***Original Research Article***

**Prevalence and Correlation of Red Blood Cell Indices and Iron Deficiency Anemia Among Patients Tested at Masvingo Provincial Hospital, Zimbabwe**

**Abstract**

Iron deficiency anemia is a significant public health concern, particularly in developing countries. It affects a significant proportion of the population. This study assessed the prevalence of Iron Deficiency Anemia among patients at Masvingo Provincial Hospital from January 2024 to August 2024. The study also analyzed the correlation between Red Blood Cell indices and the diagnosis of Iron deficiency anemia. The study used a cross sectional designed which involved examining patient records of patients who were tested for Full blood Count at Masvingo Provincial Hospital. The study used the established criteria. A total of 97 patients were included in the study with data collected on clinical history and laboratory results.Ethical approval was obtained from the University’s research and ethics committee( AUREC). Permission was also obtained from MPH laboratory where the research was conducted. Also, this study adhered to ethical guidelines and principles to ensure the protection of the patients’ rights and welfare. Confidentiality and anonymity was maintained throughout the research process and all data was securely stored. The prevalence of Iron deficiency anemia was found to be 46% showing that it was a significant health issue in Zimbabwe. A correlation analysis was conducted using statistical methods to establish the link between red blood cell indices and Iron deficiency anemia. Results showed that lower MCH and MCV values were strongly associated with Iron deficiency anemia while MCHC also showed a moderate negative correlation. The mean MCV for all the IDA patients was 75.3 which was below the normal range of 80-100fL. The mean MCH for all IDA patients was 25.5 which was below the normal range of 27-32 pg. the mean MCHC for IDA patients was 31.6 which was below normal range of 32-36 g/dL. Out of 40 males, 17 had Iron deficiency anemia giving a prevalence of 42.5%. out of 57 females, 28 females had Iron deficiency anemia giving a prevalence of 49.1%. The gender-based prevalence is higher in females than in males. Strong negative correlations between RBC indices and Hemoglobin were seen. In conclusion, the study shows the high prevalence of iron deficiency anemia among patients tested at Masvingo Provincial Hospital and also establishes the inverse relationship between red blood cell indices and Iron deficiency anemia. The findings brought by this research advocate for the use of red blood cell indices as diagnostic and monitoring tools for Iron deficiency anemia. The study recommends nutritional interventions, supplementation, education and awareness, addressing underlying causes and also policy implementation in order to address the issue of Iron deficiency anemia.

***Keywords:*** *Iron deficiency anemia (IDA)****,*** *Red Blood Cell Indices****,*** *Mean Corpuscular Volume (MCV)****,*** *Mean Corpuscular Hemoglobin (MCH)****,*** *Mean Corpuscular Hemoglobin Concentration (MCHC)*

**List of Abbreviations**

MPH- Masvingo Provincial Hospital

IDA- Iron deficiency anemia

MCV- Mean corpuscular volume

MCH- Mean corpuscular hemoglobin

MCHC- Mean corpuscular hemoglobin concentration

RBC- Red blood cell

AUREC- Africa University Research Ethics Committee

**Introduction**

Iron deficiency anemia is a common nutritional disorder affecting billions of people worldwide. It is estimated that iron deficiency anemia affects more than 1.62 billion individuals worldwide [1]. Iron deficiency anemia is caused by inadequate iron intake or malabsorption. It occurs when the body does not have enough iron to produce hemoglobin, the protein found in red blood cells that transports oxygen from the lungs to cells throughout the body [2]. IDA has negative health and social consequences, especially among infants, young children, and women [3]. Iron deficiency anemia (IDA) is a prevalent global health issue with30% of the world’s population being affected with it. IDA affects both developed and developing nations [3]. Iron deficiency is the most prevalent and widespread nutritional disorder in the world affecting approximately 1.62 billion people globally [1]. Red blood cell (RBC) indices provide useful information about the status of red blood cells, such as size, number and hemoglobin concentration, and can indicate the presence of anemia [4]. Mean corpuscular volume (MCV) is often used as a screening test for IDA because low MCV is a common early sign of this condition [5]. Mean corpuscular hemoglobin concentration (MCHC) and mean corpuscular hemoglobin (MCH) may also be altered in IDA [6].

Red blood cell indices obtained from a complete blood count test are laboratory parameters used to evaluate the size, shape, morphological characteristics and hemoglobin content of RBCs [4]. This provides important information about an individual’s iron status and degree of anemia. These indices include mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC). These red blood cell indices are helpful in differentiating IDA from other causes of anemia as they tend to be relatively low in IDA due to impaired hemoglobin synthesis [7]. In Zimbabwe, iron deficiency remains highly prevalent largely due to poor dietary habits and high parasitic infections [8-9]. However, limited local research has looked into the link between red blood cell indices and IDA. Therefore, this study aimed to look into the correlation between red blood cell indices (MCV, MCH, MCHC) and IDA among patients tested at Masvingo Provincial Hospital, Zimbabwe between January 2024 and August 2024.

# RESEARCH METHODOLOGY

## Research design

The research used an observational cross-sectional study which involved secondary data analysis of routinely collected clinical laboratory data.

### Study setting

This study was conducted at Masvingo Provincial Hospital, Zimbabwe. Masvingo Provincial Hospital is a referral hospital in Zimbabwe. It recently started serving as a teaching hospital for Great Zimbabwe University College of Health Sciences and receives patients from across the province.

## Study population

The study population included both inpatients and outpatients who had a full blood count test performed at Masvingo Provincial Hospital between January 2024 to August 2024. Having a diverse demographic population helped in understanding IDA across different age groups as well as different socioeconomic backgrounds.

##### Sampling procedure

A stratified random sampling method was used which allowed division of a population into smaller subgroups for example age and gender.

##### Inclusion criteria

Inclusion criteria included both genders aged from 18 to 70 years. It also included all anemic patients regardless of the type of anemia. The HB% values were HB% < 10gm/dL for females and HB% < 12gm/dL for males. This is because patients with these results are usually considered anemic. Also, including different age groups and genders helped to see if the prevalence differed according to age and gender. Samples with Hb% <10gm/dL were further evaluated for IDA by serum ferritin estimation using serum and a chemiluminescence immune analyzer.

##### Exclusion criteria

The exclusion criteria included patients who had received iron supplements prior to testing, pregnant women as pregnancy causes changes in indices and iron levels, patients who had received blood transfusions in the past 3 months prior to testing, results from specimen with hemolysis and also clotted samples. Also, records with missing demographic details like age, gender were excluded. Alcoholic patients as well as malnourished patients were also excluded.

## Data collection procedure

Written permission was obtained from the Masvingo Provincial Hospital laboratory administration as well as the Provincial Medical Director. Medical records fulfilling the selection criteria was sequentially selected and reviewed. Relevant data was extracted onto data extraction forms. No personal identifiers were recorded to ensure confidentiality and anonymity.

## Ethical considerations

Ethical approval was obtained from the University’s research and ethics committee (AUREC). Permission was also obtained from MPH laboratory where the research was conducted. Also, this study adhered to ethical guidelines and principles to ensure the protection of the patients’ rights and welfare. Confidentiality and anonymity were maintained throughout the research process and all data was securely stored. No personal identifiers were recorded. The data was only accessible to authorized researchers. Since there was no direct interaction with patients, informed consent was not required.

**RESULTS**

**Fig 1 showing distribution of IDA and non-IDA patients.**

**Gender- Based Prevalence**

Out of the sample size of 97, 57 were female and 40 were male. The prevalence of iron deficiency anemia as per gender was calculated.

**Table 1: below shows the total population for each gender as well as the gender-based prevalence**

|  |  |  |  |
| --- | --- | --- | --- |
| GENDER | ANEMIA CASES | TOTAL POPULATION FOR EACH GENDER | PREVALENCE  (%) |
| Male | 17 | 40 | 42.5 |
| Female | 28 | 57 | 49.1 |

**Figure 2: shows distribution of males with and without IDA**

**Figure 3: showing distribution of female patients with or without IDA**

Out of 40 males, 17 had Iron deficiency anemia giving a prevalence of 42.5%. out of 57 females, 28 females had Iron deficiency anemia giving a prevalence of 49.1%. The gender-based prevalence is higher in females than in males. The red blood cell indices measured were MCV, MCH and MCHC. The mean and standard deviation was calculated for each parameter.

**Table 2: below shows the mean and standard deviation for each parameter as well as the normal range**

|  |  |
| --- | --- |
| **RBC INDEX** | **Mean Standard Deviation(SD)** |
| MCV (fL) | 75.3 |
| MCH(pg) | 24.5 |
| MCHC (g/dL) | 31.6 |

The mean MCV for all the IDA patients was 75.3 which was below the normal range of 80-100fL. The mean MCH for all IDA patients was 25.5 which was below the normal range of 27-32 pg. the mean MCHC for IDA patients was 31.6 which was below normal range of 32-36 g/dL.

**Table 3: the correlation coefficient and p-value for each parameter**

|  |  |  |
| --- | --- | --- |
| RBC INDEX | CORRELATION COEFFICIENT (r) | p-value |
| MCV | -0.76 | <0.001 |
| MCH | -0.65 | <0.001 |
| MCHC | -0.42 | <0.001 |

Correlation between MCV and Anemia

r= -0.76 (p< 0.001)

**Figure 4: showing correlation between MCV and IDA**

Correlation between MCH and Anemia

r= -0.65 (p<0.001)

**Figure 5: showing correlation between MCH and IDA**

Correlation between MCHC and Anemia

r= -0.42 (p <0.001)

**Figure 6: Correlation between MCHC and IDA**

**Discussion**

The study surveyed a total of 97 patients who underwent full blood count tests between January 2024 and August 2024. Among these patients, 45 individuals were diagnosed with Iron deficiency anemia resulting in a prevalence rate of 46%. This prevalence is in line with global trends which show that IDA accounts for about 50% of anemia cases [10]. There was a high prevalence at Masvingo Provincial Hospital because it is a referral hospital for people that come from rural settings. As a result, poverty and limited access to nutritious food amongst these people increase their chances of getting IDA. Apart from the above, provincial hospitals usually have limited resources for screening and treatment. This leads to patients being underdiagnosed or undertreated for such conditions. Masvingo Provincial Hospital also serves as a referral center for regions where many people may have conditions like HIV/AIDS. This increases the people’s susceptibility to anemia. Due to limited finances, some people from these low-income areas may not eat foods containing iron thereby increasing their risk [11]. Also, some of the people may lack nutritional education and may not know the importance of including iron rich foods to their diet. In addition, poor sanitation in regions covered by Masvingo Provincial Hospital may increase parasitic infections particularly hookworm infections and this may contribute to an increase in the number of IDA cases. Some of the patients may have cultural practices which limit the intake of iron-rich foods and this eventually leads to more cases of IDA [8]. The findings also show that women, particularly those of reproductive age showed a higher prevalence rate of 49.1% compared to men (42.5%). This difference shows the impact of menstrual blood loss especially in those that experience heavy menstrual periods [8]. Also, pregnancy and lactation require high iron intake and some of the patients may not have enough iron intake thereby increasing chances of getting IDA. Some women from these low-income areas may also value the nutritional needs of other family members at the expense of their own since women are expected to put others first in most cultures. This may cause them to have inadequate iron in their bodies. Also, women are more susceptible to chronic diseases for example gastrointestinal diseases. These conditions may lead to blood loss and malabsorption of nutrients thereby increasing risk of IDA.

The study focused on key red blood cell indices which are MCV, MCH and MCHC. The average values were;

* MCV: 75.3fL with the normal range being 80-100fL
* MCH: 24.5pg with the normal range being 27-32pg
* MCHC: 31.6g/dL with the normal range being 32-36g/dL

These findings indicate microcytic and hypochromic characteristics typical of IDA. Patients with IDA had significantly lower MCV and MCH values as compared to non-IDA patients. This shows that they can be useful in indicating IDA. This aligns with findings from other studies. MCV mainly measures the average volume of RBCs. IDA leads to decreased iron in the body which is crucial for hemoglobin synthesis. As a result of this decrease, the body compensates by producing smaller red blood cells. This can be referred to as microcytic anemia and this causes a lower MCV value. MCH is a measure of the average amount of hemoglobin per red blood cell. Since iron is crucial in hemoglobin synthesis, lack of iron results in a reduction in the hemoglobin produced in each RBC. This then contributes to this decrease in MCH below the normal range in patients with IDA. MCHC on the other hand, measures the concentration of hemoglobin in a given volume of RBCs. In IDA, the combination of production of smaller RBCs which results in lower MCV and decreased hemoglobin levels which results in lower MCH leads to lower concentration of hemoglobin thereby lowering the MCHC value [12-15].

To assess the relationship between red blood cell indices and IDA, correlation analysis were performed using Spearman’s rank correlation coefficient. This revealed;

* A strong negative correlation between IDA and MCV (r= -0.76, p<0.001)
* A moderate negative correlation between IDA and MCH (r=0.65, p<0.001)
* A week negative correlation between IDA and MCHC (r= 0.42, p<0.001)

These correlations indicate that as the severity of anemia increases, RBC indices decline. This also aligns with findings from other studies thereby highlighting the effectiveness in diagnosis of IDA. The findings show that there was a significant correlation between lower RBC indices and the presence of IDA. MCV measures the average volume of RBCs [16]. The negative correlation between MCV and IDA indicates that as the severity of IDA increases, the average size of these RBCs decreases. This is because when the body lacks enough iron, it produces smaller and more pale red blood cells. As the iron levels continue to decrease, the body continues to produce RBCs that are increasingly smaller hence the negative correlation. MCH indicates the average amount hemoglobin per RBC. The negative correlation between MCH and IDA shows that as IDA severity increases, the amount of hemoglobin content per RBC decreases. The lack of iron in IDA, leads to decreased hemoglobin synthesis and subsequently low hemoglobin levels in RBCs. The body tries to compensate for this decrease by producing more RBCs. However, these RBCs still contain low hemoglobin content hence why there is a negative correlation. MCHC measures the average concentration of hemoglobin in a given volume of RBCs. The negative correlation between MCHC and IDA shows that as IDA becomes more severe, the average concentration of hemoglobin in RBCs decreases [17]. This happens at a slower rate than MCH and MCHC hence why it has the lowest correlation coefficient. This shows that even though lack of iron decreases the hemoglobin content in RBCs, the RBCs may have a consistent volume. However, a decrease in hemoglobin content leads to a decrease in concentration hence why there is still a negative correlation.

**Conclusion**

The study highlights the prevalence of iron deficiency anemia among patients tested at Masvingo Provincial Hospital. It also establishes the correlation between RBC indices and IDA. The study indicates a prevalence rate of 46% for IDA among the patient population chosen with a higher incidence observed in women. The analysis of RBC indices revealed patterns associated with IDA thereby making them useful as diagnostic indicators. Strong negative correlations between RBC indices and Hemoglobin were seen. This showed the link between severity of anemia and these indices. Despite certain limitations, the study highlights the importance of early diagnosis and management of IDA. The study calls for targeted public health interventions to reduce the burden of IDA particularly in vulnerable populations.

## References

1. Wang L, Liang D, Huangfu H, Shi X, Liu S, Zhong P, Luo Z, Ke C, Lai Y. Iron deficiency: Global trends and projections from 1990 to 2050. Nutrients. 2024;16(20):3434.
2. Obeagu GU, Altraide BO, Obeagu EI. Iron deficiency anemia in pregnancy and related complications with specific insight in Rivers State, Nigeria: a narrative review. Annals of Medicine and Surgery. 2025:10-97.
3. Rahayu EM, Sitorus NL, Yuningrat N. Role of Midwives on supporting IDA prevention & screening: learning from international guideline/practice & evidence. Journal of Indonesian Specialized Nutrition. 2024;2(4):9-18.
4. Thyagaraju B, Doddagowda SM. A Comparative Study of Peripheral Smear Findings with RBC Indices and Automated Analyzer Generated RBC Histograms in the Diagnosis of Anemia's. Journal of Health and Allied Sciences NU. 2024.
5. Almashjary MN. Reticulocyte hemoglobin content: advancing the frontiers in Iron-deficiency Anemia diagnosis and management. Journal of Applied Hematology. 2024;15(1):1-8.
6. Ding N, Ma YH, Guo P, Wang TK, Liu L, Wang JB, Jin PP. Reticulocyte hemoglobin content associated with the risk of iron deficiency anemia. Heliyon. 2024;10(3).
7. Broekaert IJ, Assa A, Borrelli O, Saccomani MD, Homan M, Martin‐de‐Carpi J, Mas E, Miele E, Misak Z, Sila S, Thomson M. Approach to anaemia in gastrointestinal disease: A position paper by the ESPGHAN Gastroenterology Committee. Journal of Pediatric Gastroenterology and Nutrition. 2025.
8. Obeagu EI. Prevalence and risk factors of heavy menstrual bleeding in Africa: a narrative review. Annals of Medicine and Surgery. 2025:10-97.
9. Kimeli P, Mwacalimba K, Tiernan R, Mijten E, Miroshnychenko T, Nautrup BP. Important diseases of small ruminants in sub-Saharan Africa: A review with a focus on current strategies for treatment and control in smallholder systems. Animals: an Open Access Journal from MDPI. 2025;15(5):706.
10. Seydel GS, Bayraktar M, Ayan D. The prevalence of anemia, iron deficiency, and iron deficiency anemia in adult migrants in Nigde, Turkey. Postgraduate Medicine. 2025:1-8.
11. Kamran S, Uusitalo O. How informal financial service institutes facilitate the financial inclusion of low-income, unbanked consumers. International Journal of Bank Marketing. 2024;42(6):1232-1263.
12. Iolascon A, Andolfo I, Russo R, Sanchez M, Busti F, Swinkels D, Aguilar Martinez P, Bou‐Fakhredin R, Muckenthaler MU, Unal S, Porto G. Recommendations for diagnosis, treatment, and prevention of iron deficiency and iron deficiency anemia. Hemasphere. 2024;8(7): e108.
13. Khan RU, Almakdi S, Alshehri M, Haq AU, Ullah A, Kumar R. An intelligent neural network model to detect red blood cells for various blood structure classification in microscopic medical images. Heliyon. 2024;10(4).
14. Hussaini H, Obeidat K, Abusal AM, Fadeyi O, Habib I, Chaudhari SS, Wei CR, Hirani S, Hussaini Jr H. The Prognostic Value of Red Blood Cell Distribution Width-to-Albumin Ratio (RAR) in Predicting Mortality and Severity in Acute Pancreatitis: A Systematic Review and Meta-Analysis. Cureus. 2025;17(3).
15. Liu S, Zhang H, Zhu P, Chen S, Lan Z. Predictive role of red blood cell distribution width and hemoglobin-to-red blood cell distribution width ratio for mortality in patients with COPD: evidence from NHANES 1999–2018. BMC Pulmonary Medicine. 2024;24(1):413.
16. Pullakhandam S, McRoy S. Classification and explanation of iron deficiency anemia from complete blood count data using machine learning. BioMedInformatics. 2024;4(1):661-672.
17. Saba A, Komali G, Shrivastava D, Alghafli MA, Alazmi FM, Aljudaya SA, Heboyan A, Srivastava KC. Comparative Assessment of Blood Parameters Including RBC, Hb, PCV, Red Cell Indices, Serum Ferritin, and Salivary Candidal Growth in Female Patients with Iron Deficiency Anemia and Iron Deficiency. Journal of Pharmacy and Bioallied Sciences. 2024;16(Suppl 5): S4804-10.