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Prevalence of Iron Deficiency and Anemia among Eligible Blood Donors at Kenyatta National Hospital, Kenya

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

Aims: To determine the prevalence of iron deficiency and anemia among eligible whole blood donors attending Kenyatta National Hospital in Nairobi, Kenya.
Study Design: Cross-sectional study
Place and Duration of Study: Kenyatta National Hospital, Blood Transfusion Unit, between March 2021 and August 2021.
Methodology: A total of 202 prospective donors were allowed to donate whole blood based on donor recruitment creteria. Of these, 173 were males and 29 were females donors aged 18-57 years. Participants included, 119 (58.9%) first-time donors and 83 (41.1%) repeat donors. Eight mililitres (8 ml) of blood sample was drawn from each donated unit, 4ml was put into plain tube and the remaing was put into ethylene diamine tetraacetic acid tube. Serum ferritin levels were analyzed by Mini Vidas ® using enzyme linked florescent assay technique while hemoglobin levels was estimated by cell count analyzer (Humacount 5D ®). Results were summarized in medians and 95% interquartile ranges and compared using either Kruskal-Wallis test or Mann–Whitney U test as appropriate.

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Results: The overall prevalence of iron deficiency (serum ferritin <15 µg/ml) was 2.48%. The prevalence of iron deficiency in female donors was 6.98% compared with 1.73% in males. The overall prevalence of anemia was 7.42% (males Hb <13.0/dl and female Hb <12.0g/dl). The median serum ferritin concentration was 128 µg/ml. The median ferritin levels among male donors (131 µg/ml) were significantly higher compared to female donors (84.65 µg/ml) (*P*=0.01). There was also a significant difference between donors age group and serum ferritin levels (*P*=0.008). The study further observed a significant positive correlation between donors' hemoglobin concentrations and serum ferritin levels (*P*=0.001).
Conclusion: Iron deficiency and anemia are prevalent among eligible blood donors in Nairobi, Kenya. There is need to review hemoglobin cut-off values based on gender and to incorporate serum ferritin tests in routine donor screening protocols. Furthermore, repeat donors should be educated on iron deficiency and iron supplementation.

Keywords: Blood donor; anemia; hemoglobin ferritin and iron deficiency.

1. INTRODUCTION

Iron deficiency is defined as a medical disorder stemming from disparities between body iron stores and tissue iron requirements. It is the leading cause of anemia, affecting approximately 500 million people worldwide [1]. In resource-limited countries, in adults the dominant cause of iron deficiency is chronic blood loss emanating from the gastrointestinal tract or uterine [2]. Regular blood donation has been cited as being beneficial for several reasons such as challenging bone marrow to sustain hematopoietic activity and continuously produce red cells, regular blood donation also hinders the accumulation of iron which can form free radicals in the body [3]. Donation of one unit of whole blood results in the loss of approximately 247± 17 mg of iron. Mozaheb et al, observed first and second donations do not adversely affect donors' iron stores [4], this is assuming that the donors are already in an iron sufficient state. However, donors with history of multiple donations have their iron stores decreased due to negative iron balance. In addition, continuous /regular donation can lead to iron deficiency or anemia [5]. Moreover, the number of donations within one year is more predictive for decreased ferritin concentrations compared to the number of donors in a donors' lifetime [4].

In Kenya, the current practice of screening hemoglobin alone among blood donors may fail to detect early stages of iron deficiency and abnormal hematological parameters among donors with normal hemoglobin levels. A common challenge facing repeat blood donors is an iron deficiency, which primarily affects younger age, females, and regular donors [6]. The WHO [7] urges member countries to monitor donor iron stores by screening serum ferritin levels regularly. Kenya has a uniform hemoglobin cut-off value (12.5g/dl) despite the existence of the WHO definition for anemia (hemoglobin level <12 g/dl for females and <13 g/dl for male blood donors). Prospective blood donors with lower hemoglobin values without any signs or symptoms for anemia are typically disqualified from donating blood to prevent progression to iron-deficient anemia (IDA). Additionally, deferral of prospective donors with reduced hemoglobin values guarantees hematological profiles of donated units meet the standard thresholds [8].

The screening of an individual iron status is not precise, since various parameters indicate the status of different parts in the body. For instance, assessment of serum ferritin measures storage iron, while assessment transferrin saturation and serum iron reflect the supply of iron to tissues. Red cell zinc protoporphyrin, erythrocyte ferritin and serum transferrin receptors indicate the supply of iron to bone marrow. Mean corpuscular volume, percentage of hypochromic erythrocytes and reticulocyte hemoglobin concentration can also be used to asses iron in the bone marrow. However, all these parameters are affected by other factors such as sex, age, inflammation, infection, and smoking [9].

The most reliable and sensitive tool for screening blood donor iron status is plasma/serum ferritin levels [4]. Ferritin is the main iron storage protein in the human body. Ferritin molecule is an intracellular protein shell consisting of 24 subunits surrounding an iron core that carries up to 4500 iron atoms. In a healthy individual, small quantities of ferritin are secreted into the blood stream. The concentration of serum ferritin is positively correlated with the amount of total body iron stores in the absence of inflammation [9]. The current study, aimed to determine the

prevalence of iron deficiency and anemia among eligible blood donors by screening serum ferritin concentrations and hemoglobin levels, respectively.

2. METHODOLOGY

2.1 Study Area

This study was conducted at Kenyatta National Hospital, Blood Transfusion Unit (KNH-BTU). The facility is located in Nairobi County, the capital city of Kenya. It serves as the largest referral hospital providing specialized medical care to the country's population, in addition to referrals from neighboring countries. The current study commenced in March 2021 and ended in August 2021.

2.2 Study Population

We conducted a cross-sectional study targeting prospective blood donors presenting for donation of whole blood at KNH. A systematic random sampling technique was used to recruit 384 prospective donors aged 18 - 57 years. Of these, only 202 participants were allowed to donate whole blood based on donor recruitment criteria.

2.3 Laboratory Procedures

Serum ferritin concentrations (sFe) and hemoglobin levels (HB) were determined for all donated units. Four milliliters was drawn from donated units via the bleeding line into ethylene diamine tetraacetic acid (EDTA) and four milliliters into plain tubes. Serum ferritin concentrations were analyzed using the Mini Vidas ® equipment which uses enzyme-linked fluorescent assay technique, while hemoglobin levels were analyzed by a hematology analyzer (HumaCount 5D ®).

2.4 Statistical Analysis

Statistical analysis was performed using Microsoft Excel and SPSS version 20. Iron deficiency was defined according to the WHO guidelines; sFe concentrations <15ng/dl and anemia as HB <12.0g/dl in females and <13.0g/dl in males. Non-parametric data collected in this study were analyzed using the Mann Whitney U test, Kruskal Wallis H test and Spearman's correlation tests. Statistical significance was set at a *P* value of <.05.

3. RESULTS

The demographic distribution of the study population based on gender, age group, donor status, and donor type is presented in (Table 1). Out of 202 eligible blood donors, male donors were the majority constituting 173 (86.6%). The median age was 28 years, with the age group 20-29 years having the highest number of participants 99 (49%). First time donors were the majority compared to repeat donors (119 vs. 83), respectively. Family replacement donors were the majority 200 (90%) with only 2 (1%) voluntary non remunerated donors.

Table 1. Socio-demographic characteristics of blood donor

Characteristics		Donors (n=202)	Frequency (%)
Gender	Male	173	86.6%
	Female	29	14.4%
Age group	<19	11	5.4%
	20-29	99	49%
	30-39	68	33.7%
	40-49	19	9.4%
	>50	5	2.5%
Donor status	First-time	119	58.9
	Repeat	83	41.1%
Donor type	Voluntary	200	99%
	Replacement	2	1%

N=number

Table 2. Prevalence of iron deficiency and anemia among blood donors

	Cut-off values	Male (n = 173)	Female (n = 29)	Overall (n = 202)
Ferritin concentration	Iron deficiency (<15 µg/ml)	3 (1.73%)	2 (6.89%)	5(2.48%)
	Healthy (>15 – 200 µg/ml)	122 (70.52%)	20 (68.97%)	142(70.29%)
	Iron overload (>200 µg/ml)	48 (27.75%)	7 (14.14%)	55(27.23%)
Hemoglobin	Male (<13.0g/dl)	15(8.67%)	-	15(7.42%)
	Female (< 12.0g/dl)	-	0	0

n= number

Table 3. Serum ferritin levels based on blood donors gender

Attribute	Category	Number (n=202)	Median (IQR) (µg/ml)	Minimum (µg/ml)	Maximum	Mann Whitney U test Statistic
Gender	Male	173	131 (85.22)	11.91	488.11	*P*=0.010*
	Female	29	84.65 (147.14)	13.21	349.57	
	Overall	202	128 (124.34)	11.91	488.11	

*n= number, IQR=interquartile range, Overall=male and female, * Significant at the p< 0.05 level*

Table 4. Comparison of serum ferritin concentrations and donor age group

Attribute	Category	n=202	Median (IQR) (µg/ml)	Minimum (µg/ml)	Maximum (µg/ml)	Kruskal Wallis H Statistic
Age group	<19	11	67.45(61.42)	11.98	198.43	P=0.008*
	20-29	99	119.76(101.7)	11.91	472.12	
	30-39	68	140.09(74.94)	13.21	488.18	
	40-49	19	152.48(84.83)	66.52	462.10	
	>50	5	93.29 (160.91)	35.48	243.50	

*n= number, IQR=interquartile range, * Significant at the p< 0.05 level*

Among the 202 participants the prevalence of iron deficiency was 2.48% (serum ferritin <15 µg/ml). The prevalence of iron deficiency in female donors was 6.89% while in male donors it was 1.73%. Based on WHO definition of anemia (Hb <13g/dl in men and <12.0g/dl in women) Fifteen male donors had anemia translating to an overall prevalence of 7.42%, no female donor had anemia. Majority of donors were healthy (70.2%) and about 27.2% had iron overload. Table 2 compares the prevalence of iron deficiency and anemia based on gender using serum ferritin concentrations and hemoglobin levels, respectively.

The serum ferritin levels ranged from 11.91µg/ml to 4.88.11µg/ml with a median of level of 128µg/ml. Male donors had significantly higher ferritin levels (131µg/ml) compared to female donors (84.65µg/ml) (U=1759, P=0.010) (Table 2). A comparison of serum ferritin concentration and donors' age group revealed that age group 40-49 years had the highest median ferritin concentrations (152.48µg/ml) (Table 3). There was a positive correlation between blood donors' Hb levels and serum ferritin concentrations (rs= 0.317, P <0.001).

4. DISCUSSION

Iron is an essential element with vital functions that includes muscle metabolism, DNA synthesis and oxygen transport [10]. Blood donation centers are responsible for safeguarding blood donors' from developing iron deficiency and anemia [3]. They also have a crucial role in promoting voluntary blood donation in setups like Kenya, where hospital-based donation is primarily from family replacement donors. Early detection of iron deficiency and anemia among prospective donors would allow necessary changes in donation intervals and advice on the use of iron supplements [11]. This study analyzed iron status and hemoglobin levels among eligible blood donors presenting to donate whole blood at Kenyatta National Hospital.

The current study found the prevalence of iron deficiency (serum ferritin< 15µg/ml) at 2.48%. This prevalence is consistent with Saudi Arabian and Iranian studies that observed a prevalence of 2.17% and 2.14%, respectively [11,12]. These findings were attributed to an increase in donations that resulted in a decrease in donor

iron stores. Other studies with the same serum ferritin cut-off values found a higher prevalence of iron deficiency. For instance, Gunnarsdóttir et al, observed a prevalence of 11% among blood donors in Iceland [13], and Mozaheb et al, published a prevalence of 20% among Iranian blood donors [4]. This variation could be attributed to differences in gender, nutritional status of donors, prevalence of conditions associated with iron deficiency, the number of donations per year, and last donation intervals.

Previous studies with a higher prevalence of iron deficiency had reduced ferritin threshold values (serum ferritin concentration <12µg/ml). For instance, Ali et al, reported a prevalence of 24% among eligible blood donors in Sokoto, Nigeria [14]. Another study with the same serum ferritin cut-off values (<12µg/ml) reported a prevalence of 20.6% among regular blood donors at Port Harcourt, Nigeria [15]. There are several reasons attributed to high incidences of depleted iron stores in developing countries. The main reason for iron deficiency anemia in resource-limited countries is parasitic infestation such as; malaria, roundworms, whipworms, and hookworms [16].

In our study, female blood donors had a higher prevalence of iron deficiency than male donors (6.89% vs. 1.73%, respectively). This finding agrees with a study in Sokoto, North Western Nigeria, which reported the prevalence of iron deficiency among female and male donors at 11.8% and 7.4%, respectively [14]. Another study on Iceland donors documented 22% and 1% as the prevalence of iron deficiency among female and male donors, respectively [13]. This marked difference could be attributed to variation in sample size, demographic and geographical characteristics, the number of donations per year, nutritional status of donors and prevalence of conditions associated with iron deficiency. Kenya's current donor recruitment guidelines demand a pre-donation hemoglobin level of above 12.5g/dl before blood donation. Hemoglobin level below this cut-off value has been cited as the leading cause for donor deferral. A previous report by Njenga et al. [17] found that low hemoglobin accounts for about 11.6% of all donor deferral cases in Kenya. Screening for iron status and hemoglobin concentrations among prospective donors enables the prediction of donors at risk of subsequent anemia and hence appropriate for deferral [4].

Globally there are variations regarding the acceptable minimum hemoglobin cut-off level for both male and female donors. For instance, in countries like Kenya and Nigeria, the recommended cut-off value for hemoglobin among both genders is 12.5 g/dl; in Brazil, the minimum hemoglobin requirement for male donors is 13g/dl and females 12 g/dl. According to the European council, the hemoglobin cut-off values for blood donation are 12.5 g/dl and 13.5 g/dl for female and male donors, respectively [18]. The rationale for a single cut-off value for hemoglobin for all donors is that females represent the highest number of donors deferred due to low hemoglobin. Most of them are likely to have hemoglobin levels near 12.5 g/dl. In contrast, male donors selected for blood donation with this cut-off value may be anemic [18]. The current study found 8.6% of male donors allowed to donate whole blood were anemic. According to Mast measuring hemoglobin concentration alone is insufficient to qualify blood donors' fitness to donate blood [19]. Furthermore, majority of techniques available for screening hemoglobin are unable to detect latent stages of iron deficiency.

In our study, there was a significant difference in serum ferritin levels between male and female donors. The median ferritin level was 128µg/ml, with male donors having the highest median ferritin count compared to female donors (147.14µg/ml vs. 85.22µg/ml, respectively). These observations shows Kenyan levels are higher compared to a study on Iceland blood donors which found the median ferritin count of 51µg/ml, with male and female donors recording 86.4µg/ml and 26.6µg/ml, respectively [15]. Our observations were similar with a previous study in Nigeria, which indicated that female donors had slightly lower serum ferritin concentrations than male donors [14]. According to Deepa et al, there is a definite relationship between female donors' reproductive age and low ferritin concentrations [18]. This finding was attributed to their inability to restore dietary iron lost from physiological demands, menstruation, and parasitic infections. Abdullah further reported that a donation frequency of up to 5 pints per year could not be restored by dietary iron absorption, resulting in iron deficiency [11].

This study demonstrated a significant difference between serum ferritin concentrations and donors' age groups with a gradual increase in ferritin levels with advancing donors' age. Another study on Iranian blood donors reported insignificant difference between ferritin levels and donors' ages [4]. This difference could be

attributed to variation in blood donors' age distributions between the two countries. In pre-pubertal individuals, no significant difference can be observed between ferritin concentrations, ages, and the sexes. Difference emerge only after the onset of menstruation with lower sFe levels in females, a situation that changes 10 years after menopause when HB and sFe levels become similar to that of age-matched men [14].

4. CONCLUSION

Applying the existing donor recruitment criteria, this study shows the existence of a high prevalence of iron deficiency and anemia among eligible female and male blood donors, respectively. There is also a significant difference in serum ferritin levels between male and female donors. These findings highlight the need to review the current donor selection guidelines to incorporate other screening tests such as ferritin levels that would allow detection of iron deficiency among donors. Finally, there is need to educate regular blood donors regarding iron deficiency and iron supplementation.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

All eligible study participants provided written consent to being included in the study.

ETHICAL APPROVAL

The Kenyatta National Hospital –University of Nairobi Ethical Review Committee approved this study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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