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Iron Deficiency among Blood Donors in Sokoto, North Western, Nigeria

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Abstract

Objectives: There is a paucity of information on the prevalence of iron deficiency among blood donors in Sokoto, North Western, Nigeria. The present study was, therefore, designed to investigate the prevalence and socio-demographic factors associated with iron deficiency among blood donors in Sokoto, North Western, Nigeria using a combination of haemoglobin haematocrit and serum ferritin measurements. Materials and methods: One hundred and fifty consecutively recruited whole blood donors, comprising of 148 (98.7%) family replacement donors and 2 (1.3%) voluntary non-remunerated donors, 145 male (96.7%) and 5 (3.33%) female blood donors aged 18 - 60 years with mean age 39 ± 21 years constituted the subjects for this study. Subjects included farmers 55 (43.3%), 56 civil servants (37.3%) and 39 (26%) students. The full blood count was carried out using Mythic 22 CT fully automated haematology analyser (Orphee SA, Switzerland). Serum was tested for ferritin using a human ferritin enzyme immunoassay kit—ACCU Diag™ ELISA Ferritin kit (Diagnostic Automation/Cortez Diagnostic Inc. California (U.S.A). Result: Three haematological parameters (haemoglobin, packed cell volume and serum ferritin) were assessed among blood donors. The haemoglobin, packed cell volume and ferritin levels were significantly lower among regular voluntary remunerated blood donors (13.5 ± 0.00, 43.5 ± 2.0 and 34.88 ± 0.00) compared to Family replacement donors (14.10 ± 2.40, 45 ± 3.0 and 74.12 ± 45.20) respectively (p = 0.01, 0.01 and 0.001 respectively). The mean haemoglobin, packed cell volume and ferritin levels were compared among donors based on gender. The haemoglobin, packed cell volume and ferritin were significantly higher among male donors (14.2 ± 2.0, 44 ± 4.0 and 78.02 ± 49.10) compared to female donors (12.35 ± 2.5, 42 ± 3.0 and 42.2 ± 32.13) (p = 0.01, 0.01 and 0.001 respectively). The mean haemoglobin, packed cell volume and ferritin levels were compared among donors based on occupational groups. The haemoglobin, packed cell volume and ferritin were significantly higher among civil servants compared to farmers and students (p = 0.01). Conclusion:

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Iron deficiency is prevalent among blood donors in Sokoto, North Western, Nigeria. There is a need to review the screening tests for the selection of blood donors and include serum ferritin measurement in the donor screening menu as well as provide iron supplementation for regular blood donors.

Keywords

Iron Deficiency, Blood Donors, Sokoto, Nigeria

1. Introduction

Iron deficiency is a global public health problem and the most common nutritional deficiency in both developing and developed countries [1]. A healthy individual can donate blood up to four times a year [2]. A cut-off value of haemoglobin of 12.5 g/dL is often recommended before a blood donation is made. Regular blood donation puts a significant toll on iron stores. Blood donation leads to substantial iron loss, as about 0.5 mg iron is lost per each millilitre of blood donated. If not compensated efficiently, the iron loss may eventually lead to iron deficiency [3]. Iron stores are approximately 30% lower in female donors than in male donors and regular blood donation predisposes to iron deficiency (ID) [4]. A previous report among a total of 3094 blood donors indicated that the prevalence of ID in new female donors was 12.0% compared with 1.3% in males. The prevalence of ID in female whole blood only donors was 26.4% and it increased with donation frequency and decreased with age [5]. The mean serum iron was significantly higher among subjects with no previous history of blood donation and an increase in the number of donations resulted in an increase in the frequency of depleted iron stores and subsequently in erythropoiesis with iron deficiency [6]. Regular blood donation can lead to ID. Screening donors' serum ferritin levels at the time of first donation and subsequently once every year is a very rational way to pick up iron deficiency in a voluntary blood donor population [6]. There is paucity of data on the prevalence of iron deficiency among blood donors in the Sokoto, North Western Nigeria. The present study was, therefore, designed to assess the prevalence of iron deficiency and its associated socio-demographic factor using a combination of Haemoglobin, packed cell volume and serum ferritin measurements.

2. Materials and Methods

2.1. Study Area

Usmanu Danfodiyo University Teaching Hospital Sokoto is located in Sokoto State at the extreme Northwest of Nigeria between longitude 05˚ and 11˚ to 13˚ and 03˚ East and between latitude 13˚ and 0˚ to 13˚ and 06˚ North. The state shares border with the Republic of Niger to the North, Kebbi State to the West and Southeast and Zamfara State to the East. The state covers land area of about 60.33 km^2. Report from the 2007 National population commission indicated that the state had a population of 3.6 million. The indigenous inhabitants of the area are the Hausa and Fulani. Other ethnic group resident in the area includes Igbo, Yoruba, Ebira, and Igala. Hausa is the commonly spoken language; traders form the greater percentage of the population, while the rest are civil servants, farmers, artisans and of other occupation. The study was conducted in the teaching hospital with various categories of blood donors. Report from the 2007 National Population Commission indicated that the State had a population of 3.6 million (NPC, 2007) [7].

2.2. Study Population

One hundred and fifty apparently healthy consecutively-recruited blood donors visiting the blood bank in Usmanu Danfodiyo University Teaching Hospital for blood donation purpose constituted the subjects for this case study. Donors were categorized into 2 groups (family replacement donors and voluntary non-remunerated blood donors. A family replacement donor is one who gives blood when it is required by a member of the donor's family or community while voluntary non-remunerated donors are donors who donate blood out of altruism. Voluntary, non-remunerated blood donation is the cornerstone of a safe and adequate national blood supply.

2.3. Inclusion Criteria

All consecutively—recruited, consenting blood donors aged 18 - 60 years, resident in Sokoto without any history of long-term medication use, illness, history of recent blood transfusion in the last 4 months and menstruation (female) visiting the Blood Transfusion Department of Usmanu Danfodiyo University Teaching Hospital Sokoto for Blood donation purpose were recruited into the study.

2.4. Exclusion Criteria

All Blood donors visiting the Transfusion Laboratory of Usmanu Danfodiyo University Sokoto for Blood Transfusion purpose who did not meet the inclusion criteria were excluded from the study. Ethical approval was sought from the ethical committee of Usmanu Danfodiyo University Sokoto, Nigeria.

2.5. Statistics

Statistical analyses were conducted using SPSS (version 18) software. Comparisons between populations were made using the Student's t-test for parametric data and the Mann-Whitney test for non-parametric data. A p-value of <0.05 denoted a statistically significant difference in all statistical comparisons.

2.6. Sampling and Methods

About 6 millilitres of whole blood were collected using monovette vacutainer syringe into EDTA anticoagulated tube and plain tubes without anticoagulant. The EDTA anticoagulated blood was used for Full Blood Count investigation to obtain the haemoglobin and haematocrit. The full blood count was carried out using Mythic 22 CT fully automated haematology analyser (Orphee SA, Switzerland). The analyser is a fit for purpose fully automated 22-parameter haematology analyser with associated low reagent consumption and less maintenance. It is based on the impedance technology for cell counting. Sample collected into the plain tube was allowed to clot and the serum was obtained. Serum was tested for ferritin using a human ferritin enzyme immunoassay kit—ACCU Diag™ ELISA ferritin kit (Diagnostic Automation/Cortez Diagnostic Inc. California (U.S.A). Test procedures were conducted as described in the manufacturer's standard operating manual included with the kit. The ferritin quantitative test is based on a solid phase enzyme-linked immunosorbent assay (ELISA).

3. Results

One hundred and fifty consecutively-recruited whole blood donors, comprising of 148 (98.7%) family replacement donors and 2 (1.3%) voluntary non-remunerated donors aged 18 - 60 years with mean age 39 ± 21 years made up of 145 male (96.7%) and 5 (3.33%) female constituted the subjects for this study. Subjects were made up of farmers 55 (43.3%), 56 civil servants (37.3%) and 39 (26%) students. Three haematological parameters (haemoglobin, packed cell volume and ferritin) were assessed among blood donors. The haemoglobin, packed cell volume and ferritin levels were significantly lower among regular voluntary remunerated blood donors compared to family replacement donors ($p = 0.01$). **Table 1** showed the mean values of some haematological parameters based on donor type. The mean haemoglobin, packed cell volume and ferritin levels were compared among donors based on gender. The haemoglobin, packed cell volume and ferritin were significantly higher among male donors compared to female donors ($p = 0.01$). **Table 2** showed the mean values of haematological parameters based on gender. The mean haemoglobin, packed cell volume and ferritin levels were compared among donors based on occupational groups. The haemoglobin, packed cell volume and ferritin were significantly higher among civil servants compared to farmers and students ($p = 0.01$). **Table 3** showed the mean values haematological parameters based on occupational group of donors.

4. Discussion

Serum ferritin concentration thus appears to be a sensitive index of iron stores. Ferritin is a ubiquitous intracellular protein that stores iron and releases it in a controlled fashion. Ferritin levels are considered the gold standard for the diagnosis of iron-deficiency [8]. Several studies have used serum ferritin concentration as an indicator of iron stores [9]-[11]. Previous report indicates that virtually all patients with serum ferritin concentrations less than 15 ng/mL are iron deficient, with a sensitivity and specificity of 59% and 99%, respectively [12].

Table 1. Mean values of haematological parameters based on donor type.

Parameter	Donor type		P-value
	VNRD	FRD	
Haemoglobin (g/dl)	13.5 ± 0.00	14.10 ± 2.40	0.01
Haematocrit (%)	43.5 ± 2.0	45 ± 3.0	0.01
Serum ferritin (ng/ml)	34.88 ± 0.00	74.12 ± 45.20	0.001

Legend: *VNRD*: *Voluntary non remunerated donor*. *FRD*: *Family replacement donors*.

Table 2. Mean values of haematological parameters based on Gender.

Parameter	Gender		P-value
	Male (n = 145)	Female (n = 5)	
Haemoglobin (g/dl)	14.2 ± 2.0	12.35 ± 2.5	0.01
Haematocrit (%)	44 ± 4.0	42 ± 3.0	0.01
Serum ferritin (ng/ml)	78.02 ± 49.10	42.2 ± 32.13	0.001

Table 3. Mean values haematological parameters based on occupational group of donors.

Parameter	Occupational group			P-value
	Farmers (n = 65)	Civil servants (n = 56)	Students (n = 39)	
Haemoglobin (g/dl)	12.5 ± 2.1	13.3 ± 2.9	13.21 ± 2.0	0.01
Haematocrit (%)	41.5 ± 4.0	43.8 ± 2.5	42 ± 2.5	0.01
Serum ferritin (ng/ml)	78.02 ± 49.10	92.5 ± 36	87.8 ± 50.5	0.01

A cut-off limit of 30 ng/mL may increase its sensitivity to 92% [13]. Blood donation results in a substantial (200 - 250 mg) loss of iron at each collection procedure, during which up to 425 - 475 mL of whole blood are withdrawn, and subsequent mobilisation of iron from body stores [13] [14].

In this present study, we observed a prevalence of iron deficiency (SF < 12 ng/ml) of 36 (24%). There is a paucity on information on ferritin levels among blood donors in Nigeria. Our finding is however consistent with report by Jeremiah and Koate [15] who obtained isolated iron deficiency (serum ferritin < 12 ng/mL) in 20.6% of their cohort of three hundred and forty-eight unselected consecutive whole blood donors in Port Harcourt, Nigeria. A previous report that investigated iron stores among Nigerian donors obtained a mean ferritin level of 49.19 ± 5.1 ng/ml and indicated that some blood donors may have pre-latent or latent iron deficiency at the time of donation and may manifest as iron deficient after blood donation [16]. Our finding is also consistent with previous report which indicated that the frequency of iron deficiency is high in blood donors and more dependent on the frequency of donation than on the accumulated number of donations [17]. The general impact of blood donation on iron status has been studied in Danish males. Iron stores were assessed by serum (S-) ferritin and haemoglobin (Hb) in a population survey comprising 1433 males in age cohorts of 30, 40, 50, and 60 years; 389 (27%) were blood donors and 1044 (73%) non-donors. Donors had lower serum ferritin, median 95 micrograms/l, than non-donors, median 136 micrograms/l. Serum ferritin values less than 15 micrograms/l (depleted iron stores) were seen in 3.3% of donors vs. 0.4% of non-donors, and serum ferritin values of 15 - 30 micrograms/l (small iron stores) in 9.8% of donors vs. 1.4% of non-donors. Iron-deficiency anaemia (serum ferritin less than 15 micrograms/l and Hb less than 129 g/l) was seen in 0.26% of donors vs. 0.10% of non-donors [18].

Iron stores were estimated in 333 professional blood donors by serum ferritin assay in Pakistan. Iron deficiency or depleted iron stores assessed by low serum ferritin levels (less than 12 ng/ml) were found in 15% donors. Anaemia (Hb less than 13 g/d1) was found in 284 (85%) donors, 51 (18%) of these had iron deficiency or low ferritin levels [9]. A previous study included ninety-two regular blood donors and 95 first time blood donors in Malaysia indicated a prevalence of iron deficiency in 7.4% of all first time donors as compared to 17.4% in regular donors [19]. Similarly a previous report in India indicated that an increase in donation frequency was accompanied by a significant decrease in serum ferritin; values < 15 microg/l. They obtained a prevalence of iron deficiency in 21 and 46 per cent of male and female donors respectively who donated once per year, in 29

and 27 per cent in those who donated twice per year and in 49 and 100 per cent in those who donated thrice per year [14]. Adediran and colleagues in Lagos obtained a mean serum ferritin was 102.46 ± 80.26 ng/mL among their cohort of 30 first-time volunteer blood donors and 41.46 ± 40.33 ng/mL among their cohort of 52 regular donors [20].

Serum ferritin levels were determined in 500 Spanish blood donors of both sexes chosen at random and in 200 suitors for blood donation, used as control group. Iron deficiency was defined by ferritin values < 15 ng/dL. The mean ferritin value in men was 86.0 ng/dL, and in women this was 27.1 ng/dL. With respect to the control group, blood donors showed increased iron deficiency, 7.4% for men and 11.8% for women. Highly significant direct correlation was found in male donors between total donations, last-year donations and age, and between total number of donations and age in female donors [21].

Iron deficiency is the commonest cause of anaemia worldwide and healthy blood donors are estimated to lose about 236 mg of iron with each donation. In a previous report, the serum ferritin level were found to be significantly lower among the regular donors (62.0 ± 39.78 ng/ml) compared to first time donors (90.7 ± 66.63) and second group donors (114.12 ± 66.97). The serum ferritin levels gradually decrease according to the number of donations and there was a significant correlation between frequency of donations and the serum ferritin level (r2 = 0.082) [22]. Our finding is however at variance with previous report by Vilzu and co-workers who found no significant difference between ferritin levels in controls and donors donating less than 20 units [23].

Blood donation leads to substantial iron loss, as about 0.5 mg iron is lost per each millilitre of blood donated. If not compensated for efficiently, the iron loss may eventually lead to anaemia, though non-anaemic iron deficiency per se may be problematic. A cross-sectional, descriptive, and analytic study was conducted among 91 male volunteer blood donors aged from 20 to 50 years attending three IBTO stations located in central areas of Tehran, and 63 apparently healthy controls that were matched for age, gender, monthly income, height, and weight. The levels of Hb, Hct, and iron status indices were all significantly lower in the subjects than in controls and a gradual but significant decrease in iron status indices in each time of blood donation was found. Frequency of blood donation per year was also inversely correlated with Hb, Hct, serum ferritin and, but was directly correlated with TIBC [24].

Iron deficiency anaemia is an important limiting factor for the number of donations in regular donors. A previous study was conducted to evaluate the prevalence of iron deficiency and its related factors in 337 blood donors at Yazd blood transfusion centre, Iran. Results showed that the prevalence of reduction in iron stores increased with an increase in the number of donations. The prevalence of iron deficiency in female and male regular donors was 78% and 28%, whereas 55.6% and 16% of these donors had iron deficiency anaemia [25].

There are several factors that may be responsible for the high prevalence of iron deficiency among blood donors in Sokoto, Nigeria. The most common causes of iron deficiency and anaemia in sub Saharan Africa include; malaria, nutritional deficiencies of iron and folate, parasitic diseases such as hookworm whipworms and roundworms, haemoglobinopathies such as sickle cell disease and recently human immunodeficiency virus infection [26]-[29]. Previous report among Danish blood donors indicates that iron deficiency as an important problem, especially among menstruating women donating frequently and that the risk of iron depletion was largely explained by sex, menopausal status, donation frequency, dietary and supplemental iron intake [30].

Early detection of iron deficiency among blood donors would allow appropriate re-adjustment of donation intervals and would guide the use of iron supplementation. It has recently been recommended that short-term iron supplementation combined with adjustments of haemoglobin acceptance levels may reduce the rate of donor deferral for low haemoglobin [31].

The mean serum ferritin levels was significantly higher among FRD compared to regular voluntary non-remunerated donors (66 ± 54 versus 35 ± 10 ng/ml) (p = 0.01). Our study indicates that ferritin level is significantly lower in regular blood donors. This finding is consistent with previous reports which indicated that the ferritin concentrations decreased significantly with an increase in the number of donations [32]. Repeated blood donations might diminish iron status. A previous report suggest that it could be safe to donate 2 - 3 units/year without an appreciable incidence of iron deficiency, provided that the pre-donation haemoglobin and ferritin values are >/=14.7 g/dL and 58.9 mug/L, respectively [33]. The pathophysiology behind blood donation-related iron depletion may involve hepcidin, a recently discovered peptide that acts by inhibiting iron absorption and promoting iron retention in reticuloendothelial macrophages. Previous report indicates that pro-hepcidin levels increases in relation to blood donation frequency per year [34]. Previous report indicates a significant correlation between hepcidin and serum ferritin [35]. Previous report suggest that there are newer tests (reticulocyte haemo-

globin content, percentage of hypochromic red cells, and soluble transferrin receptor) that can potentially play a role in the monitoring of iron stores in donors [36].

The mean haemoglobin and packed cell volume levels was significantly higher among FRD compared to regular voluntary non-remunerated donors. Our finding is at variance with a previous report by Adediran and colleagues [37] in Lagos, Nigeria which suggest that hemoglobin concentration, packed cell volume, and serum iron levels are not significantly affected by regular blood donation and that regular blood donors appear to have reduced iron stores compared with controls. Our finding is also at variance with previous report by Flesland and colleagues [38] who reported that the haemoglobin concentration in regular blood donors was not significantly different from that of first-time donors. Similarly, Szymczy-Nuzka and Woloweic [39] reported a normal haemoglobin and haematocrit in their cohort of 151 regular male donors who had given over ten units of whole blood at a frequency of 4 - 6 units per year. Our finding is also however consistent with previous report by Djalali and colleagues [40] and that of Jeremiah and Koate [15] who reported a significantly lower haemoglobin and packed cell volume in regular blood donors when compared with healthy controls.

The haemoglobin, haematocrit and serum ferritin levels were significantly higher among male donors compared to female donors. Our finding is consistent with previous reports which indicated that anaemia is significantly higher in female donors compared with male donors. In pre-pubertal humans no major differences can be found between the sexes in red blood cell count or haemoglobin. Only after the onset of menstruation does a difference emerge [41]. Not until 10 years after the menopause does this situation revert in women, when the haemoglobin concentration becomes similar to that of aged-matched men. Our finding is consistent with a previous report among Iranian blood donors in which the prevalence of iron deficiency was higher in female (78%) compared to and male regular donors (28%) [42]. Also a previous report among Thai blood donors indicated that depleted iron stores (SF < or = 15 ng/mL) is higher among female donors (32.65%) compared to male (21.21%). Previous report indicates that there are substantial gender-related differences in Hb and other indicators of iron status during infancy [43] [44]. Previous report by Shalini and colleagues [45] indicated that anaemia is significantly higher in female donors compared with male donors. Similarly, a previous study among 500 Spanish blood donors of both sexes indicated that iron deficiency (ferritin values < 15 ng/dL) was 7.4% for men and 11.8% for women [21]. A previous report had queried why women should have lower reference limits for haemoglobin and ferritin concentrations [46]. In pre-pubertal humans no major differences can be found between the sexes in red blood cell count or haemoglobin and serum ferritin concentrations. Only after the onset of menstruation does a difference emerge [47]. Not until 10 years after the menopause does this situation revert in women, when the haemoglobin concentration becomes similar to that of aged matched men.

Haemoglobin, haematocrit and serum ferritin level was significantly higher among civil servants compared to farmers and students. The reason for this occupational difference in haemoglobin and ferritin level is unknown. However, civil servants are more educated. They are likely to have more access to finance to support better nutrition, live a better quality life and protection from factors that predispose people to anaemia and low iron stores.

Current guidelines in Sokoto and other parts of Nigeria require a pre-donation haemoglobin level of ≥12 g/dl before blood donation. Low haemoglobin below this threshold is usually a common reason for donor deferral. Pervious report indicates that low haemoglobin deferral occurs in about 10% of attempted whole blood donations and that it is commonly a consequence of iron deficiency anaemia particularly among pre-menopausal women who often have iron deficiency anaemia caused by menstruation and pregnancy and thus have low haemoglobin deferral on their first donation attempt [48]. This study indicate the urgent need to review current guidelines in Nigeria and other developing countries which require the determination of haemoglobin and haematocrit levels before blood donation. Previous report suggest that screening for Hb and iron indices enables prediction of donors at risk of subsequent anaemia and who would most benefit from prevention strategies [49]. Haemoglobin and haematocrit measurements alone seem unsuitable for use as a screening tool for the diagnosis of iron depletion in blood donors. Previous report indicates that just measuring the hemoglobin level is not sufficient for selecting donors. In addition, testing of the ferritin level and iron supplementation are recommended in regular donors with more than one donation per year [50]. In other to ensure the objective of ensuring the safety of blood donors and recipient, there is the urgent need to introduce routine ferritin testing into the donor screening menu in Nigeria in particular and sub Saharan Africa in general to protect the safety of blood donors. A significant number of our cohort of donors despite being eligible to donate blood based on current guidelines of pre-donation haemoglobin of ≥12.5 g/dL) had suboptimal ferritin level, a reflection of low iron status. Serum

iron concentration and ferritin level measurements may be an objective way to ensure a safer blood donation process particularly among regular blood donors. Our observation is consistent with results from a previous study which showed that subclinical iron deficiency is prevalent even among blood donors that meet the Hb criteria for blood donation [51].

5. Conclusion

This current study indicates that there is a high prevalence of iron deficiency among blood donors in Sokoto, North Western Nigeria. There is a need to review the screening tests for the selection of blood donors and include serum ferritin measurement in the donor screening menu as well as provide iron supplementation for regular blood donors. The serum ferritin levels should possibly be determined at the time of first donation and subsequently once every year and donors found to be iron-deficient should be offered iron supplementation to protect blood donors.

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Conflict of Interest

The authors declare that there is no conflict of interest with this study.

Limitations

In this study we did not collect data on how many blood donors are vegetarians. Significant populations in Sokoto, North Western Nigeria are predominantly Muslims. The number of vegetarians in the area is significantly low. It may have been useful to provide some discussion on the correlation between vegetarians and iron deficiency. Predominant numbers of blood donors in Nigeria are family replacement donors. Family replacement donor is one who gives blood when it is required by a member of the donor's family or community. The number of voluntary donated blood in Nigeria is significantly lower compared to developed countries. In this present study we had only 2 voluntary donors among our consecutively recruited 150 blood donors. We have had to base our conclusions on comparing 148 family replacement donors to 2 voluntary donors. The disparity of the numbers in two groups may be too big to compare and to draw a conclusion. Similarly subjects recruited into this study were predominantly male. The number of women who donate blood in this environment is significantly low compared to observation in developed countries. Education, awareness and religious misconceptions may be responsible for this low female gender-related participation in the blood donation process in Sokoto, Nigeria.

References

[1] World Health Organization (2001) Iron Deficiency, Anaemia Assessment, Prevention, and Control. A Guide for Programme Managers. Geneva.

[2] Boulton, F., Collis, D., Inskip, H., *et al*. (2000) A Study of the Iron and HFE Status of Blood Donors, Including a Group Who Failed the Initial Screening for Anaemia. *British Journal of Haematology*, **108**, 434-439. http://dx.doi.org/10.1046/j.1365-2141.2000.01878.x

[3] Djalali, M., Neyestani, T.R., Bateni, J. and Siassi, F. (2006) The Effect of Repeated Blood Donations on the Iron Status of Iranian Blood Donors Attending the Iranian Blood Transfusion Organization. *International Journal for Vitamin and Nutrition Research*, **76**, 132-137. http://dx.doi.org/10.1024/0300-9831.76.3.132

[4] Simon, T.L., Garry, P.J. and Hooper, E.M. (1981) Iron Stores in Blood Donors. *JAMA*, **245**, 2038-2043. http://dx.doi.org/10.1001/jama.1981.03310450030018

[5] Salvin, H.E., Pasricha, S.R., Marks, D.C. and Speedy, J. (2014) Iron Deficiency in Blood Donors: A National Cross-Sectional Study. *Transfusion*. Early View. http://dx.doi.org/10.1111/trf.12647

[6] Abdullah, S.M. (2011) The Effect of Repeated Blood Donations on the Iron Status of Male Saudi Blood Donors. *Blood*

Transfusion, **9**, 167-171.

[7] National Population Commission (NPC) (2007) National Census Figures. Abuja, Nigeria.

[8] Clark, S.F. (2009) Iron Deficiency Anaemia: Diagnosis and Management. *Current Opinion in Gastroenterology*, **25**, 122-128. http://dx.doi.org/10.1097/MOG.0b013e32831ef1cd

[9] Agba, F. and Khan, R.A. (1989) Serum Ferritin Levels in Professional Blood Donors. *JAMA*, **39**, 124-126.

[10] Akpotuzor, J.O., Isong, C., Okpokam, O.C. and Etukudo, M.H. (2008) Levels of Serum Iron, Total Iron Binding Capacity, Transferrin Saturation Fraction and Packed Cell Volume of Blood Donors in Calabar, Cross River State, Nigeria. *Pakistan Journal of Nutrition*, **7**, 500-502.

[11] Milman, N. (1996) Serum Ferritin in Danes: Studies of Iron Status from Infancy to Old Age, during Blood Donation and Pregnancy. *International Journal of Hematology*, **63**, 103-135. http://dx.doi.org/10.1016/0925-5710(95)00426-2

[12] Guyatt, G.H., Oxman, A.D., Ali, M., Willan, A., McIlroy, W. and Patterson, C. (1992) Laboratory Diagnosis of Iron-Deficiency Anemia: An Overview. *Journal of General Internal Medicine*, **7**, 145-153. http://dx.doi.org/10.1007/BF02598003

[13] Mast, A.E., Blinder, M.A., Gronowski, A.M., Chumley, C. and Scott, M.G. (1998) Clinical Utility of the Soluble Transferrin Receptor and Comparison with Serum Ferritin in Several Populations. *Clinical Chemistry*, **44**, 45-51.

[14] Mittal, R., Marwaha, N., Basu, S., Mohan, H. and Ravi Kumar, A. (2006) Evaluation of Iron Stores in Blood Donors by Serum Ferritin. *Indian Journal of Medical Research*, **124**, 641-646.

[15] Jeremiah, Z.A. and Koate, B.B. (2010) Anaemia, Iron Deficiency and Iron Deficiency Anaemia among Blood Donors in Port Harcourt, Nigeria. *Blood Transfusion*, **8**, 113-117.

[16] Usanga, E.A. (1990) Iron Stores of Nigerian Blood Donors as Assessed by Serum Ferritin Concentration. *Central African Journal of Medicine*, **36**, 170-173.

[17] Cancado, R.D., Chiatone, C.S., Alonso, F.F., *et al*. (2001) Iron Deficiency in Blood Donors. *Sao Paulo Medical Journal*, **119**, 132-134. http://dx.doi.org/10.1590/S1516-31802001000400003

[18] Milman, N. and Kirchhoff, M. (1991). Influence of Blood Donation on Iron Stores Assessed by Serum Ferritin and Haemoglobin in a Population Survey of 1433 Danish Males. *European Journal of Haematology*, **47**, 134-139. http://dx.doi.org/10.1111/j.1600-0609.1991.tb00136.x

[19] Nadarajan, V.S. and Eow, G.I. (2002) Anaemia and Iron Status among Blood Donors in a Blood Transfusion Unit in Malaysia. *The Malaysian Journal of Pathology*, **24**, 99-102.

[20] Adediran, A., Uche, E.I., Adeyemo, T.A., Damulak, D.O., Akinbami, A.A. and Akanmu, A.S. (2013) Iron Stores in Regular Blood Donors in Lagos, Nigeria. *Journal of Blood Medicine*, **4**, 75-80.

[21] Hernández Lamas, M.C., López Pérez-Lanzac, J.C., Prat Arrojo, I., Sánchez Gordo, F., Arleth Christensen, E. and Sánchez Font, E. (1994). Determination of Serum Ferritin: Ideas for Avoiding Induced Ferropenia in Blood Donors. *Sangre*, **39**, 9-14.

[22] Norashikin, J., Roshan, T.M., Rosline, H., Zaidah, A.W., Suhair, A.A. and Rapiaah, M. (2006) A Study of Serum Ferritin Levels among Male Blood Donors in Hospital Universiti sains Malaysia. *The Southeast Asian Journal of Tropical Medicine and Public Health*, **37**, 370-373.

[23] Vilsu, I., Apksha, B. and Snehalata, C. (2008) Iron Status of Regular Voluntary Blood Donors. *Asian Journal of Transfusion Science*, **2**, 9-12. http://dx.doi.org/10.4103/0973-6247.39504

[24] Javadzadeh Shahshahani, H., Attar, M. and Taher Yavari, M. (2005) A Study of the Prevalence of Iron Deficiency and Its Related Factors in Blood Donors of Yazd, Iran, 2003. *Transfusion Medicine*, **15**, 287-293. http://dx.doi.org/10.1111/j.0958-7578.2005.00590.x

[25] Boulahriss, M. and Benchemsi, N. (2008) Iron Deficiency in Frequent and First Time Female Blood Donors. *East African Journal of Public Health*, **5**, 157-159.

[26] Dreyfuss, M.L., Stoltzfus, R.J., Shrestha, J.B., Pradhan, E.K., LeClerq, S.C., Khatry, S.K., Shrestha, S.R., Katz, J., Albonico, M. and West Jr., K.P. (2000) Hookworms, Malaria and Vitamin a Deficiency Contribute to Anemia and Iron Deficiency among Pregnant Women in the Plains of Nepal. *Journal of Nutrition*, **130**, 2527-2536.

[27] Mockenhaupt, F.P., Rong, B., Günther, M., Beck, S., Till, H., Kohne, E., Thompson, W.N. and Bienzle, U. (2000) Anaemia in Pregnant Ghanaian Women: Importance of Malaria, Iron Deficiency, and Haemoglobinopathies. *Translation of the Royal Society Tropical Medicine and Hygiene*, **94**, 477-483. http://dx.doi.org/10.1016/S0035-9203(00)90057-9

[28] Morón, C. and Viteri, F.E. (2009) Update on Common Indicators of Nutritional Status: Food Access, Food Consumption, and Biochemical Measures of Iron and Anemia. *Nutrition Reviews*, **67**, S31-S35. http://dx.doi.org/10.1111/j.1753-4887.2009.00156.x

[29] Olayiwola, I.O. and Ketiku, A.O. (2006) Sociodemographic and Nutritional Assessment of the Elderly Yorubas in Nigeria. *Asia Pacific Journal of Clinical Nutrition*, **15**, 95-101.

[30] Rigas, A.S., Sørensen, C.J., Pedersen, O.B., Petersen, M.S., Thørner, L.W., Kotzé, S., Sørensen, E., Magnussen, K., Rostgaard, K., Erikstrup, C. and Ullum, H. (2014) Predictors of Iron Levels in 14,737 Danish Blood Donors: Results from the Danish Blood Donor Study. *Transfusion*, **54**, 789-796. http://dx.doi.org/10.1111/trf.12518

[31] Pasricha, S.R., McQuilten, Z.K., Keller, A.J. and Wood, E.M. (2011) Hemoglobin and Iron Indices in Nonanemic Premenopausal Blood Donors Predict Future Deferral from Whole Blood Donation. *Transfusion*, **51**, 2709-2713. http://dx.doi.org/10.1111/j.1537-2995.2011.03173.x

[32] Lee, C.K., Wong, H.K., Hong, J., Leung, J.N.S., Tsoi, W.C. and Lin, C.K. (2013) A Study of the Pre-Donation Hemoglobin and Iron Status among Hong Kong Chinese Blood Donors. *Transfusion*, **53**, 322-327. http://dx.doi.org/10.1111/j.1537-2995.2012.03788.x

[33] Djalali, M., Neyestani, T.R., Bateni, J. and Siassi, F. (2006) The Effect of Repeated Blood Donations on the Iron Status of Iranian Blood Donors Attending the Iranian Blood Transfusion Organization. *International Journal for Vitamin and Nutrition Research*, **76**, 132-137. http://dx.doi.org/10.1024/0300-9831.76.3.132

[34] Boinska, J., Żekanowska, E. and Kwapisz, J. (2010) Pro-Hepcidin and Iron Metabolism Parameters in Multi-Time Blood Donors. *International Journal of Laboratory Hematology*, **32**, 483-490. http://dx.doi.org/10.1111/j.1751-553X.2009.01207.x

[35] Fleury, G.T. and Means, R.T. (2003) Serum Hepcidin in Clinical Specimens. *British Journal of Haematology*, **2**, 996-1000.

[36] Wish, J.B. (2006) Assessing Iron Status: Beyond Serum Ferritin and Transferrin Saturation. *Clinical Journal of the American Society of Nephrology*, **1**, S4-S8. http://dx.doi.org/10.2215/CJN.01490506

[37] Adediran, A., Uche, E.I., Adeyemo, T.A., Damulak, D.O., Akinbami, A.A. and Akanmu, A.S. (2013) Iron Stores in Regular Blood Donors in Lagos, Nigeria. *Journal of Blood Medicine*, **4**, 75-80.

[38] Flesland, O., Eskelund, A.K., Flesland, A.B., *et al*. (2004) Transferrin Receptors in Serum. A New Tool in the Diagnosis and Prevention of Iron Deficiency in Blood Donors. *Transfusion and Apheresis Science*, **31**, 11-16. http://dx.doi.org/10.1016/j.transci.2004.01.011

[39] Szymczyk-Nuzka, M. and Wolowiec, D. (2003) Iron Stores in Regular Blood Donors. *Polskie Archiwum Medycyny Wewnetrznej*, **110**, 1415-1421.

[40] Djalali, M., Neyestani, T.R., Bateni, J. and Siassi, F. (2006) The Effect of Repeated Blood Donations on the Iron Status of Iranian Blood Donors Attending the Iranian Blood Transfusion Organization. *International Journal for Vitamin and Nutrition Research*, **76**, 132-137. http://dx.doi.org/10.1024/0300-9831.76.3.132

[41] Achie, L.N., Olorunshola, K.V. and Mabrouk, M. (2011) A Study of Some Red Cell Indices in Menopausal Women in Zaria, Nigeria. *Asian Journal of Medical Sciences*, **3**, 154-157.

[42] Javadzadeh Shahshahani, H., Attar, M. and Taher Yavari, M. (2005) A Study of the Prevalence of Iron Deficiency and Its Related Factors in Blood Donors of Yazd, Iran, 2003. *Transfusion Medicine*, **15**, 287-293. http://dx.doi.org/10.1111/j.0958-7578.2005.00590.x

[43] Domellöf, M., Lönnerdal, B., Dewey, K.G., Cohen, R.J., Rivera, L.L. and Hernell, O. (2002) Sex Differences in Iron Status during Infancy. *Pediatrics*, **110**, 545-552. http://dx.doi.org/10.1542/peds.110.3.545

[44] Wieringa, F.T., Berger, J., Dijkhuizen, M.A., Hidayat, A., Ninh, N.X., Utomo, B., Wasantwisut, E. and Winichagoon, P. (2007) Sex Differences in Prevalence of Anaemia and Iron Deficiency in Infancy in a Large Multi-Country Trial in South-East Asia. *British Journal of Nutrition*, **98**, 1070-1076. http://dx.doi.org/10.1017/S0007114507756945

[45] Bahadur, S., Pujani, M., and Jain, M. (2011) Donor Deferral Due to Anemia: A Tertiary Care Centre-Based Study. *Asian Journal of Transfusion Science*, **5**, 53-55. http://dx.doi.org/10.4103/0973-6247.76001

[46] Rushton, D.H., Dover, R., Sainsbury, A.W., Norris, M.J., Gilkes, J.J. and Ramsay, I.D. (2001) Why Should Women Have Lower Reference Limits for Haemoglobin and Ferritin Concentrations than Men? *British Medical Journal*, **322**, 1355-1357. http://dx.doi.org/10.1136/bmj.322.7298.1355

[47] Valberg, L.S., Sorbie, J., Ludwig, J. and Pelletier, O. (1976) Serum Ferritin and the Iron Status of Canadians. *Canadian Medical Association Journal*, **114**, 417-421.

[48] Mast, A.E. (2014) Low Hemoglobin Deferral in Blood Donors. *Transfusion Medicine Reviews*, **28**, 18-22. http://dx.doi.org/10.1016/j.tmrv.2013.11.001

[49] Pasricha, S.R., McQuilten, Z.K., Keller, A.J. and Wood, E.M. (2011) Hemoglobin and Iron Indices in Nonanemic Premenopausal Blood Donors Predict Future Deferral from Whole Blood Donation. *Transfusion*, **51**, 2709-2713. http://dx.doi.org/10.1111/j.1537-2995.2011.03173.x

[50] Mozaheb, Z., Khayami, M. and Sayadpoor, D. (2011) Iron Balance in Regular Blood Donors. *Transfusion Medicine*

and Hemotherapy, **38**, 190-194. http://dx.doi.org/10.1159/000328812

[51] Baart, A.M., van Noord, P.A., Vergouwe, Y., Moons, K.G., Swinkels, D.W., Wiegerinck, E.T., de Kort, W.L. and Atsma, F. (2013) High Prevalence of Subclinical Iron Deficiency in Whole Blood Donors Not Deferred for Low Hemoglobin. *Transfusion*, **53**, 1670-1677. http://dx.doi.org/10.1111/j.1537-2995.2012.03956.x

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