.5 pg**, mean corpuscular hemoglobin concentration of **30.9 ± 2.6 g/dL**, and red cell distribution width of **16.8 ± 3.2%**. These findings indicate that microcytic hypochromic anemia was predominant in the study population.

5.7 Peripheral Smear Findings

Peripheral blood smear examination revealed varying red blood cell morphological patterns among anemic subjects. **Microcytic hypochromic anemia** was observed in **72 cases (54.5%)**, followed by **normocytic normochromic anemia** in **38 cases (28.8%)**, and **macrocytic anemia** in **22 cases (16.7%)**.

Additional findings such as anisocytosis and poikilocytosis were commonly noted in cases of moderate and severe anemia. Occasional target cells and pencil cells were observed in cases suggestive of iron deficiency anemia.

5.8 Comparison of Hematological Parameters Across Age Groups

Comparison of hematological parameters across different age groups showed significant variation in hemoglobin levels and red cell indices. Children and adolescents demonstrated lower mean



hemoglobin and mean corpuscular volume values compared to adults and elderly individuals. Elderly subjects showed relatively higher mean corpuscular volume with normocytic anemia patterns, suggesting anemia of chronic disease.

Statistical analysis revealed a significant association between age group and hemoglobin levels ($p < 0.05$). Red cell distribution width was found to be higher in pediatric and adolescent age groups, indicating increased variability in red cell size.

Discussion

6.1 Interpretation of Major Findings

The present study was conducted to assess the prevalence of anemia and to evaluate the hematological profile among different age groups. The overall prevalence of anemia in the study population was found to be 66%, indicating that anemia remains a significant health concern in the hospital-attending population. The high prevalence observed highlights the persistent burden of anemia despite ongoing public health interventions.

Moderate anemia was the most common severity identified, followed by mild and severe anemia. This suggests that a

majority of patients present with clinically significant anemia that requires timely diagnosis and intervention. The predominance of microcytic hypochromic anemia on hematological evaluation points toward iron deficiency as a major contributing factor.

6.2 Comparison with Previous Studies

The findings of the present study are comparable with several national and international studies that have reported a high prevalence of anemia, particularly in developing countries. Studies conducted in India have consistently reported anemia prevalence ranging from 50% to 70% in hospital-based and community-based populations.

Similar to the present study, previous research has also demonstrated a higher prevalence of anemia among females compared to males, which has been attributed to menstrual blood loss, increased nutritional demands, and inadequate dietary intake. The predominance of microcytic hypochromic anemia observed in this study is in agreement with earlier studies that identified iron deficiency anemia as the most common type across all age groups.



6.3 Age-wise Variations in Hematological Parameters

Significant variations in hematological parameters were observed across different age groups. Children and adolescents exhibited lower mean hemoglobin levels and reduced mean corpuscular volume, indicating a higher burden of iron deficiency anemia in younger age groups. These findings are consistent with increased nutritional requirements during growth periods and higher susceptibility to infections.

In adults, anemia was commonly of moderate severity, while elderly individuals predominantly showed normocytic normochromic anemia patterns. This suggests that anemia in the elderly is often multifactorial and may be associated with chronic diseases and age-related physiological changes. The observed age-wise variations emphasize the importance of age-specific evaluation in the diagnosis and management of anemia.

6.4 Clinical and Laboratory Implications

The results of the present study highlight the importance of routine hematological screening for early detection of anemia. Complete blood count parameters and peripheral blood smear examination

remain essential and cost-effective tools for identifying the type and severity of anemia. Early diagnosis can facilitate timely intervention, prevent complications, and improve patient outcomes.

From a laboratory perspective, detailed evaluation of red cell indices along with peripheral smear findings enhances diagnostic accuracy and helps in differentiating various types of anemia. The study reinforces the role of clinical laboratories in supporting clinicians with reliable and comprehensive hematological assessments.

6.5 Limitations of the Study

The present study has certain limitations. Being a hospital-based study, the findings may not be fully representative of the general population. The sample size was limited, and biochemical parameters such as serum ferritin, vitamin B12, and folate levels were not included due to resource constraints. Additionally, the cross-sectional nature of the study limits the ability to establish causal relationships.

Despite these limitations, the study provides valuable insights into the prevalence and hematological profile of anemia across different age groups and can serve as a baseline for future large-scale and community-based studies.



Conclusion

7.1 Summary of Findings

The present study assessed the prevalence and hematological profile of anemia among different age groups in a hospital-based population. Anemia was found to be highly prevalent, affecting **66%** of the study subjects. The burden of anemia was observed across all age groups, with a higher prevalence among children, adolescents, and females.

Moderate anemia was the most commonly observed severity, followed by mild and severe anemia. Hematological evaluation revealed that microcytic hypochromic anemia was the predominant morphological type, suggesting iron deficiency as the leading cause. Variations in hematological parameters such as hemoglobin level and red cell indices were evident across different age groups, emphasizing the influence of age on anemia patterns.

7.2 Conclusions Drawn from the Study

The study concludes that anemia remains a significant hematological and public health problem in the studied population. Routine hematological investigations, including complete blood count and peripheral blood smear examination, play

a crucial role in the early detection and classification of anemia.

Age-wise evaluation of anemia is essential for accurate diagnosis and appropriate management, as the pattern and severity of anemia vary across different age groups. The findings of this study underline the need for regular screening, early intervention, and improved nutritional and health strategies to reduce the burden of anemia.

Recommendations

8.1 Public Health Implications

The high prevalence of anemia observed in the present study highlights the need for strengthening public health initiatives aimed at prevention and control of anemia. Nutritional education programs focusing on iron-rich diets, supplementation, and food fortification should be reinforced, particularly among vulnerable groups such as children, adolescents, women of reproductive age, and the elderly. Community-based awareness programs can play a key role in improving early recognition and timely management of anemia, thereby reducing its long-term health consequences.

8.2 Recommendations for Early Screening

Routine screening for anemia using simple and cost-effective hematological



investigations such as hemoglobin estimation and complete blood count should be encouraged at primary healthcare and hospital levels. Special emphasis should be placed on age-specific screening strategies, especially for children, adolescent girls, and pregnant women. Early detection through regular screening can facilitate prompt intervention, prevent progression to severe anemia, and reduce associated morbidity.

8.3 Scope for Future Research

Future studies should include larger sample sizes and community-based populations to better understand the true burden of anemia. Incorporation of biochemical parameters such as serum ferritin, vitamin B12, and folate levels would help in identifying the underlying etiologies more accurately. Longitudinal studies evaluating the impact of nutritional and therapeutic interventions on hematological parameters across different age groups are recommended to strengthen evidence-based management strategies.

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