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Comparative Analysis of Haematological and Some Selected Immunological Parameters among Three Categories of Blood Donors in Ibadan, Nigeria

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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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ABSTRACT

Blood transfusion is a life-saving procedure essential for various medical conditions. The primary objective of blood transfusion is to ensure the safety, adequacy, accessibility, and efficiency of the blood supply at all levels. The safety of blood transfusions hinges on the careful screening of

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donors. However, the lack of timely access to well-screened, safe blood has led to many preventable deaths in Nigeria. This study aimed to assess and compare demographic characteristics, as well as certain hematological and immunological parameters (CD4 and CD41), to provide a foundation for revising Nigeria's blood transfusion policy.

The research was conducted at the Blood Bank Unit of the University College Hospital (UCH) in Ibadan, focusing on three categories of blood donors: commercial donors (CD), family replacement donors (FRD), and voluntary non-remunerated blood donors (VNBD), the latter being considered the safest and used as a control group in the study. A total of 360 apparently healthy donors were recruited. Hematological analyses were performed using a Sysmex 5-part hematology auto analyzer (CELL-DYN/EMERALD 22), CD4 counts were obtained via the BD FACSPresto™ CD4 Auto Analyzer, and CD41 levels were measured using a Human CD41 ELISA Kit. The data were analyzed using the Statistical Package for Social Sciences (SPSS) Version 25.0, with statistical significance set at $P<0.05$.

The comparison of hematological parameters among the three donor groups showed a decrease in the mean values of white blood cell (WBC) count, platelet count, and red blood cell (RBC) count in FRD compared to VD, though these differences were not statistically significant. However, significant decreases were observed in CD compared to VD in WBC count ($p=0.012$), platelet count ($p=0.044$), packed cell volume (PCV) ($p=0.024$), hemoglobin (HB) ($p=0.009$), mean corpuscular volume (MCV) ($p=0.013$), mean corpuscular hemoglobin (MCH) ($p=0.042$), and mean corpuscular hemoglobin concentration (MCHC) ($p=0.004$). CD4 levels were also lower in FRD and CD groups compared to VD, but without statistical significance. Similarly, CD41 levels were reduced in FRD and CD compared to VD, though these differences were not statistically significant either.

In conclusion, the study revealed compromised erythropoiesis in commercial donors due to repeated donations, as well as weakened immune status and potential poor platelet quality. Given the insufficient number of VNBDs to meet the country's needs and the clinical abnormalities detected in readily available commercial donors, encouraging family replacement donors who demonstrated similar hematological and immunological profiles to voluntary donors should be prioritized. Additionally, implementing stricter screening protocols that assess comprehensive hematological parameters and immunological markers, such as CD4, would improve donor safety and enhance the quality of blood products for recipients.

Keywords: Blood donor; voluntary donor; commercial donor; family replacement donor; hematological parameters; immunological parameters.

1. INTRODUCTION

Blood donors are individuals who appear to be in good health and donate their blood for patients in need of transfusions. These donors typically undergo medical laboratory tests and physical screenings to ensure they are suitable for donation. Donors are classified into three main categories: voluntary non-remunerated, family replacement, and commercial (paid) donors. Additionally, they can be categorized as first-time or repeat donors [1]. Commercial donors give blood in exchange for money or other benefits, and they may be malnourished, in poor health, or at risk of carrying diseases that could endanger recipients during transfusions [2]. Family replacement donors provide blood when requested by a hospital or family member to replace blood needed for a hospitalized relative or friend. Voluntary non-remunerated donors are those who donate blood altruistically, without expecting compensation [3].

Studies suggest that among these three categories, the safest blood comes from voluntary, unpaid donors [4,5]. The World Health Organization (WHO) also recommends that blood donation should always be voluntary to ensure safe transfusions [2]. Many wealthier countries and international blood transfusion organizations support this approach, advocating for voluntary non-remunerated blood donors (VNRD) as the sole source of blood, based on safety concerns, and discouraging family replacement and paid donors [3]. However, the situation in Nigeria presents significant challenges. The demand for blood far exceeds the supply that voluntary donors can provide. Despite efforts to recruit voluntary donors, they remain scarce, and the blood they contribute is not enough to meet the daily needs of the country. According to studies by Ahmed et al. [6] and Allain [3], voluntary donations account for only about 5% of the blood used in Nigeria. The country still relies heavily on family replacement

and commercial donors, even though these groups are associated with higher risks of transfusion-related infections [5]. Nigeria, as a member of WHO, has made some progress in recruiting voluntary donors, but the country's efforts have not been enough to make voluntary donation the dominant source of blood [7]. This has led to a continued dependence on commercial and family replacement donors, both of which come with heightened risks. These challenges highlight the urgent need for improved recruitment strategies for voluntary donors and more comprehensive screening protocols for all blood donors.

Hematological parameters such as hemoglobin (Hb), hematocrit (Hct), red blood cell count, white blood cell count, and platelet count are essential clinical indicators used to assess health and detect diseases in individuals. These parameters are widely used in medical practice to evaluate the health of blood donors [8]. CD41 is a protein encoded by the ITGA2B gene and is found on the surface of platelets and a few other hematopoietic cells. It belongs to the IIb/IIIa integrin family, which plays a key role in platelet aggregation by acting as a receptor for fibrinogen and other extracellular matrix molecules [9]. Platelet aggregation is a crucial process for clotting, and it is mediated by fibrinogen binding to the glycoprotein IIb/IIIa receptor on platelets [10].

The expression of CD41 was assessed across the three categories of blood donors to evaluate the prevalence of Glanzmann thrombasthenia (GT), a rare inherited disorder. GT is caused by a deficiency in CD41/CD61, which impairs platelet aggregation and leads to increased bleeding (Bellucci and Caen, 2002) [11]. The condition is typically diagnosed by reduced or absent platelet aggregation (Canult *et al.,* 2014). While previous studies have shown that family replacement donors are closer to voluntary donors in terms of the prevalence of viral markers and overall safety [5], commercial donors still provide the bulk of blood donations in developing countries like Nigeria [6,5]. Given the reliance on paid donors, there is a need for comprehensive screening of potential blood donors and a re-evaluation of commercial donors, particularly in areas not currently covered by screening. This study aimed to assess specific hematological and immunological parameters (CD4 and CD41) among the three donor categories to guide potential revisions to Nigeria's blood transfusion policy.

2. MATERIALS AND METHODS

2.1 Sample Selection and Collection

A total of 360 apparently healthy prospective blood donors, comprising 120 family replacement donors, 120 commercial donors, and 120 voluntary donors (302 males and 58 females), were recruited for this study from the University Teaching Hospital Blood Bank in Ibadan. The age range of these donors was between 18 and 60 years. Before the collection process began, informed consent was obtained from all participants using a consent form. Following this, relevant demographic and health-related data were gathered using a structured questionnaire.

2.2 Blood Collection

After completing the questionnaire, 5 ml sample of antecubital venous blood was collected from each of the 360 donors and dispensed into EDTA bottles for further analysis. Blood of these 360 blood donors was screened for transfusion transmissible infections (TTIs) with Determine Rapid Test Kit (ABBOTT). Confirmatory Antibodies were determined by Enzyme linked immunosorbent assay (ELISA) (Genscreen™ ULTRA HIV Ag-Ab) for confirmation.

2.3 Analysis of Haematological Parameters

The hematological parameters measured in this study included white blood cell count, neutrophils, eosinophils, basophils, lymphocytes, packed cell volume (PCV), hemoglobin level, platelet/lymphocyte ratio, red blood cell count, mean cell volume (MCV), mean cell hemoglobin (MCH), mean cell hemoglobin concentration (MCHC), and mean platelet volume (MPV). These parameters were determined using a hematology auto-analyzer, specifically the CELL-DYN/EMERALD 22 model, to ensure accurate and efficient analysis of the blood samples collected from the donors.

2.4 Immunological Analysis

ABSOLUTE CD4 Analysis: Absolute CD4 T lymphocyte was analyzed using the BD FACSPresto CD4 Auto Analyzer, which operates on the flow cytometry method. This technique allowed for the precise measurement of CD4 T lymphocyte counts, providing crucial

immunological data for each blood donor sample.

CD41 (Glycoprotein11b) Counts Analysis: CD41 (Glycoprotein 11b) was counted using the Human CD41 ELISA Kit Reagent (CAT# EKHU-2309, LOT#: p2022613, MELSIN). This assay operates on the principle of flow cytometry for accurate quantification of CD41 levels in the blood samples.

2.5 Statistical Analysis

Statistical Package for the Social Sciences (SPSS) version 25.0 was used for all data analysis in this study. Frequency and percentage were used to summarize categorical variables and mean/ standard deviation (SD) was used to summarize the quantitative variables. Chi-square was used to test the association of categorical variables while One Way ANOVA was used to determine the mean level of the quantitative variables and pearson correlation was used to determine the association between haematological parameters, CD4 and CD41. $P < 0.05$ was considered to be statistically significant.

3. RESULTS

The basic characteristics of the participants enrolled in this study are presented in Table 3.1. A total of 360 apparently healthy blood donors were voluntarily recruited. These donors were classified into three groups based on their donation type: Voluntary non-remunerated donors (VD) (n = 120), family replacement donors (FRD) (n = 120), and commercial donors (CD) (n = 120). The mean age across the groups showed that VD and FRD participants tended to be older compared to CD participants. More than 80% of the participants in each group were aged between 18 and 50 years. The majority of the participants were male, with the CD group consisting entirely of males (100%), while 80% of VD donors and 71.7% of FRD donors were male. In terms of occupation, most of the donors were either civil servants (46.7%) or artisans (76.7%), indicating that the participants represented a wide range of professions.

3.1 Hematological Parameters

Table 3.2 outlines the results of the hematological parameter comparisons between VD and FRD donors. No significant differences were observed in the hematological values between these two groups, suggesting that both VD and FRD donors exhibited similar profiles for all the parameters analyzed.

In contrast, Table 3.3 compares the hematological parameters between VD and CD donors. Significant differences were noted between the two groups. Commercial donors (CD) showed a marked increase in parameters such as neutrophil-to-lymphocyte ratio (NLR), packed cell volume (PCV), mean cell volume (MCV), mean cell hemoglobin (MCH), and mean cell hemoglobin concentration (MCHC) compared to VD donors. On the other hand, VD donors had significantly lower levels of white blood cells (WBC), platelets, PCV, hemoglobin (HGB), red blood cells (RBC), and red cell indices compared to CD donors. However, no significant differences were found in other parameters, such as lymphocytes, basophils, eosinophils, monocytes, neutrophils, platelet distribution width (PDW), platelet-large cell ratio (P-LCR), platelet-to-lymphocyte ratio (PRL), and mean platelet volume (MPV) between the two groups.

Table 3.1. Demographic and clinical characteristics of three categories of blood donors

Characteristics		VD	FRD	CD
Number (Prevalence)		120 (100%)	120 (100%)	120 (100%)
Mean age (years)		48.0 ± 9.26	46.1 ± 6.69	32.4 ± 13.26
Age (years):	18 – 30	46 (38.3	34 (28.3)	14 (11.7)
31 – 40		36 (30)	44 (36.7)	36 (30)
41 – 50		24 (20)	38 (31.7)	46 (38.3)
51 – 60		14 (11.7)	4 (3.3)	24 (20)
Gender:	Male	96 (80)	86 (71.7)	120 (100)
Female		24 (20)	34 (28.3)	0
Occupations:	Student	18 (15)	26 (21.7)	4 (3.3)
Civil servant		56 (46.7)	42 (35)	24 (20)
Artisan		46 (38.3)	52 (43.3)	92 (76.7)

VD = voluntary donors, FRD = family relative donors, CD = Commercial donors,

Table 3.2. Comparison of Heamatological Parameters, between voluntary and family replacement donors in UCH, Ibadan

Parameters	Voluntary donor	Family replacement	P-value
WBC (x 10^9/L)	7.99 ± 2.97	6.65 ± 1.74	0.382
Neutrophil (%)	50.77 ± 9.49	52.47 ± 9.95	0.755
Lymphocytes (%)	37.23 ± 14.50	36.47 ± 13.10	0.796
Monocytes (%)	3.79 ± 1.64	4.21 ± 2.29	0.376
NLR	1.02 ± 0.52	1.01 ± 0.74	0.963
Eosinophil (%)	2.11 ± 1.36	2.05 ± 1.19	0.440
Basophil (%)	1.32 ± 0.66	1.40 ± 0.68	0.121
Platelet (x 10^9/L)	202.02 ± 56.4	192.13 ± 57.1	0.204
MPV (fL)	14.43 ± 9.46	13.68 ± 8.36	0.643
PDW (%)	14.27 ± 2.43	13.32 ± 1.67	0.051
P-LCR (%)	20.09 ± 4.78	19.00 ± 5.27	0.335
PLR	13.32 ± 1.15	12.04 ± 1.89	0.205
PCV (%)	40.85 ± 5.33	38.12 ± 4.96	0.724
HBG (g/dL)	14.79 ± 1.89	13.08 ± 1.69	0.765
MCV (fL)	81.62 ± 5.92	81.01 ± 7.15	0.954
MCH (Pg)	32.01 ± 3.31	32.28 ± 6.88	0.989
MCHC (g/dL)	34.08 ± 7.01	32.66 ± 18.89	0.795
RBC (x 10^{12}/L)	5.00 ± 3.30	5.13 ± 3.28	0.479

The values are mean ± standard deviation, Student t-test was used to compare the means and p = 0.05, WBC = white blood cells count, NLR = Neutrophil: Lymphocytes ratio, PCV = Packed cells volume, HBG = heamoglobin level, PLR = Platelet/ Lymphocytes ratio, RBC = red blood cell, MCV = Mean cell volume, MCH = Mean cell haemoglobin, MCHC = Mean cell haemoglobin concentration , MPV = Mean platelet volume

Table 3.3. Comparison of Haematological Parameters, between voluntary and commercial donors in UCH, Ibadan

Parameters	Voluntary donor	Commercial donor	P-value
WBC (x 10^9/L)	7.99 ± 2.97	4.44± 1.84	0.012*
Neutrophil (%)	50.77 ± 9.49	56.52 ± 10.71	0.155
Lymphocytes (%)	38.69 ± 14.50	32.15 ± 8.93	0.087
Monocytes (%)	3.79 ± 1.64	4.43 ± 2.56	0.639
NLR	1.02 ± 0.52	1.41 ± 0.74	0.023*
Eosinophil (%)	2.11 ± 1.36	2.04 ± 1.38	0.440
Basophil (%)	1.32 ± 0.66	1.41 ± 0.77	0.673
Platelet (x 10^9/L)	202.02 ± 56.4	165.14 ± 35.1	0.044*
MPV (fL)	14.43 ± 9.46	16.94 ± 9.09	0.059
PDW (%)	14.27 ± 2.43	13.58 ± 2.59	0.111
P-LCR (%)	20.09 ± 4.78	18.74 ± 5.76	0.151
PLR	13.32 ± 1.15	12.04 ± 1.89	0.205
PCV (%)	40.85 ± 5.33	31.20 ± 6.36	0.024*
HBG (g/dL)	14.79 ± 1.89	10.16 ± 1.05	0.009*
MCV (fL)	81.62 ± 5.92	73.57 ± 7.98	0.013*
MCH (Pg)	32.01 ± 3.31	24.15 ± 7.24	0.042*
MCHC (g/dL)	34.08 ± 7.01	26.83 ± 17.41	0.004*
RBC (x 10^{12}/L)	5.00 ± 3.30	3.74 ± 1.68	0.019*

** represent significance P=0.05 compared to VD*

WBC = white blood cells count, NLR = Neutrophil: Lymphocytes ratio, PCV = Packed cells volume, HBG = heamoglobin level, MCH = mean corpuscular hemoglobin, MCHC = mean corpuscular hemoglobin concentration, PLR = platelet/ Lymphocytes ratio, RBC = red blood cell

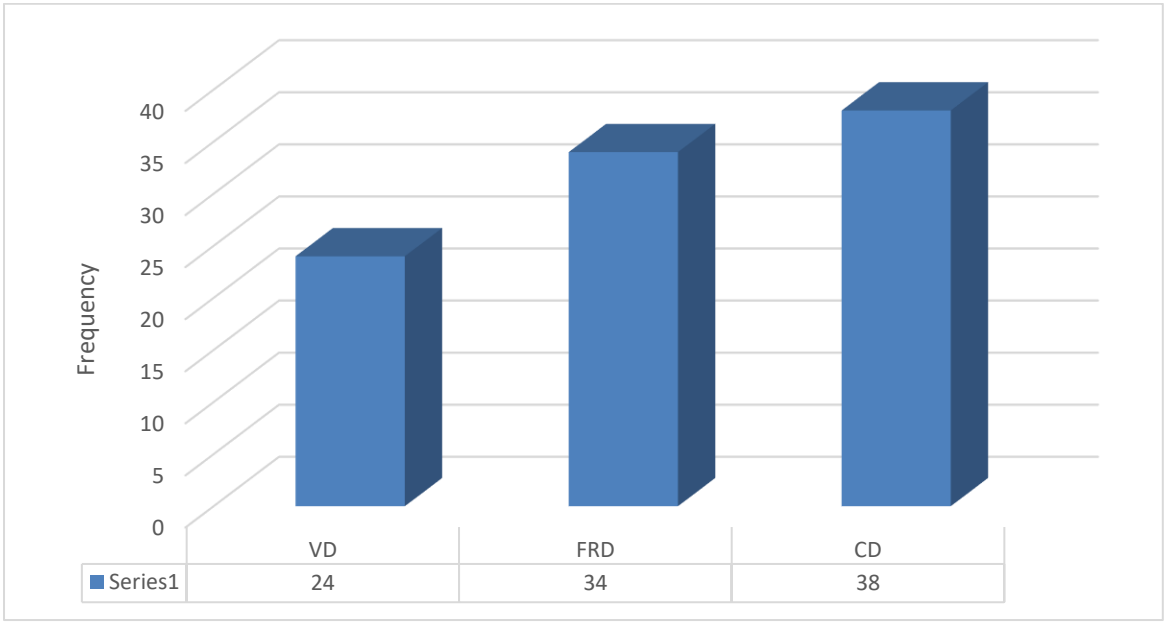

Fig. 3.1. The incidence of low CD4⁺ count among different categories of donor (VD, FRD, and CD)

The comparison of CD4⁺ cell count between VD and FRD, VD and CD yielded no significant differences (p= 0.879) and (p= 0.064) respectively

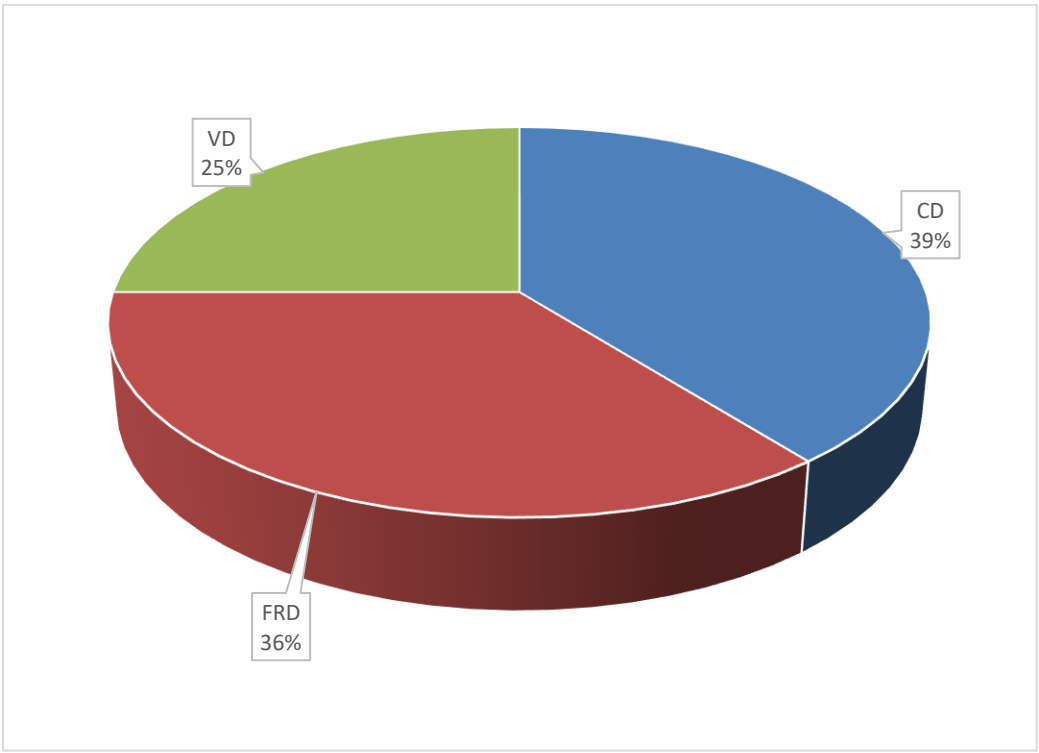

Fig. 3.2. The distribution of low CD41 expression among the three categories of donors (VD, FRD, and CD)

Plasma level of CD41 in VD compared to FRD and CD (P= 0.564 and P= 0.067) respectively. Low CD41 in each category was as follow; VD (7), FRD (11), and CD (10), this resulted to prevalence of 5.8%, 9.2% and 8.3% respectively

3.2 CD4+ and CD41 Count Analyses

Fig. 3.1 highlights the incidence of low CD4+ counts among the different donor categories. $CD4^+$ lymphocytes were enumerated among the three categories of donors in UCH, Ibadan. Although the result showed that commercial donors (CD) had the highest incidence of low CD4+ counts, followed by family replacement donors (FRD), while voluntary donors (VD) had the lowest incidence of low CD4+ counts. However, the comparison of $CD4^+$ cell count between VD and FRD, VD and CD both yielded no significant differences (p= 0.879) and (p= 0.064) respectively.

Similarly, Fig. 3.2 presents the distribution of low CD41 expression across the three donor categories. The findings of this study revealed no significant differences in the plasma level of CD41 in VD compared to FRD and CD (P= 0.564 and P= 0.067) respectively. Nonetheless, the expression of CD41 was moderately reduced among CD, though the difference was not significant compared to VD. Low CD41 in each category was as follow; VD (7), FRD (11), and CD (10), this resulted to prevalence of 5.8%, 9.2% and 8.3% respectively.

4. DISCUSSION

Comparative analysis of demographic characteristics, some haematological parameters, CD4 and CD41 counts among three categories of apparently healthy blood donors in U. C. H. Ibadan, Nigeria was carried out in this study. In line with the standards set by the World Health Organization (WHO) and the National Blood Transfusion Services (NBTS), blood for transfusion should be sourced from non-remunerated volunteer donors [1]. In this study, voluntary donors (VD) were considered the control group to compare with two other categories of donors: family replacement donors (FRD) and commercial donors (CD). Unfortunately, the blood supply from voluntary donors falls short of meeting the high demand for blood transfusions in Nigeria. On the other hand, paid (commercial) donors remain the major source of blood procurement. Commercial donors, who are motivated by financial compensation, are often willing to donate blood frequently, as noted by previous studies [6,5]. However, the safety and quality of blood from commercial donors are frequently called into question [1].

In this study 360 potential blood donors were recruited from the University College Hospital (UCH) Blood Bank in Ibadan, Southwest Nigeria. The donors were divided equally among the three categories: 120 voluntary donors, 120 family replacement donors, and 120 commercial donors. All donors were eligible for blood donation and were recruited at the UCH blood bank unit. The participants were categorized based on their reason and manner of donation. A standard questionnaire and interview were used to collect relevant information after informed consent was obtained [12]. The consent form was modified slightly for this study. Questionnaires offer the advantage of easy administration and the ability to collect a large volume of data [13]. The participants' ages ranged from 18 to 60 years, which aligns with the global practice of adult involvement in blood donation. WHO guidelines also recommend that blood donors should fall within the age range of 18 to 60 years, which was supported by a few previous studies highlighting the importance of age in screening donors [2,1]. Among the commercial donors, 100% were male, while 80% of the voluntary donors were male and 20% female. Family replacement donors consisted of 71.7% males and 28.3% females. This result reflects the dominance of male donors in this study, a trend supported by previous research. Blood donation tends to be viewed as a male-dominated activity, with studies by Jeremiah et al. [14] and Osuji et al. [15] showing that the majority of donors (91%) were male. This could be one of reasons why women are not deeply involved in blood donating process which could be due to their regular monthly menstruation. Due to the blood loss from menstruation, women often have hemoglobin levels that are not optimal for blood donation [16]. Additionally, the study found that most of the donors, though not statistically significant across the three categories, were artisans. Specifically, 44.8% of the artisans participated in the study (P= 0.059). This finding aligns with previous studies, such as Lugos et al. [17], which also highlighted the prevalence of artisans among blood donors. The results suggest that blood donor recruitment efforts in Nigeria should focus on reaching out to groups like artisans, businessmen, traders, and market workers.

Blood is a complex fluid composed of various blood cells suspended in a yellowish liquid called plasma. The blood cells include red blood cells (erythrocytes), white blood cells (leukocytes), and platelets (thrombocytes). Hematological

parameters, which measure these components, are widely used as clinical indicators to assess an individual's health and detect disease conditions [8]. Among the blood cells, white blood cells (WBCs) play a crucial role in the body's defense system. WBCs consist of granulocytes, lymphocytes, and monocytes (WHO, 2015). Their primary function is to protect the body against foreign invaders, a task they often accomplish through antibody production. In this study, WBC parameters, including both differential population counts and absolute counts, were evaluated to explore variations among the different categories of blood donors. The results showed no significant differences in WBC levels between voluntary donors (VD) and family replacement donors (FRD) (P= 0.382). However, contrary to the findings of Benedict et al. [1], WBC counts were significantly lower in commercial donors (CD) when compared to VD (P = 0.012). This finding aligns with the study by Okpokam et al. [18], who also reported a significant decrease in WBC counts among commercial donors.

The differences in WBC counts among CD may be due to immune deficiency, which could increase the rate of WBC apoptosis or lower the rate of new cell formation [19]. Immune deficiency or poor immune function could be particularly prevalent among commercial donors, who may not prioritize their health and nutritional status as carefully as voluntary donors do. The study also evaluated the absolute and mean percentage of lymphocytes across the different donor groups. No significant differences in lymphocyte percentages were observed between VD and FRD (P= 0.796). However, a substantial reduction in lymphocyte percentages was found in CD compared to VD (P= 0.087). Although the difference was not statistically significant, the percentage decrease was severe. This observation supports previous studies on the abnormal reduction of hematological values among healthy blood donors, such as those reported by Balogun et al. [20], Osuji et al. [15], and Lugos et al. [17] in their research on blood donors in Jos, Nigeria. These studies noted that commercial donors often exhibit lower values for various hematological parameters.

In contrast, Okpokam et al. [18] found significantly increased lymphocyte counts among commercial donors with repeated donations, which differ from the results of this study. The lower lymphocyte levels observed in commercial donors here could be linked to several factors, including malnutrition and immune deficiency. Many commercial donors, driven by financial gain, may not maintain adequate nutrition or monitor their health status closely [19]. Additionally, the reduction in lymphocytes could be a sign of compromised immune function, as lymphocytes are a key component of the immune system. These results suggest that commercial blood donors may face significant health risks due to lower WBC and lymphocyte levels, possibly caused by malnutrition or underlying immune deficiencies. These findings emphasize the need for stricter health screenings and better education regarding proper nutrition and health maintenance, particularly among paid blood donors.

In this study, the mean values of Packed Cell Volume (PCV) and Hemoglobin (HBG) were analyzed across three categories of blood donors: Voluntary Donors (VD), Family Replacement Donors (FRD), and Commercial Donors (CD). No significant differences were observed in the PCV and HBG values between VD and FRD. However, a notable reduction in the mean values of Hematocrit (HCT) and HBG was found in the CD group compared to the VD group (P= 0.024 and P= 0.009, respectively). These findings align with previous studies by Benedict et al. [1] and Erhabor et al. [21], which also reported significant decreases in HBG and PCV values among commercial donors. Frequent donations by CD could explain this, as repeated donations may lead to depleted iron reserves and reduced hemoglobin levels, increasing the risk of anemia. According to WHO guidelines, anemia is defined as having an Hb level below 11g/dl for both males and females (WHO, 2013). The low HBG and PCV values suggest an inadequate bone marrow response to erythropoiesis [19], exacerbated by frequent donations from commercial donors, often exceeding the recommended maximum of four times per year.

Red Blood Cell (RBC) counts and indices (Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Volume (MCV), and Mean Corpuscular Hemoglobin Concentration (MCHC) were also evaluated. The comparison between VD and FRD showed no significant differences in RBC count (P= 0.479), MCH (P = 0.954), MCV (P= 0.989), and MCHC (pP= 0.795). However, when comparing VD and CD, significant reductions in RBC count (P = 0.019), MCV (P= 0.013), MCH (P= 0.042), and MCHC (P= 0.004) were observed. Similar findings have

been reported by Hoque et al. [22], indicating that frequent donations by commercial donors may impair erythropoiesis and result in lower RBC levels and associated indices. The study also assessed platelet counts and platelet indices. There were no significant differences between VD and FRD groups (P= 0.345), but platelet counts were significantly lower in the CD group compared to VD (P= 0.044). This finding raises concerns about the quality of blood donations from commercial donors. A low platelet count could undermine the intended purpose of blood transfusions, particularly when aimed at treating thrombocytopenia (a condition characterized by low platelet counts). Thrombocytopenia can lead to bleeding disorders and anemia, which has been linked to substantial health and economic consequences (Bakhubaira, 2013). Low platelet counts in commercial donors might render their blood ineffective for transfusions meant to address such conditions.

These observations are consistent with studies conducted by Balogun et al*.* [20], Osuji et al. [15], and Lugos et al*.* [17], who also reported low hematological values in blood donors in Jos, Nigeria. However, the findings contradict the results of Hoque et al. [22], highlighting the variability in blood donor health profiles across different studies. These findings suggest that commercial donors, while contributing significantly to the blood supply in Nigeria, often exhibit reduced hematological parameters, including PCV, HBG, RBC counts, and platelet levels. This raises concerns about the overall quality of blood procured from commercial donors and highlights the need for improved screening and perhaps limiting the frequency of donations from this group. The study supports the notion that voluntary donors, who exhibit healthier hematological profiles, should be prioritized for blood donation, aligning with the standards set by WHO and the National Blood Transfusion Services (NBTS).

The absolute CD4+ T-lymphocyte count is a critical measure of an individual's immune health and is often linked with monitoring HIV infections. However, there are other infections and factors that can also affect immune status, which is not always accounted for in studies focusing solely on HIV. In this study, CD4+ lymphocyte counts were assessed among three categories of blood donors at the University College Hospital (UCH), Ibadan, to evaluate the impact of blood donation on the immune system. Comparing the CD4+ cell counts among voluntary donors (VD), family replacement donors (FRD), and commercial donors (CD), there were no statistically significant differences between VD and FRD (P= 0.879), or VD and CD (P= 0.064). Although all the donors tested negative for HIV 1 and 2, the CD group showed a notable but non-significant reduction in CD4+ counts. This observation, while not within the direct scope of this study, may point to underlying immune deficiencies or compromised immune function in the commercial donors.

These findings are consistent with the study by Joseph et al. [23], which examined the prevalence and predictors of CD4+ T-lymphocytopenia among HIV-negative patients in Uganda. Similarly, Babatunde et al. [24] reported significantly lower absolute CD4+ counts among adult residents of Ilorin, Nigeria. Mishra et al. [25] also documented low CD4+ counts in healthy Nepalese male adults. However, these results contradict earlier findings by Bainbridge *et al.* (2012), who reported an increase in CD4+ counts following plasmapheresis. Stricker *et al.* (1995) also suggested that repeated plasma donations might enhance CD4+ counts and benefit HIV-infected individuals by improving their immune function. The divergence between these studies and the current findings highlights the need for further research into the factors influencing CD4+ counts among commercial donors. In addition to CD4+ counts, this study evaluated the expression of CD41, a glycoprotein receptor found on platelets and some hematopoietic cells. CD41 is part of the IIb/IIIa integrin family and acts as a receptor for fibrinogen and various extracellular matrix molecules, playing a crucial role in platelet aggregation [9]. Deficiency in CD41 can result in Glanzmann thrombasthenia (GT), a rare inherited autosomal recessive disorder characterized by reduced or absent platelet aggregation due to a lack of CD41 expression [11]. This condition is usually diagnosed by the absence of platelet aggregation in response to physiological agonists such as collagen, epinephrine, and arachidonic acid [26]. The study found no significant differences in plasma CD41 levels between VD and FRD ($p = 0.564$), or between VD and CD ($p = 0.067$). However, the expression of CD41 was moderately reduced in commercial donors, though not to a statistically significant degree. The prevalence of low CD41 expression was as follows: 5.8% in VD, 9.2% in FRD, and 8.3% in CD. Despite the absence of

substantial data on the prevalence of CD41 deficiency among blood donors, this finding suggests that commercial donors may be at a higher risk for conditions related to reduce platelet function, such as Glanzmann thrombasthenia (GT) [27-30]. Individuals with inherited platelet disorders, like GT, often experience prolonged mucocutaneous bleeding due to their platelet dysfunction [9] or reduced platelet aggregation to physiological agonists, such as collagen, epinephrine and arachidonic acid [26]. The findings of this study revealed no significant differences in the plasma level of CD41 in VD compared to FRD and CD (P= 0.564 and P= 0.067) respectively. Nonetheless, the expression of CD41 was moderately reduced among CD, though the difference was not significant compared to VD. Low CD41 in each category was as follow; VD (7), FRD (11), and CD (10), this resulted to prevalence of 5.8%, 9.2% and 8.3% respectively. There is paucity of information on prevalence of low expression of CD41 among donors to support this finding. Patients of inherited disorders of platelets are characterized by a prolonged clinical history of mucocutaneous bleeding [9]. The study sheds light on the immunological and hematological profiles of different categories of blood donors. Commercial donors, in particular, exhibited lower CD4+ counts and moderate reductions in CD41 expression, pointing to potential immune compromise and platelet dysfunction. These findings call for closer scrutiny of blood donation practices, especially among commercial donors, to ensure the safety of blood transfusion for recipients and the health of donors [31-35].

5. CONCLUSION

Since there are no adequate voluntary donors (that believed to be the safest) to donate sufficient blood for most of our patients in dire need of blood in Nigeria and paid donors and family replacement donors are readily available, family replacement donors that are usually non-remunerated donors should be encouraged for donation based on comparable or similar haematological and immunological parameters to the voluntary and first-time donors.

Some abnormal haematological parameters, immune compromise with low value of immunological values discovered in commercial donors (CD) in this study when compared well with VD and RFD has demonstrated limitations of commercial blood donation with regards to the suitability of donors, therefore, there is need to establish a scientific basis for holistic screening of potential blood donors and specifically to re-evaluate CD for other area that is not currently being screened for since they are the donors that provide the bulk of blood donations in Nigeria. Stringent haematological screening that includes determination of full haematological parameters rather than haemoglobin alone and immunological parameters like CD4 would certainly improve donor safety and quality product for the recipient. By doing so, units of blood in our blood banks will be boosted to accommodate unexpected and emergency cases associated with massive blood loss and thereby reducing hemorrhagic-associated mortality significantly.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

We hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

ETHICAL APPROVAL

As per international standards or university standards written ethical approval has been collected and preserved by the author(s).

CONSENT

As per international standards or university standards, respondents' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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