EUROPEAN JOURNAL OF BIOMEDICAL AND PHARMACEUTICAL SCIENCES
http://www.ejbps.com

ISSN 2349-8870
Coden USA: EJBPBO
Volume: 13
Issue: 1
Year: 2026

FACTORS SHAPING FERRITIN AND HEMOGLOBIN STATUS IN BLOOD DONORS IN TOGO

Afangbom Kossi[1*], Melila Mamatchi[1], Feteke Lochina[2], Satchi Kuévi[1], Améyran Koami[1], Agoh Kékéli[1], Amouzou Kou'santa[3]

*[1]University of Lomé, Faculty of Sciences, Department of Biochemistry P.O. Box 1515 Lomé 01, Togo.
[2]University of Lomé, Faculty of Health Sciences P.O. Box 1515 Lomé 01, Togo.
[3]University of Kara; Faculty of Science and Technology, Department of Life and Earth Sciences P.O. Box 404, Kozah 1, Kara, Togo.

***Corresponding Author: Afangbom Kossi**
University of Lomé, Faculty of Sciences, Department of Biochemistry P.O. Box 1515 Lomé 01, Togo.

DOI: https://doi.org/10.5281/zenodo.18150546

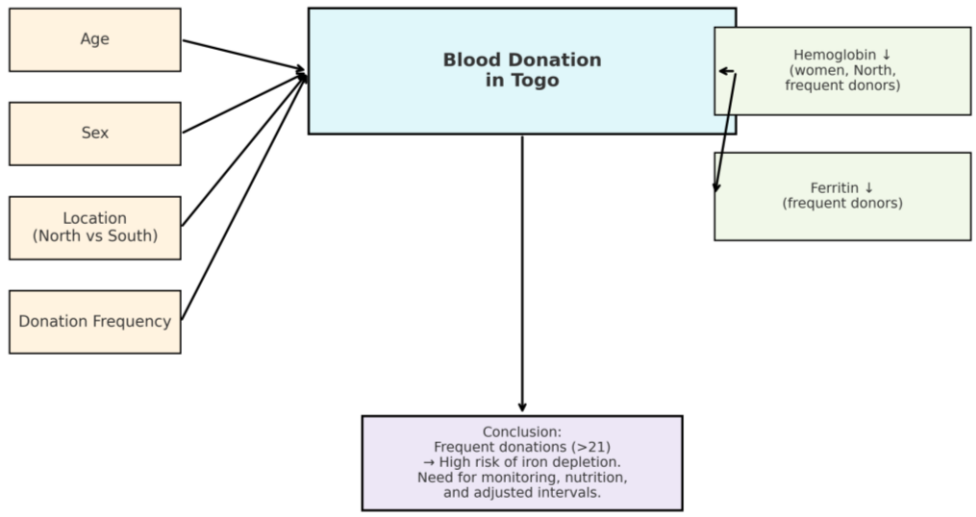
How to cite this Article: Afangbom Kossi[1]*, Melila Mamatchi[1], Feteke Lochina[2], Satchi Kuévi[1], Améyran Koami[1], Agoh Kékéli[1], Amouzou Kou'santa[3]. (2026). FACTORS SHAPING FERRITIN AND HEMOGLOBIN STATUS IN BLOOD DONORS IN TOGO. European Journal of Biomedical and Pharmaceutical Sciences, 13(1), 153–162.

Article Received on 05/12/2025 **Article Revised on 25/12/2025** **Article Published on 05/01/2026**

ABSTRACT
Blood donation, essential for public health, may place frequent donors at risk of iron depletion and iron deficiency anemia, particularly in resource-limited settings such as Togo. This descriptive and analytical study, conducted from May 2024 to April 2025 among 390 voluntary donors in two blood transfusion centers, assessed the influence of age, sex, geographic location, and donation frequency on hemoglobin (Hb) levels and ferritin concentrations. Male sex and residence in the South were associated with higher Hb, while ferritin did not vary significantly by sex or location. Age showed a weak negative correlation with Hb and no significant association with ferritin. Donation frequency emerged as the most critical determinant, with donors having ≥21 donations showing significantly lower Hb ($p < 0.001$) and ferritin ($p < 0.01$). These findings highlight the importance of targeted monitoring of at-risk donors to prevent anemia and ensure transfusion safety.

KEYWORDS: Blood donors; Age, sex and donation frequency; Iron stores and hemoglobin status; Togo.

GRAPHICAL ABSTRACT



INTRODUCTION

Blood donation is a cornerstone of public health systems, ensuring the availability of blood for medical emergencies, surgical interventions, and the treatment of chronic conditions such as severe anemia and hematologic disorders. The safety and sustainability of blood supply depend not only on the number of donors but also on the management of risks associated with donation, particularly the impact on donor health. While blood donation is a vital act for public health, repeated donations may negatively affect donors' iron balance and hematological parameters. One of the most frequent complications is iron depletion, which may lead to iron deficiency anemia, one of the most prevalent nutritional disorders worldwide.[1] This concern is especially relevant in resource-limited settings such as Togo, where healthcare infrastructures and nutritional resources are often insufficient.[2-4]

Ferritin and hemoglobin (Hb) are key biomarkers for assessing iron status in individuals. Ferritin, the primary protein for iron storage, reflects the body's reserves, while hemoglobin is essential for oxygen transport in the blood. A reduction in either parameter may indicate iron depletion, thereby increasing the risk of iron deficiency anemia. This condition not only disqualifies potential donors but also threatens their well-being.[5] Consequently, the monitoring of iron status in blood donors is crucial to safeguard donor health and ensure transfusion safety. Preventing anemia, particularly among frequent donors, remains a major challenge to the continuity of blood donation programs.

Several determinants influence variability in iron status among blood donors. Age, sex, donation frequency, and living environment (urban vs. rural) are recognized as important factors.[6-7] Women of reproductive age are at higher risk of iron deficiency due to menstrual blood loss.[8] Similarly, young male donors who donate frequently may experience progressive iron depletion if not adequately monitored.[9] Donation frequency is especially critical, as repeated donations without sufficient recovery time can lead to significant reductions in ferritin and hemoglobin levels.[10]

In the Togolese context, disparities in lifestyle, diet, and access to healthcare between rural and urban areas may further influence donor health.[11] In rural settings, limited access to iron-rich foods and healthcare services increases the risk of iron deficiency anemia. Conversely, in urban areas, although healthcare access is better, lifestyle factors such as stress and sedentary behavior may also affect iron metabolism. These disparities underscore the need to evaluate sociodemographic and behavioral determinants of donor health to improve anemia prevention strategies.

The present study therefore aimed to assess the influence of age, sex, donation frequency, and living environment on ferritin and hemoglobin levels among blood donors in Togo. The findings are expected to inform donor management policies, improve prevention strategies against iron deficiency, and ensure the sustainability and safety of blood donation in this context.

MATERIAL AND METHODS

Study Design, Period, and Setting

This was a cross-sectional, descriptive, and analytical study conducted from May 2024 to April 2025. Participants were voluntary blood donors recruited from two transfusion centers in Togo: the National Blood Transfusion Center in Lomé (CNTS-Lomé, South) and the Regional Blood Transfusion Center in Sokodé (CRTS-Sokodé, North).

Study Population

The minimum sample size was estimated using the classical formula (Schwartz) for the estimation of a proportion:

$$n = \frac{Z^2 \times p(1-p)}{d^2}$$

where Z is the critical value for a 95% confidence interval (1.96), p is the expected prevalence, and d is the desired absolute precision. In the absence of reliable local data for the main variable, $p = 0.5$ (a conservative value maximizing variance) and $d = 0.05$ were used, yielding a theoretical minimum sample size of 385 participants. To increase statistical power and considering donor availability, all first-time and regular donors who met the defined inclusion criteria and were present during the data collection period according to the schedule established by the research team were included, resulting in a total of 390 participants.

The study population therefore consisted of 390 blood donors, including both first-time and regular donors. Donors were stratified into six groups according to the total number and frequency of donations performed: 1; 2 – 5; 6 – 10; 11 – 15; 16 – 20; and ≥ 21 donations. In Togo, national blood donation regulations set a minimum interval of three months between consecutive donations for men and four months for women. In the present study, this official interval was adopted as a reference for donor selection and classification. Only donors who met these criteria were included in the analysis. Here, a regular donor is defined as any donor who consistently attends appointments and does not miss any scheduled donations in accordance with national regulations (four donations per year for men and three donations per year for women).

Inclusion Criteria

Eligible participants were those judged fit for blood donation by a physician. Criteria included: age 18 – 60 years, body weight ≥ 50 kg, good physical and mental health, no risk of transfusion-transmissible infections (HIV, hepatitis B and C, syphilis), and no history of chronic alcohol consumption or tobacco use.[12-13]

Non-Inclusion Criteria

Individuals were excluded from the outset if they did not meet these requirements. Specifically, exclusion applied to:

- Non-voluntary donors (coerced donation),
- Pregnant or lactating women (inadvertently presenting for donation),
- Individuals who refused to provide informed consent,
- Individuals declared medically unfit after clinical screening.

Exclusion Criteria

Donors initially included were subsequently excluded if they:

- Withdrew consent after enrollment,
- Had invalid samples (e.g., hemolyzed or insufficient),
- Were found to have acute or intercurrent infections during donation (malaria, severe infection, etc.),
- Had unusable biological results (e.g., incomplete blood count).

Data Collection

For each donor, sociodemographic data (age, sex, place of residence, number of previous donations) were collected using pre-tested questionnaires. Two blood samples (5 mL each) were drawn simultaneously:

One in a dry tube for the assessment of iron biomarkers, centrifuged at 3500 rpm for 5 minutes, then transported in a cold container at 0 °C for biochemical analysis using turbidimetric assay on cobas c®. Readings were taken at 570/800 nm against blank.

One in an EDTA tube for complete blood count performed with automated analyzers (Mindray BC-3000 Plus and URIT 3000 Plus).

Iron deficiency was defined as serum ferritin < 30 ng/mL for men and < 15 ng/mL for women. Anemia was defined as hemoglobin (Hb) < 13 g/dL in men and < 12 g/dL in women. Iron deficiency anemia was considered when both anemia and iron deficiency were present.[14-15]

Analyses were performed at the laboratories of Sylvanus Olympio University Hospital (CHU-SO) and the National Institute of Hygiene (INH) in Togo.

Statistical Analysis

Data entry was performed with Excel 2016. Statistical analyses were carried out using GraphPad Prism 10.4.2 and R software. Differences were considered significant at $p < 0.05$. Multivariate logistic regression was performed to examine the relationships between anemia, iron deficiency, iron deficiency anemia, and the explanatory variables.

Ethical Considerations

Ethical approval was obtained from the Bioethics Committee for Health Research of Togo under reference number 034/2023/CBRS dated September 30, 2022. Authorization was also obtained from the administrative authorities of the blood transfusion centers. Study objectives and procedures were explained to all donors, and only those providing written informed consent were included.

Data confidentiality was strictly ensured and results were communicated to participants after laboratory analysis.

RESULTS

Pearson Correlation

Pearson correlation analyses revealed several significant relationships between variables. Age was weakly but significantly negatively correlated with hemoglobin (Hb) levels ($r = –0.138$; $p < 0.05$), suggesting a slight decline in Hb with increasing age. In contrast, no significant correlation was observed between age and ferritin ($r = –0.028$; $p > 0.05$). A positive and significant correlation was found between Hb and ferritin ($r = 0.335$; $p < 0.001$), indicating that higher Hb levels were associated with higher ferritin concentrations.

Table 1: Pearson Correlation between Age, Hemoglobin, and Ferritin.

Variables	Age	Hb	Ferritin
Age	1	–0.138* ($p < 0.05$)	–0.028 ($p > 0.05$)
Hb	–0.138* ($p < 0.05$)	1	0.335*** ($p < 0.001$)
Ferritin	–0.028 ($p > 0.05$)	0.335*** ($p < 0.001$)	1

Student's t-test

Hemoglobin

The Student's t-test showed a highly significant difference in Hb levels between sexes ($t = –4.34$; $p < 0.001$). The negative sign indicated that women had significantly lower mean Hb than men.

With respect to geographic location, donors from the North exhibited significantly lower Hb levels compared to those from the South ($t = –3.02$; $p < 0.01$).

In contrast, ferritin levels did not differ significantly by sex or location ($p > 0.05$).

Table 2: Student's t-test for Independent Variables (Sex, Location) and Dependent Variables (Hb, Ferritin).

Test	Hb	Ferritin
Sex	t = –4.34*** ($p < 0.001$)	t = –1.54 ($p > 0.05$)
Location	t = –3.02** ($p < 0.01$)	t = –0.60 ($p > 0.05$)

ANOVA

Analysis of variance revealed a significant effect of donation frequency on both Hb and ferritin levels. Hb differed significantly across donation groups ($F = 10.38$; $p < 0.001$), while ferritin also varied significantly ($F = 3.34$; $p < 0.01$).

Table 3: ANOVA Results for Donation Frequency, Hb, and Ferritin.

Test	Hb	Ferritin
ANOVA	F = 10.38*** ($p < 0.001$)	F = 3.34** ($p < 0.01$)

Tukey's HSD Post-hoc Test

Ferritin

Post-hoc comparisons indicated that only donors with ≥ 21 donations had significantly lower ferritin compared to those with < 2 donations ($p = 0.042$; CI: –41.58 to –0.46). No other pairwise comparisons were significant.

Table 4: Effect of Donation Frequency on Ferritin (Tukey HSD).

Comparison	Difference in Means	Lower bound	Upper bound	*p* adjusted
[16; 20] - [11; 15]	-16.7728125	-40.522694	6.9770694	0.3299557
[2; 5] - [11; 15]	-0.6529348	-22.302068	20.9961980	0.9999993
[6; 10] - [11; 15]	-1.7301923	-24.264874	20.8044898	0.9999284
< 2 - [11; 15]	5.2871774	-18.674572	29.2489268	0.9884541
≥ 21 - [11; 15]	-15.7324010	-34.440044	2.9752416	0.1552173
[2; 5] - [16; 20]	16.1198777	-6.931325	39.1710803	0.3411455
[6; 10] - [16; 20]	15.0426202	-8.842205	38.9274457	0.4628036
< 2 - [16; 20]	22.0599899	-3.175668	47.2956477	0.1251271
≥ 21 - [16; 20]	1.0404115	-19.273349	21.3541723	0.9999904
[6; 10] - [2; 5]	-1.0772575	-22.874343	20.7198283	0.9999920
< 2 - [2; 5]	5.9401122	-17.329320	29.2095446	0.9777772
≥ 21 - [2; 5]	-15.0794662	-32.891736	2.7328032	0.1497807
< 2 - [6; 10]	7.0173697	-17.078137	31.1128762	0.9606406
≥ 21 - [6; 10]	-14.0022087	-32.880871	4.8764536	0.2757883
≥ 21 - < 2	-21.0195784	-41.580644	-0.4585126	0.0418259

with n = 65

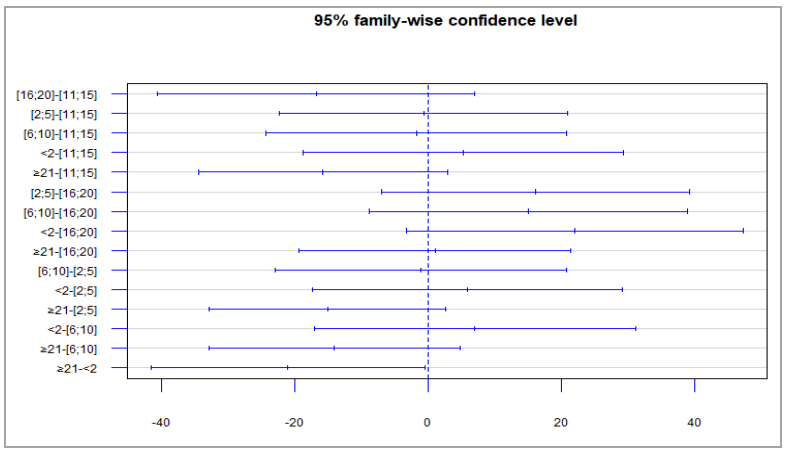


Figure 1: Effect of Blood Donation Frequency on Ferritin Concentration.

Hemoglobin

Tukey's test revealed that donors with < 2 donations had significantly higher Hb compared to those with 11–15 donations ($p < 0.001$) and 16–20 donations ($p < 0.001$). Similarly, very frequent donors (≥ 21 donations) had significantly lower Hb than those with 2–5 ($p < 0.01$) and 6–10 donations ($p < 0.01$). The largest difference was between < 2 and ≥ 21 donations (mean difference = –2.71; $p < 0.001$).

Table 5: Effect of donation frequency on Hb (Tukey HSD).

Comparison	Difference in Means	Lower bound	Upper bound	*p* adjusted
[16; 20] - [11; 15]	-0.09437500	-1.47418418	1.2854342	0.9999596
[2; 5] - [11; 15]	0.82369565	-0.43406522	2.0814565	0.4171857
[6; 10] - [11; 15]	0.83551282	-0.47369627	2.1447219	0.4473910

< 2 - [11; 15]	2.13758065	0.74546249	3.5296988	0.0002155
≥ 21 - [11; 15]	-0.57113861	-1.65800621	0.5157290	0.6595400
[2; 5] - [16; 20]	0.91807065	-0.42114699	2.2572883	0.3639881
[6; 10] - [16; 20]	0.92988782	-0.45776125	2.3175369	0.3903579
< 2 - [16; 20]	2.23195565	0.76582657	3.6980847	0.0002529
≥ 21 - [16; 20]	-0.47676361	-1.65694269	0.7034155	0.8557372
[6; 10] - [2; 5]	0.01181717	-1.25453941	1.2781737	1.0000000
< 2 - [2; 5]	1.31388499	-0.03801127	2.6657813	0.0622023
≥ 21 - [2; 5]	-1.39483427	-2.42968290	-0.3599856	0.0018815
< 2 - [6; 10]	1.30206782	-0.09782129	2.7019569	0.0848303
≥ 21 - [6; 10]	-1.40665143	-2.50345485	-0.3098480	0.0037621
≥ 21 - < 2	-2.70871926	-3.90326614	-1.5141724	0.0000000

with n = 65

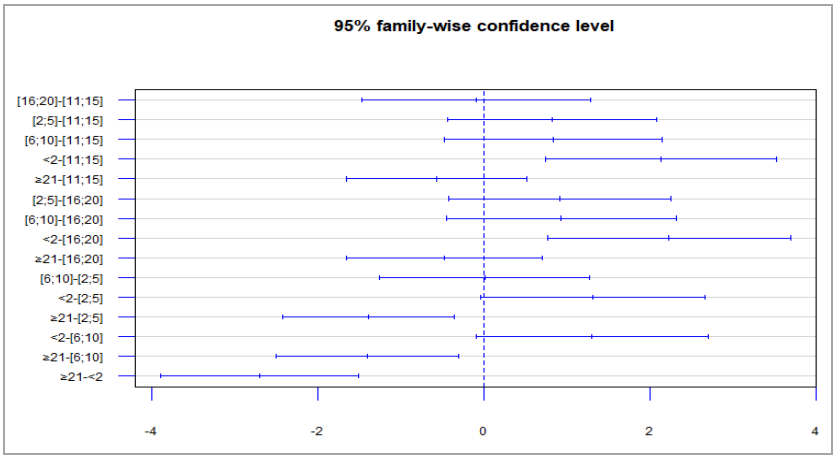


Figure 2: Effect of Blood Donation Frequency on Hb Concentration.

Multivariate Linear Regression

Hemoglobin (Hb)

Multivariate regression analysis confirmed that sex and location significantly influenced Hb. Men had higher Hb (+1.58 g/dL; β = 0.28; $p < 0.001$) than women, and Southern residents had higher Hb than those in the North (+0.70 g/dL; β = 0.14; $p < 0.01$). Age showed no significant effect ($p > 0.05$).

Donation frequency was also significant: new donors (< 2 donations) had higher Hb compared to 11–15 donations (β = +2.20; $p < 0.001$), while very frequent donors (≥ 21 donations) had lower Hb (β = –0.89; $p = 0.018$).

Table 4: Parameters of the Multivariate Linear Regression on Hemoglobin Levels.

Variable	Estimate	Std. Error	Standardized Beta	IC 95% Lwr	IC 95% Up	t value	*p*-value	Signif.
(Intercept)	10.61318	0.59563	NA	9.44071	11.78565	17.819	$p < 0,001$	***
Age	0.02081	0.01606	0.07944	-0.01079	0.05242	1.296	$p > 0,05$	
Sex M/F	1.57657	0.29187	0.28355	1.00204	2.15111	5.402	$p < 0,001$	***
Location South/North	0.69916	0.26181	0.14162	0.18379	1.21453	2.670	$p < 0,01$	**
Donation frequency [16; 20] / [11 - 15]	-0.36672	0.45946	-0.05272	-1.27116	0.53771	-0.798	$p > 0,05$	
Donation frequency [2; 5] / [11 - 15]	0.88159	0.41435	0.14777	0.06596	1.69723	2.128	$p < 0,05$	*
Donation frequency [6;10] /[11-15]	0.79692	0.42988	0.12475	-0.04929	1.64314	1.854	$p > 0,05$	.
Donation frequency < 2 / [11 - 15]	2.20442	0.46648	0.31255	1.28617	3.12268	4.726	$p < 0,001$	***
Donation frequency ≥ 21 / [11 - 15]	-0.89083	0.37455	-0.19461	-1.62813	-0.15354	-2.378	$p < 0,05$	*

with n = 65

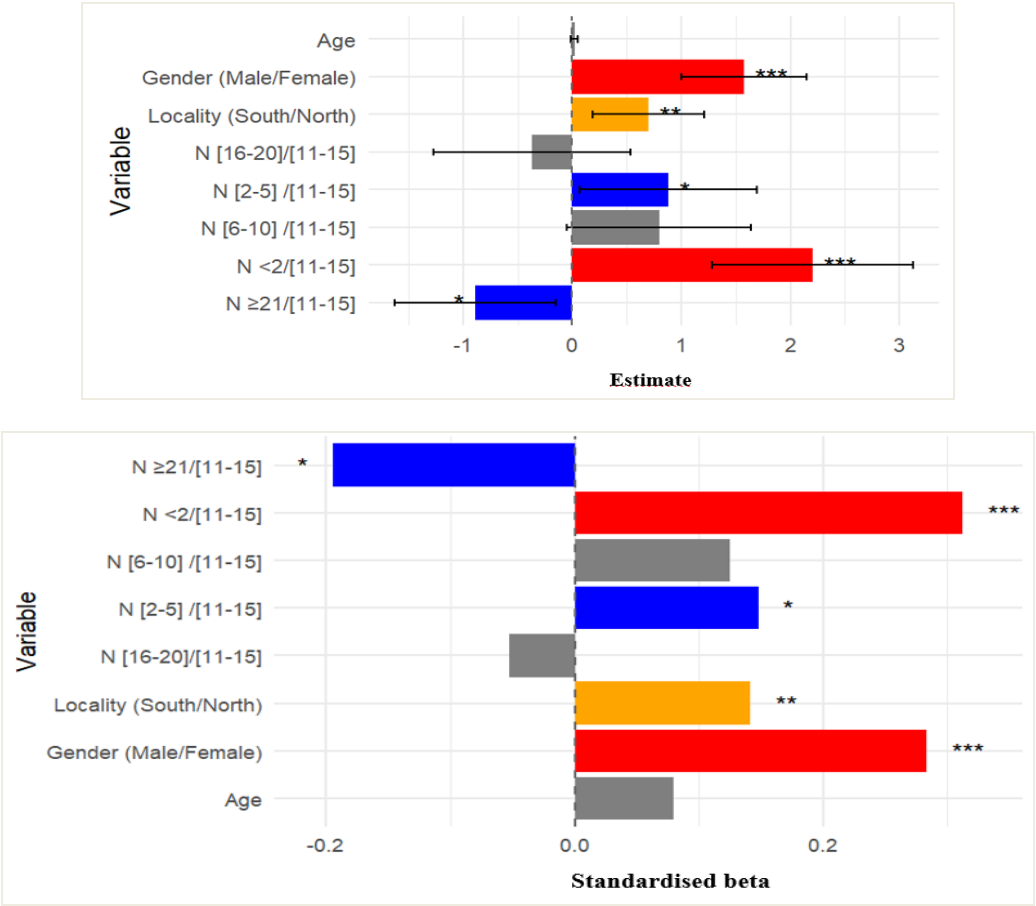


Figure 3: Factors Associated with Hb Concentration.

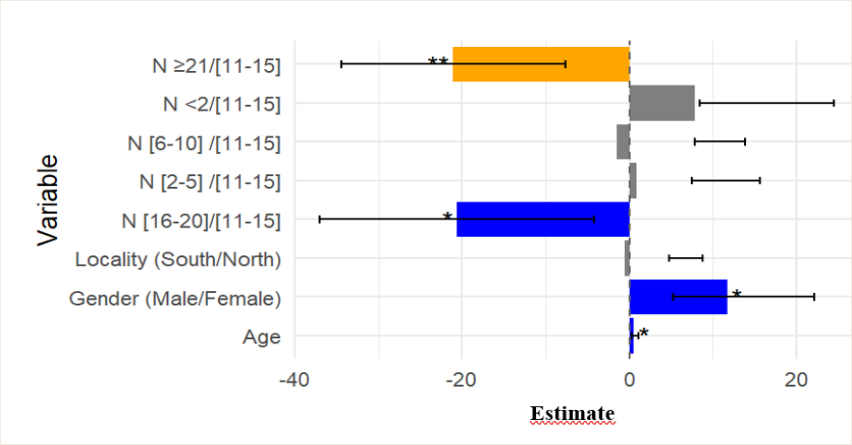
Ferritin

Regression analysis showed that ferritin increased significantly with age (β = +0.58; $p < 0.05$) and was higher in men than in women (+11.7; $p < 0.05$).

The most influential factor was donation frequency. Donors with ≥ 21 donations had significantly lower ferritin compared to 11–15 donations (β = –21.0; $p < 0.01$). Donors with 16–20 donations also had reduced ferritin (β = –20.7; $p < 0.05$). Other donation categories and geographic location were not significant predictors.

Table 5: Multivariate Linear Regression Parameters for Ferritin Concentration.

Variable	Estimate	Std. Error	Standardized Beta	IC 95% Lwr	IC 95% Up	t value	*p*-value	Signif.
(Intercept)	21.137	NA	-0.1187	42.3930	10.798	1.957	$p > 0,05$	
Age	0.578	0.1355	0.0051	1.1510	0.291	1.986	$p < 0,05$	*
Sex M/F	11.729	0.1296	1.3136	22.1452	5.291	2.217	$p < 0,05$	*
Location South/North	-0.542	-0.0067	-9.8847	8.8016	4.746	-0.114	$p > 0,05$	
Donation frequency [16; 20] / [11 - 15]	-20.651	-0.1823	-37.0475	-4.2543	8.330	-2.479	$p < 0,05$	*
Donation frequency [2; 5] / [11 - 15]	0.863	0.0089	-13.9237	15.6497	7.512	0.115	$p > 0,05$	
Donation frequency [6;10] /[11-15]	-1.499	-0.0144	-16.8402	13.8419	7.793	-0.192	$p > 0,05$	
Donation frequency < 2 / [11 - 15]	7.807	0.0680	-8.8401	24.4541	8.457	0.923	$p > 0,05$	
Donation frequency ≥ 21 / [11 - 15]	-21.042	-0.2823	-34.4085	-7.6755	6.790	-3.099	$p < 0,01$	**



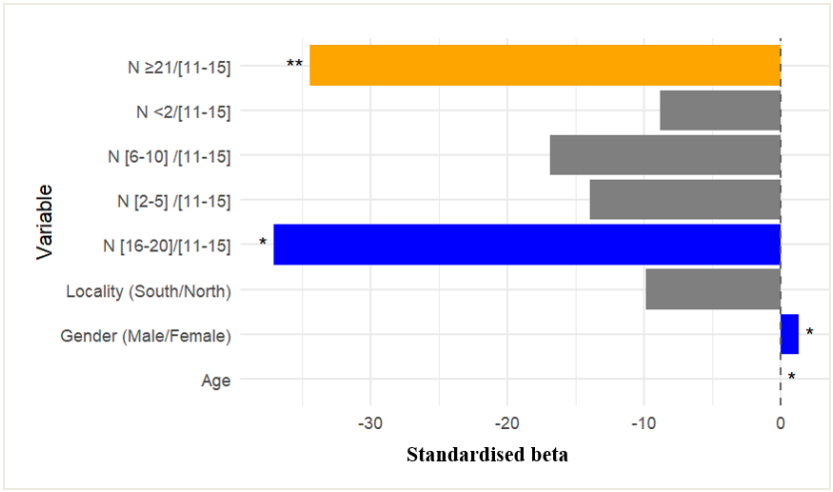


Figure 4: Factors Associated with Ferritin Concentration.

DISCUSSION

This study identified several key determinants of iron status among blood donors, primarily donation frequency and sex, while geographic disparities had a more modest impact. These findings highlight the increased vulnerability of frequent donors and female donors to iron depletion, which has both biological and clinical relevance.

Donation frequency was a major determinant of iron status, with clear biological and clinical implications. ANOVA and post-hoc tests confirmed that frequent donors (≥ 21 donations) exhibited significantly lower Hb and ferritin compared to new donors (< 2 donations). Biologically, repeated donations progressively deplete iron stores, impairing erythropoiesis and hemoglobin synthesis. Clinically, this places frequent donors at higher risk of iron deficiency, which may initially be asymptomatic but can compromise physical performance, cognitive function, and overall donor safety. These findings align with previous literature demonstrating that repeated donations without adequate recovery reduce iron stores and Hb levels.[31-32] Salvin et al.[32] emphasized the risk of silent iron deficiency among frequent donors, while Chaudhary et al.[30] noted that even 2–3 annual donations may deplete reserves without supplementation. The WHO also highlights the importance of monitoring iron status in regular donors, as iron deficiency may occur even in the absence of overt anemia.[14-15]

Building on donation frequency, age-related variations also carry biological and clinical significance. Pearson correlation analysis revealed a weak negative correlation between age and Hb ($r = –0.138$; $p < 0.05$), suggesting a gradual decline in Hb with advancing age. Biologically, this may reflect cumulative nutritional deficiencies, reduced intestinal iron absorption, or chronic conditions impairing erythropoiesis. Clinically, monitoring Hb in older donors can detect early declines before symptomatic anemia occurs.[16-17] In contrast, no significant correlation was observed between age and ferritin ($r = –0.028$; $p > 0.05$), possibly due to high inter-individual variability influenced by inflammation, infection, or subclinical chronic conditions, since ferritin also acts as an acute-phase protein.[13-14]

Sex emerged as another critical determinant of iron status, with both biological and clinical implications. The Student's t-test showed significantly lower Hb in women compared to men. Biologically, this is explained by menstrual blood losses, repeated pregnancies, and often insufficient dietary iron intake.[14,22] Hormonal regulation also contributes: estrogens inhibit hepcidin expression,

enhancing iron absorption,[23-24] whereas testosterone stimulates erythropoiesis.[25-26] Clinically, these sex-based differences underscore the need for targeted monitoring, including ferritin measurement and nutritional counseling. Regression analyses reinforced that sex was the strongest predictor of Hb, with men having significantly higher levels ($\beta = 0.28$; $p < 0.001$).

Geographic disparities further illustrate the biological and clinical complexity of iron status. Donors from the North exhibited lower Hb compared to those from the South, likely reflecting regional differences in nutrition, socioeconomic status, healthcare access, and exposure to endemic infections such as malaria.[28-29] Clinically, this suggests that region-specific strategies are necessary to prevent iron depletion. No significant differences in ferritin were observed by sex or location, likely due to ferritin's dual role as a storage protein and acute-phase reactant, which may mask early iron deficiency.[14] Previous studies also indicate that ferritin may remain normal despite functional iron deficiency in regular donors.[30] Residence in the South predicted higher Hb, reflecting environmental and nutritional advantages and possibly altitude effects on erythropoietin production.[33]

Finally, integrating these determinants highlights the central physiological and clinical relationship between Hb and ferritin. The positive correlation between Hb and ferritin ($r = 0.335$; $p < 0.001$) confirms that adequate iron stores are essential for hemoglobin synthesis and prevention of iron deficiency anemia, a major global public health concern, particularly in low-resource settings.[18-19] However, the moderate correlation strength suggests that other factors—vitamin B12 or folate deficiencies, occult blood losses, chronic inflammation, or parasitic infections—may influence Hb in tropical regions.[20-21] Age showed no significant association with Hb in regression analyses, consistent with prior studies indicating that age alone does not determine hematological status in otherwise healthy adults.[16]

Ferritin was significantly influenced by age and sex, with higher levels in older donors and men, as previously observed in Western and African populations.[8,19,34] Nonetheless, donation frequency remained the strongest determinant: very frequent donors (≥ 21 donations) had markedly reduced ferritin, consistent with findings from the REDS-II (RISE) study showing progressive iron depletion among high-frequency donors.[12]

Overall, this study demonstrates that iron status in blood donors is shaped by biological (sex, age), geographic (region), and behavioral (donation frequency) determinants, each with clear biological and clinical relevance. Frequent donations, particularly among women and young donors, represent the greatest risk factor for iron depletion. These findings emphasize the need for individualized monitoring of donors, as Hb cut-off values may vary across populations.[35] Such monitoring should include periodic ferritin testing, tailored donation intervals, nutritional counseling, and targeted supplementation to preserve donor health and ensure transfusion safety.

Limitations of the Study

Although the overall sample of 390 participants allowed for certain analyses, the limited size of some subgroups, such as frequent donors or specific age categories, reduced the statistical power to detect small differences. Data collection was also constrained by the donors' available time and the need to avoid disrupting the activities of the blood transfusion centers, which limited the inclusion of all first-time and regular donors.

Furthermore, several factors that could influence iron status, including diet, general health, and the presence of chronic infections, were not systematically assessed, which may explain the moderate strength of the observed correlations.

CONCLUSION

This study demonstrates that donation frequency and female sex are the primary determinants of iron status among blood donors in Togo, with frequent donations being associated with a significant decrease in hemoglobin and ferritin levels. Geographic and behavioral factors also play a role, although ferritin's dual function as both a storage protein and an acute-phase reactant may obscure subclinical deficiency. These findings highlight the importance of individualized donor management, particularly for those who have made more than 21 donations, including periodic ferritin monitoring, adjustment of donation intervals, nutritional counseling, and iron supplementation, in order to preserve donor health and ensure transfusion safety.

Feasibility and Economic Viability of Ferritin Screening Among Blood Donors in Togo

Technical Feasibility

Automated immunoassay-based ferritin testing (immunoturbidimetry or chemiluminescence) is feasible in major transfusion centers, such as CNTS Lomé and Sokodé, within routine operations.

Economic Viability

The cost of ferritin testing is relatively high compared to the average budget for blood transfusion in Togo. Universal screening of all donors is therefore not economically viable in the short term. A selective approach targeting regular donors, who are at highest risk of iron deficiency, is more realistic. Demonstrating the benefits of this practice for donor and recipient safety could support increased funding for transfusion services.

Pragmatic Alternatives

In the interim, iron status can be monitored indirectly through regular hemoglobin measurements, combined with iron supplementation programs for regular donors. Gradual implementation of ferritin testing at reference

centers or through outsourcing can assess feasibility, cost–benefit, and potential for future expansion.

Protocol for Ferritin Testing in Regular Blood Donors

1. Objective

Monitor iron status in regular donors to prevent deficiency and ensure transfusion safety.

2. Target Population

Regular blood donors.

3. Process

- **Reception & Triage:** Standard questionnaire, clinical assessment, rapid hemoglobin test (HemoCue® Hb 301 / Hb 201+), and immediate eligibility decision.
- **Sampling:** Serum tube collected alongside routine serology for delayed ferritin testing.
- **Analysis:** Automated immunoassay at CNTS Lomé (Roche cobas e 411, Abbott ARCHITECT i1000SR, Siemens Centaur CP) or outsourced weekly (e.g., INH).
- **Results & Follow-up:** Delivered within 24–72 hours; thresholds:
  - Ferritin < 15 µg/L → temporary deferral + supplementation
  - Ferritin 15–30 µg/L → extended donation interval (12–16 weeks) + nutritional advice
  - Ferritin ≥ 30 µg/L → regular donation allowed
- **Communication:** Results recorded in donor file; abnormal results communicated via phone/SMS for guidance.

4. Monitoring Frequency

Annual ferritin testing for regular donors, more frequent if abnormalities are detected.

This protocol ensures donor flow is not interrupted (eligibility based on hemoglobin), while implementing a structured, delayed ferritin monitoring system to protect donor health

AUTHORS' CONTRIBUTIONS

Conceived and designed the experiments: MM and AK. Performed the experiments: MM AK AK SK and AK. Analyzed the data: MM AK, BM and AK. Contributed reagents/materials/analysis tools: BM MM and AK. Wrote the paper: AK and MM.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

REFERENCES

1. Bryant BJ, Yau YY, Arceo SM, Hopkins JA. Iron deficiency in frequent blood donors. Transfusion, 2012; 52(4): 702–7.
2. Fillet AM, Martinaud C, Malard L, Le Cam S, Hejl C, Chenus F, Gross S. Prévalence de la carence martiale chez les donneurs de sang total en France–Étude FERRIDON. Transfus Clin Biol., 2019; 26(3): S23–4.
3. Goldman M, Uzicanin S, Scalia S, O'Brien S. Iron deficiency in Canadian blood donors: is it time to act? Transfus Med Rev., 2017; 31(3): 173–9.
4. Mast AE, Schlumpf KS, Wright DJ, Custer B, Spencer B, Murphy EL, et al. Demographic correlates of low hemoglobin deferral among prospective whole blood donors. Transfusion, 2010; 50(8): 1794–802.
5. Milman N. Anemia – still a major health problem in many parts of the world! Ann Hematol., 2011; 90(4): 369–77.
6. Rigas AS, Sørensen CJ, Pedersen OB, Petersen MS, Thørner WL, Kotzé S, et al. Predictors of iron levels in 14,737 Danish blood donors: results from the Danish Blood Donor Study. Transfusion, 2014; 54(3pt2): 789–96.
7. Tagny CT, Owusu-Ofori S, Mbanya D, Deneys V. The blood donor in sub-Saharan Africa: a review. Transfus Med., 2010; 20(1): 1–10.
8. World Health Organization (WHO). Blood donor selection: guidelines on assessing donor suitability for blood donation. Geneva: WHO, 2017.
9. Yanti LN, Rofinda ZD, Syofiati R, Husni Y, E. Impact of Donation Frequency on Iron Stores and Hemoglobin Levels in Regular Blood Donors. Bioscientia Medicina, 2025; 9(5): 7401–12.
10. Kueviakoe IM, Segbena AY, Jouault H, Vovor A, Imbert M. Hematological Reference Values for Healthy Adults in Togo. ISRN Hematol., 2011; 2011: 1–6.
11. Cable RG, Glynn SA, Kiss JE, Mast AE, Steele WR, Murphy EL, et al. Iron deficiency in blood donors: the REDS-II Donor Iron Status Evaluation (RISE) study. Transfusion., 2012; 52(4): 702–11.
12. Camaschella C. Iron-deficiency anemia. N Engl J Med., 2015; 372(19): 1832–43.
13. Guralnik JM, Eisenstaedt RS, Ferrucci L, Klein HG, Woodman RC. Prevalence of anemia in persons 65 years and older in the United States: evidence for a high rate of unexplained anemia. Blood, 2004; 104(8): 2263–8.
14. Kassebaum NJ, Jasrasaria R, Naghavi M, Wulf SK, Johns N, Lozano R, et al. A systematic analysis of global anemia burden from 1990 to 2010. Blood, 2014; 123(5): 615–24.
15. Patel KV. Epidemiology of anemia in older adults. Semin Hematol., 2008; 45(4): 210–7.
16. Pasricha SR, Drakesmith H, Black J, Hipgrave D, Biggs BA. Control of iron deficiency anemia in low- and middle-income countries. Blood, 2013; 121(14): 2607–17.
17. WHO. Serum ferritin concentrations for the assessment of iron status and iron deficiency in populations. Geneva: WHO, 2011.
18. WHO. The global prevalence of anaemia in 2011. Geneva: WHO, 2015.
19. Zimmermann MB, Hurrell RF. Nutritional iron deficiency. Lancet., 2007; 370(9586): 511–20.

20. Badenhorst CE, Forsyth AK, Govus AD. A contemporary understanding of iron metabolism in active premenopausal women. Front Sports Act Living, 2022; 4(58): 756–806.
21. Lehtihet M, Bonde Y, Beckman L, Berinder K, Hoybye C, Rudling M, et al. Circulating Hepcidin-25 Is Reduced by Endogenous Estrogen in Humans. PLoS One, 2016; 11(2): 1–10.
22. Mancera-Soto E, Ramos-Caballero DM, Magalhaes J, Chaves Gomez S, Schmidt WFJ, Cristancho-Mejía E. Quantification of testosterone-dependent erythropoiesis during male puberty. Exp Physiol., 2021; 106(7): 1470–81.
23. Beggs LA, Yarrow JF, Conover CF, Meuleman JR, Beck DT, Morrow M, et al. Testosterone alters iron metabolism and stimulates red blood cell production independently of dihydrotestosterone. Am J Physiol Endocrinol Metab., 2014; 307(5): E456–61.
24. Balarajan Y, Ramakrishnan U, Özaltin E, Shankar AH, Subramanian SV. Anaemia in low-income and middle-income countries. Lancet., 2011; 378(9809): 2123–35.
25. Atakouma YD, et al. État des réserves martiales chez les donneurs de sang au Togo. J Afr Hématol Oncol., 2017; 8(1): 12–8.
26. WHO. Worldwide prevalence of anaemia 1993–2005. WHO Global Database on Anaemia. Geneva: WHO, 2008.
27. Guerra CA, Gikandi PW, Tatem AJ, Noor AM, Smith DL, Hay SI, et al. The limits and intensity of Plasmodium falciparum transmission: implications for malaria control and elimination worldwide. PLoS Med., 2008; 5(2): 301–11.
28. Tchinda VH, et al. Prévalence de l'anémie chez les femmes enceintes dans les zones urbaines et rurales du Cameroun. Rev Méd Trop., 2012; 72(3): 305–10.
29. Mahida VI, Bhatti A, Gupte SC. Iron status of regular voluntary blood donors. Asian J Transfus Sci., 2008; 2(1): 9–12.
30. WHO. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Geneva: WHO; 2011.
31. Newman BH. Iron depletion by whole-blood donation affects donors of both sexes. Transfusion., 2004; 44(5): 722–4.
32. Salvin HE, Pasricha SR, Marks DC, Speedy J. Iron deficiency in blood donors: a national cross-sectional study. Transfusion, 2014; 54(10): 2434–44.
33. Beutler E, Waalen J. The definition of anemia: what is the lower limit of normal of the blood hemoglobin concentration? Blood., 2006; 107(5): 1747–50.
34. WHO. Iron Deficiency Anaemia: Assessment, Prevention and Control – A guide for programme managers. Geneva: WHO, 2001.
35. Ganz T, Nemeth E. Iron metabolism: interactions with normal and disordered erythropoiesis. Cold Spring Harb Perspect Med., 2012; 2(5): 1–13.