



## DIAGNOSTIC SIGNIFICANCE OF RED CELL INDICES IN IRON DEFICIENCY ANEMIA

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### ABSTRACT

*Among the most common nutritional disorders affecting people all over the world is iron deficiency anemia (IDA) which remains a significant challenge to the public health especially in developing countries. The current cross-sectional study is hospital based and was conducted in order to determine the diagnostic value of red cell indices to patients with iron deficiency anemia. One hundred anemic patients were used and to determine the level of hemoglobin in venous blood samples they were analyzed by an automated hematology analyzer which determines the level of red cell indices. The data obtained were in form of frequencies and percentages. It was found that there is more prevalence of anemia amongst females (62%) as they are more vulnerable both in terms of physiological and nutritional causes. Hemoglobin revealed that 47% of the patients were moderately anaemic and 28% were severely anaemic which means that there was a large burden of clinically significant anemia. The red cell indices evaluation was used to identify that 72% of patients had microcytic anemia and 76% had low mean corpuscular hemoglobin (MCH) values, justifying that there were red blood cells with hypochromic features that are characteristic of iron deficiency anemia. These results underline that red cell indices as the result of regular complete blood count studies are good diagnostic materials and are correlated with iron deficiency. The authors find that red cell indices are not only easy but also inexpensive and dependable indices to monitor early, screening and diagnosis of iron deficiency anemia in a healthcare setting that has only limited resources, thus biochemical investigations are not easily accessible.*

**Keywords:** *Iron Deficiency Anemia, Red Cell Indices, Mean Corpuscular Volume, Mean Corpuscular Hemoglobin, Microcytic Hypochromic Anemia, Complete Blood Count.*

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## 1. INTRODUCTION

Iron deficiency anemia (IDA) is one of the most widespread nutritional diseases in the global community and still presents a significant health problem to the population in developed and developing countries. It impacts people of both genders but women of reproductive age, children, and the elderly are disproportionately impacted. Iron deficiency anemia is a condition that develops as a result of insufficient dietary iron intake, impaired intestinal absorption, high physiological requirement at times of growth or pregnancy and the loss of blood through gastrointestinal infections, parasitic infections, or menstruation. The disorder causes a decrease in blood oxygen-carrying capacity thus interfering with the oxygenation of the tissues. It is clinically characterized by IDA, which is fatigue, pallor, weakness, loss of work capacity, poor cognitive ability, and poor physical and immune performance, which eventually impacts the overall quality of life.

Diagnosis Iron deficiency anemia traditionally is based on biochemical research including serum ferritin and serum iron, total iron-binding capacity and transferrin saturation that give direct data regarding stores of iron in the body. Despite the reliability of these tests as indicators of iron status, they are not available and affordable in most health care facilities especially in resource limited areas. Moreover, inflammatory conditions, infections, and chronic illnesses might also affect biochemical parameters and make them difficult to interpret. By comparison, automated complete blood count (CBC) parameters are regularly conducted, highly available, and inexpensive, so they serve as a useful first line diagnostic test when it comes to diagnosis of anemia.

The red cell indices suggested by automated hematology analyzers, that is, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and red cell distribution width (RDW) give relevant data about red blood cell morphology, hemoglobin content, and size variation. In iron deficiency anemia, such indices normally show the typical arrangement of microcytic hypochromic anemia and increased anisocytosis. These alterations frequently lead to significant shifts in the levels of hemoglobin, which makes it possible to identify iron deficiency in time. Red cell index assessment is, therefore, vital in screening, early diagnosis and distinction of red cell iron deficiency anemia among other

anemia assortments. The current research was conducted with the aim of analyzing the diagnostic value of red cell indices in iron deficiency anemia and also examining their applicability as simple, reliable and cost effective diagnostic methods in the routine clinical practice.

### 1.1 Research Objectives

- To evaluate the diagnostic significance of red cell indices (MCV, MCH, and RDW) in identifying iron deficiency anemia among anemic patients.
- To analyze the distribution and patterns of hemoglobin levels and red cell indices in iron deficiency anemia and assess their association with microcytic hypochromic anemia.
- To determine the usefulness of red cell indices obtained from routine complete blood count as cost-effective screening tools for early detection of iron deficiency anemia in resource-limited healthcare settings.

## 2. LITERATURE REVIEW

**Aedh et al. (2023)** assessed the diagnostic value of reticulocyte hemoglobin as a screening test of iron deficiency anemia and suggested a new cut-off value as a better measure of iron deficiency anemia. Their analysis showed that reticulocyte hemoglobin was a real-time measure of iron availability to support erythropoiesis and their study was less influenced on the state of inflammation than the normal biochemical markers. According to the authors, reticulocyte hemoglobin has been found to be very sensitive and specific in the identification of anemia due to iron insufficiency and concluded that it may be a valuable screening procedure, especially in a clinical environment where speed of diagnosis is a critical factor.

**Alageeli et al. (2021)** examined how reticulocyte hemoglobin content can be used in the diagnosis of functional iron deficiency in patients receiving hemodialysis. This research found that reticulocyte hemoglobin content was a valid measure of iron-restricted erythropoiesis in this population because conventional iron markers in most cases were confounded by chronic inflammation and impaired iron metabolism. The results showed that the reticulocyte hemoglobin



content was better than serum ferritin and transferrin saturation in identifying functional iron deficiency hence, its clinical importance in the treatment of anemia in hemodialyzed patients.

**Gelaw et al. (2019)** carried out an extensive review of literature to evaluate the value of reticulocyte hemoglobin content in the diagnosis of iron deficiency, iron deficiency anemia and as a follow up to iron treatment. In their review, they brought to light the fact that reticulocyte hemoglobin content was always associated with iron status, and they responded quickly in response to iron supplementation. The authors highlighted that this parameter gave a rapid and dependable estimation of iron deficiency and was applicable in distinguishing iron deficiency anemia with other forms of anemia. They established that reticulocyte hemoglobin level was the useful complement to the standard hematological and biochemical studies in diagnosis and treatment of iron deficiency anemia.

**Jahangiri et al. (2020)** performed a meta-analysis of diagnostic test accuracy to assess the approaches applied to differentiate microcytic anemia, specifically iron deficiency anemia and thalassemia. The paper has performed a systematic review of various diagnostic indices and stated that red cell indices based on routine complete blood count parameters significantly contributed to the distinction between the two conditions. According to the authors, the mean corpuscular volume and other red cell-based discriminant formulas were found to be an acceptable diagnostic index. The meta-analysis has found out that red cell indices were useful and cost-effective in the initial diagnosis and differentiation of microcytic anemia, particularly in the environment where advanced diagnostic measures are not readily available.

**Kabootarizadeh et al. (2019)** studied the performance of an intelligent diagnostic model to distinguish between iron deficiency anemia and  $\alpha$ -thalassemia trait and compared the model with traditional discriminant indices that are founded on red cell parameters. It was found that the intelligent model was more diagnostic as compared to traditional indices. Nevertheless, the authors pointed out that red cell indices continued to be basic elements of the diagnostic process and were to be considered as the key input variables to both the traditional and modern diagnostic methods. The results indicated the role of red cell indices in distinguishing the microcytic anemia and



supported their clinical use in separating iron deficiency anemia and hereditary hemoglobin disorders.

### **3. MATERIALS AND METHODS**

This is a cross-sectional study that was carried out at a tertiary teaching hospital comprising 100 patients who were anemic. Automated hematology analyzer was used to analyze hemoglobin levels as well as red cell indices and data was in form of frequencies and percentages.

#### **3.1 Study Design**

The current research was a cross-sectional descriptive hospital-based research done to determine the diagnostic value of red cell indices among patients suffering iron deficiency anemia. This is because the study design has been chosen to measure the hematological parameters at one point and determine their distribution and diagnostic importance.

#### **3.2 Study Setting**

It was conducted within the Department of Pathology of a tertiary care teaching hospital, whereby the patients who had been clinically suspected of anemia were referred to hematological investigations regularly. The laboratory test results were all performed in the central hematology laboratory and by standardized procedures.

#### **3.3 Study Population and Sample Size**

The research sample was comprised of patients with anemia diagnosis by estimating hemoglobin. The study involved a population of 100 patients. The sample was selected to be sufficient in terms of representation of the evaluation of red cell indices and their distribution in iron deficiency anemia.

#### **3.4 Inclusion Criteria**

- Patients aged 18 years and above
- Patients with hemoglobin levels below normal reference values

- Patients clinically suspected of iron deficiency anemia
- Patients who provided informed consent to participate in the study

### **3.5 Exclusion Criteria**

- Patients with known hemoglobinopathies
- Patients with anemia of chronic disease
- Patients with recent blood transfusion history
- Patients receiving iron supplementation or hematinic therapy

### **3.6 Data Collection Procedure**

All the participants were sampled with a strict aseptic precaution of the venous blood samples. An automated hematology analyzer was used to assess hemoglobin level and red cell indices, such as Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), and Red Cell Distribution Width (RDW) of blood. Systematic recording of the data obtained was undertaken so that further analysis could be done on the same.

### **3.7 Parameters Studied**

The following hematological parameters were evaluated:

- Hemoglobin concentration
- Mean Corpuscular Volume (MCV)
- Mean Corpuscular Hemoglobin (MCH)
- Red Cell Distribution Width (RDW)

These parameters were studied to determine the typical patterns that are attributed to iron deficiency anemia.

### 3.8 Statistical Analysis

The obtained data were tabulated in a spreadsheet and solved by the use of relevant statistical software. Findings were in frequencies and percentages. The results were described using tables and graphical illustrations that served to describe the red cell index distribution in the population of the study.

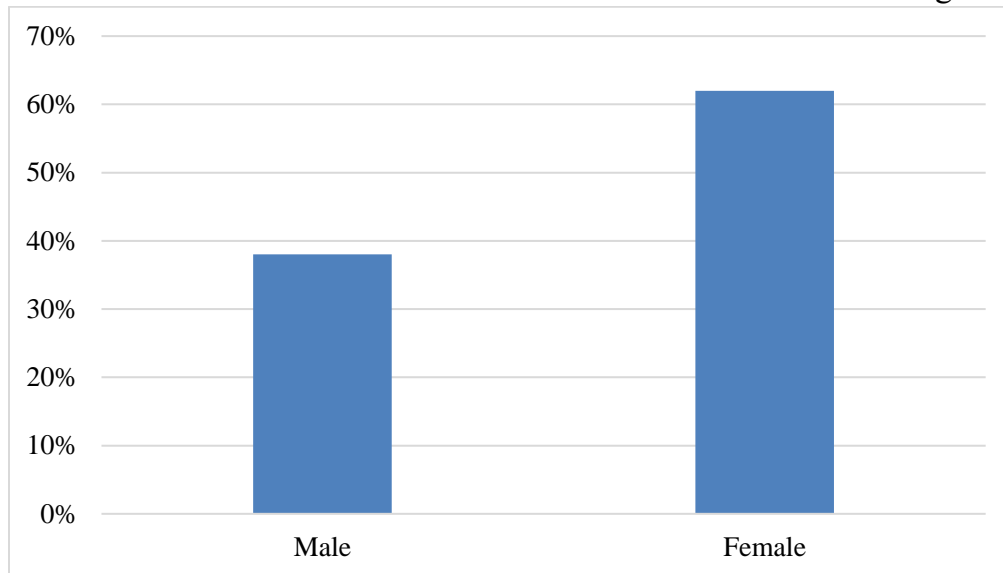
## 4. RESULT

The current research involved 100 patients with anemia diagnosis whereby the diagnostic importance of the red cell indices of iron deficiency anemia was evaluated in the current study. The hematological parameters were evaluated and given in frequencies and percentages.

Table 1 demonstrates the sample of the study participants by gender. The overall sample size was 100 patients in which 38 were males and 62 were females. Therefore, the study population of females was relatively higher than that of males. Graphical representation of this gender distribution is depicted in Figure 1 and it is evident that female participants were more dominant in the study.

**Table 1:** Distribution of Study Participants by Gender

<b>Gender</b>	<b>Number of Patients</b>	<b>Percentage (%)</b>
Male	38	38%
Female	62	62%
<b>Total</b>	<b>100</b>	<b>100%</b>



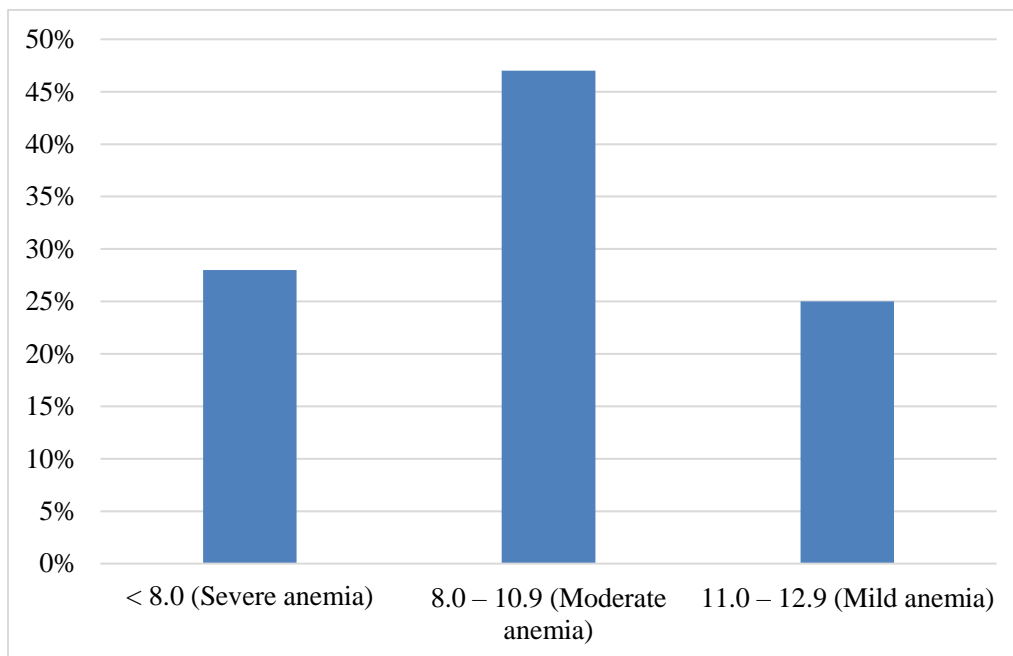
**Figure 1:** Graphical Representation of Distribution of Study Participants by Gender

The fact that the female participants were a higher percentage (62) shows that iron deficiency anemia was more evidently diagnosed in the females in the current study. Some of the factors that can be attributed to this include increased iron needs, loss of menstrual blood, nutritional deficiencies, and childbearing problems. The results are in line with the available literature which identifies an increased prevalence of iron deficiency anemia in females especially in third world economies.

Table 2 shows the distribution of patients according to the levels of hemoglobin in the study population. Among 100 patients, 28 (28%) patients were categorized under severe anemia when the hemoglobin levels were found to be below 8.0 g/dL. Forty-seven percent (47%) of the patients were moderately anaemic with hemoglobin ranging between 8.0 and 10.9 g/dL. It was noted that 25 patients had mild anemia which had a hemoglobin level between 11.0 and 12.9 g/dL (25%). Figure 2 gives a graphical display of the patients distribution with reference to hemoglobin levels.

**Table 2:** Distribution of Patients According to Hemoglobin Levels

Hemoglobin Level (g/dL)	Number of Patients	Percentage (%)
< 8.0 (Severe anemia)	28	28%
8.0 – 10.9 (Moderate anemia)	47	47%
11.0 – 12.9 (Mild anemia)	25	25%
<b>Total</b>	<b>100</b>	<b>100%</b>



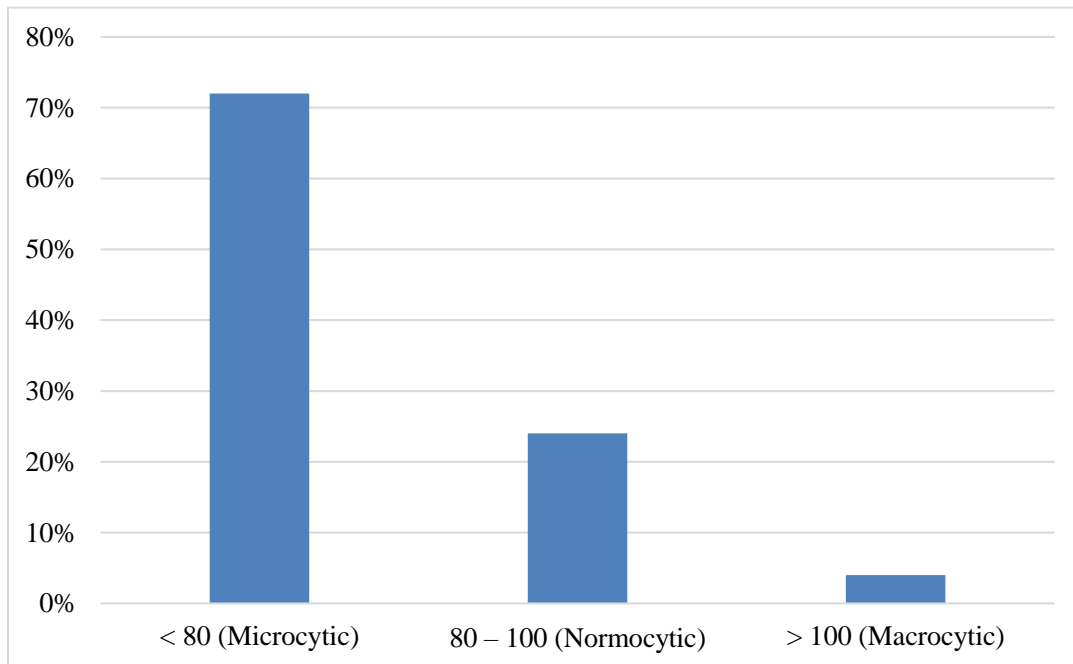
**Figure 2:** Graphical Representation of Distribution of Patients According to Hemoglobin Levels

The results suggest that moderate anemia affected most of the patients (47%), then severe anemia (28%), which points to a significant number of clinically significant anemia in the participants of the study population. This distribution implies late diagnosis and long term iron deficiency in a significant percentage of patients. The fact that more than a quarter of the cases were characterized by severe anemia underlines the significance of early screening and early intervention in order to avoid the development of the disease and the complications related to it.

Table 3 shows that the patients are distributed as per the Mean Corpuscular Volume (MCV) value. Out of the 100 study participants, 72 out of the 100 patients (72%), had MCV values less than 80 fL, which implies that they had microcytic anemia. In 24 patients (24%), normocytic indices of red cells, among which MCV values were 80-100 fL, were found. The proportion of patients having macrocytic indices with MCV values exceeding 100 fL was low 4 (4%). Figure 3 gives the graphical representation of MCV values distribution in the population of the study.

**Table 3:** Distribution of Mean Corpuscular Volume (MCV) Values

MCV (fL)	Number of Patients	Percentage (%)
< 80 (Microcytic)	72	72%
80 – 100 (Normocytic)	24	24%
> 100 (Macrocytic)	4	4%



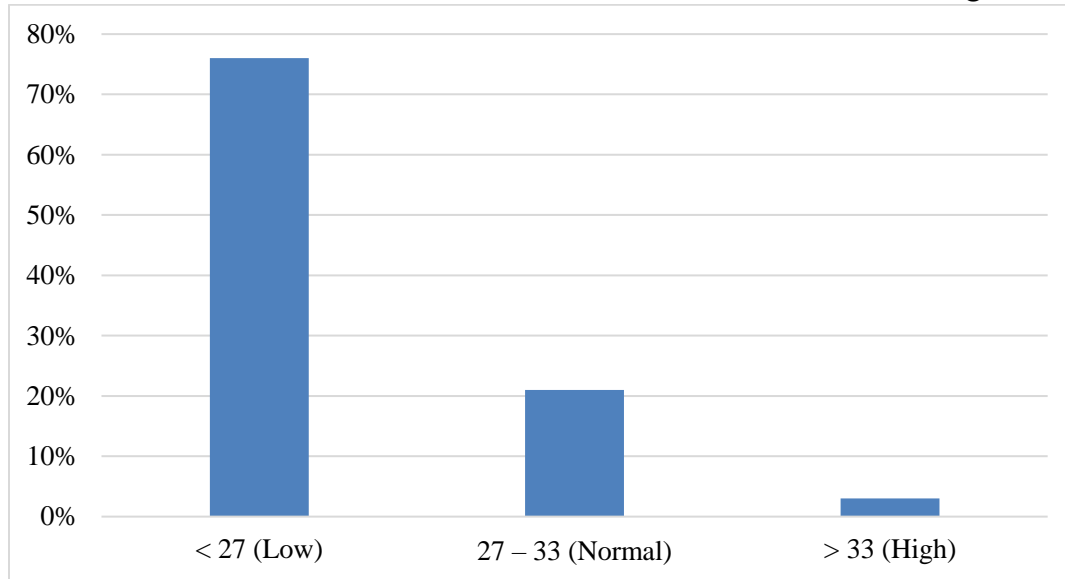
**Figure 3:** Graphical Representation of Distribution of Mean Corpuscular Volume (MCV) Values

Microcytic anemia (72) is the dominating form of anemia, which is a strong indication that the most likely cause of anemia is iron deficiency in the study population. The decreased MCV is a typical hematologic phenotype of iron deficiency anemia because the synthesis of hemoglobin is compromised. The existence of normocytic and macrocytic patterns in few of the cases might reflect an initial case of iron deficiency or cooccurrence of other nutritional deficiencies. The results indicate that MCV is a significant red cell index that can be used to diagnose iron deficiency anemia.

Table 4 indicates the number of patients by the Mean Corpuscular Hemoglobin (MCH) values. Among the 100 patients who underwent the MCH, 76 patients (76%), had MCH values less than 27 pg which is an indication of low hemoglobin in one red blood cell. MCH values with the range of 27 to 33 pg were found in 21 patients (21%), and 3 patients were found to have MCH values upper than 33 pg (3%). Figure 4 will graphically detect the distribution of Mean Corpuscular Hemoglobin values of the study participants.

**Table 4:** Distribution of Mean Corpuscular Hemoglobin (MCH) Values

<b>MCH (pg)</b>	<b>Number of Patients</b>	<b>Percentage (%)</b>
< 27 (Low)	76	76%
27 – 33 (Normal)	21	21%
> 33 (High)	3	3%



**Figure 4:** Graphical Representation of Distribution of Mean Corpuscular Hemoglobin (MCH) Values

A large percentage of patients who have low values of MCH (76) indicates the existence of hypochromia which is a typical symptom of iron deficiency anemia caused by the inability to produce hemoglobin. The results of this study support the diagnostic value of MCH as a critical red cell index to determine iron deficiency anemia. The low proportion of patients having normal or high values of MCH might be the initial phases of iron deficiency or might be other forms of anemia. In general, the findings highlight the applicability of MCH in helping to diagnose iron deficiency anemia.

## 5. DISCUSSION

The current paper has compared the diagnostic importance of red cell indices in iron deficiency anemia in 100 anemic patients in a tertiary care hospital. The findings showed more prevalence of the anemia among females (62%), which is in line with the established epidemiological trend of iron deficiency anemia, more so in the developing nations. The common causes of the iron shortage in females include the high demand of iron, bleeding at menstruation and malnutrition. The analysis of the hemoglobin levels revealed that patients had moderate anemia (47%), and severe anemia (28%), which means that the burden of clinically significant anemia is high. This trend



indicates that a significant part of the study group has been delayed in detection and iron deficiency over a long period, which requires early screening and diagnoses.

Red cell indices analysis showed typical hematological alterations in case of iron deficiency anemia. It was found that there was a preponderance of microcytic anemia with 72% patients showing a low Mean Corpuscular Volume (MCV) which is a symptom of poor hemoglobin production. On the same note, the low levels of Mean Corpuscular Hemoglobin (MCH) were observed in 76% of the cases, characteristic evidence of iron deficiency anemia, hypochromia. These results indicate that red cell indices are highly diagnostic in the determination of iron deficiency anemia using routine complete blood count parameters. The occurrence of normocytic and macrocytic patterns on a small cluster of patients can give an indication of the initial stages of iron deficiency or a combination of other nutritional deficiencies. In general, the article supports the concept of red cell indices as easy, economical, and dependable diagnostic and screening means of iron deficiency anemia, especially in a resource-constrained healthcare facility.

## 6. CONCLUSION

The current research indicates the diagnostic importance of red cell indices in iron deficiency anemia and illustrates their practical applications in the normal clinic. The high rates of anemia among females and the high rate of moderate and severe anemia indicate that iron deficiency is a huge problem in the study population. As expected, characteristic hematological findings such as low mean corpuscular volume and low mean corpuscular hemoglobin were observed in most of the patients confirming the existence of microcytic hypochromic anemia that is characteristic of iron deficiency. These results highlight the fact that red cell indices derived through a routine complete blood count are straightforward, inexpensive and dependable parameters that can be used in the early detection, screening and diagnosis of iron deficiency anemia. The study finds that red cell indices can be well applied as a starting diagnostic test, especially in resource-strained health care facilities where highly specialised biochemical studies may not be easily accessible thus helping to intervene and achieve better patient outcomes in a timely manner.

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