P-ISSN: 2811-1516
E-ISSN: 2811-1524

AL-HIKMAH JOURNAL OF HEALTH SCIENCES (AJOHS)
Official Publication of Faculty of Health Sciences
Al-Hikmah University Ilorin, Nigeria
www.alhikmahuniversity.edu.ng/centralJournal

Original Article

In-Vitro Variations in Erythrocyte Ageing Among Different Categories of Blood Donors Due to Donor-Related Factors

Sikiru Adetona Lawal[1], Daniel Ohilebo Ugbomoiko[1], Musa Abidemi Muhibi[2], Luqman Olayinka Olatunbosun[3*], Abiola Samuel Babatunde[3], Fatai Dayo Olalere[3], Tajudeen Kolawole Ogunwale[4], Sulaeman Eleha Ibrahim[4], Ameenah Ayodeji AbdulRaheem[3], Rasheed Oladimeji Lambe[3] and Ibrahim Kehinde Lawal[5]

[1]Department of Medical Laboratory Science, Igbinedion University Okada, Edo State, 302110, Nigeria.
[2]Department of Medical Laboratory Science, Edo State University, Uzairue. Edo State, 312107, Nigeria.
[3]Department of Hematology and Blood Transfusion, University of Ilorin Teaching Hospital, Ilorin, 240001, Nigeria.
[4]Department of Chemical Pathology and Immunology, University of Ilorin Teaching Hospital, Ilorin, 240001, Nigeria
[5]Department of Science Laboratory, Osun State Polytechnic, Esa Oke, Osun State, 233130, Nigeria.

ARTICLE INFO

Article History
Received 9 November, 2023
Accepted 22 November, 2023
Available online 5 December, 2023

Keywords
Donation
Frequency
Family
Remunerated
Lesions
Biomarkers

Corresponding Author
Dr. Olatunbosun, Luqman Olayinka, Department of Hematology and Blood Transfusion, University of Ilorin Teaching Hospital, Ilorin, PMB 1459, Kwara State, Nigeria. P.O BOX 4173
Phone Number: +2348030467510
Email: deluy008@gmail.com
Zip code: 240001

ABSTRACT

Blood storage lesion is a rapidly growing area of biomedical research which leaves several questions unanswered. This study assessed blood donation frequency, as it affects hematological and biochemical parameters among different categories of blood donors longitudinally over a period of 35 days at 2-6^{0}C. Ethically approved cross-sectional research involving family (n=30), remunerated donors: mild (n=30), moderate (n=30) and high frequency (n=30). One hundred milliliters (100 mL) of well-mixed blood was transferred into the satellite bag from 450mls of blood from different categories of blood donors. Haemogram, plasma Ferritin, Erythropoietin (EPO), 2, 3-diphosphoglycerate, Sodium (Na^+) and Potassium (K^+) assessed at 0, 7, 14, 21, 28 and 35 days of storage were analyzed. This study revealed acceptable normal high values in Haemogram, erythropoietin and ferritin in family donors while Remunerated donors had mild to moderate anemia, high total WBC count, higher platelet count, a very low ferritin content, low red cell indices, high EPO, hypernatremia, hyperkalaemia and high 2, 3. Diphosphoglycerate (2, 3, DPG). Significant iron deficiency anemia and electrolyte imbalance among moderate to high frequent blood donors.

Please cite this article as: Lawal, S.A., Ugbomoiko, D., Muhibi, M.A., Olatunbosun, L.O., Babatunde, A.S., Olalere, F.D., Ogunwale, K.A.T., Ibrahim, S.E., AbdulRaheem, A.A., Lambe, R.O. and Lawal, I.K. (2023). In-Vitro Variations in Erythrocyte Ageing Among Different Categories of Blood Donors Due to Donor Related Factors. *Al-Hikmah Journal of Health Sciences, 3*(1), 10 - 17.

Introduction

Blood donors represent a genetically diverse population with inherited differences in red blood cell (RBC) characteristics that may modulate predisposition to hemolysis and RBC recovery in response to various stress conditions, including cold storage of RBC units (Kanias and Gladwin, 2012). Genetic or biological factors that modulate RBC

P-ISSN: 2811-1516

E-ISSN: 2811-1524

responses to stress and favor hemolysis may impact the efficacy of RBC transfusions and increase the risk of transfusion-related complications via enhanced destruction of stored RBCs in the patient's circulation. The quality of RBC products can be greatly affected by the characteristics of donors' health status, age, sex, blood groups, lifestyle, etc. Identification of donor characteristics associated with transfusion recipient outcomes may lead to optimal selection of blood donors and donor-recipient matching. Red blood cells undergo a series of biochemical fluctuations during a 35–42-day storage period at 2°C to 6°C. Stored red blood cells undergo morphologic changes, metabolic alterations, and some degree of hemolysis during storage. During storage, red blood cells undergo depletion of potassium, 2, 3-diphosphoglycerate, ATP, lipids and membrane, with increased red cell rigidity and impaired oxygen delivery (Kim-Shapiro *et al.,* 2011). The stored units accumulate products of glycolysis, primarily protons, leading to a decrease in pH and hence, acidosis. This slowly causes a decrease in the rate of glycolysis and ATP formation, which in turn leads to loss of deformability with the formation of reversible echinocytes and eventually, the formation of irreversible spheroechinocytes. Further changes involve loss of membrane by vesiculation (Rubin *et al*., 2008). A decrease in 2, 3 DPG (diphosphoglycerate) is observed, which translates to increased affinity of hemoglobin to oxygen, consequently leading to decreased capacity of the erythrocytes to release oxygen into tissues (D'Alessandro *et al.,* 2010). The accumulation of immune-modulatory factors in stored RBC concentrates has been implicated as a potential cause of transfusion reactions (Caroline Sut *et al.,* 2017).

US FDA standards requirement for stored blood is such that hemolysis must be <1% at the end of storage and at least 75% of allogeneic erythrocytes still circulating in the recipient's blood 24 h after transfusion. To achieve this, appropriate donor selection is pivotal among other conditions. Storage duration alone is just one of the many factors that impact on RBC component properties and quality. It has long been known that RBCs from some donors store well while others store poorly (Dumont and AuBuchon, 2008; McAteer *et al*., 2010).

Consequently, energy metabolism through glucose consumption leads to lactate production, which accumulates in the RBC storage solution (Blasi *et al.,* 2012) and induces its acidification (Hess, 2010). This metabolism-related decrease of pH inhibits the glycolysis rate, and affects the 2, 3-diphosphoglycerate (2, 3-DPG) level through the activities of diphosphoglycerate mutase and phosphatase. After two weeks of storage, RBCs reportedly show 2, 3-DPG depletion (Bennett-Guerrero *et al.,* 2007). Low 2, 3-DPG levels increase the affinity of hemoglobin for oxygen, inhibiting its release and thus altering the oxygenation capacity of stored RBCs. However, 2, 3-DPG depletion appears to recover within a few hours post-transfusion.

Cold storage of RBCCs induces inactivation of membrane ionic pumps, as shown by Na^+ uptake and K^+ loss throughout the storage period. Moreover, low-temperature storage slows metabolic enzyme activities, inducing a progressive decrease in ATP levels (Bennett-Guerrero *et al.,* 2007).

WBCs in non-leukoreduced RBC concentrates have been documented to induce adverse immune effects as a result of microbial risks, transfusion-associated GVHD, and recipient immune reactions such as alloimmunization and non-hemolytic febrile transfusion reactions (Hendrickson and Hillyer, 2009). It is believed that these WBCs, upon exposure to the acidic conditions of storage and refrigeration, become activated and release cytokines, which can lead to their delivery at high concentrations during transfusion (Vamvakas and Blajchman, 2007). In addition, during routine storage of RBCs, lipids accumulate in the plasma fraction that can prime neutrophils, causing neutrophil-mediated cytotoxicity of human pulmonary endothelial cells, which has been implicated as the mechanism of lung injury in transfusion-related acute lung injury (TRALI) (Silliman *et al.,* 1994).

The efficacy of transfusing stored, refrigerated erythrocytes from remunerated commercial blood donors in improving oxygen-carrying capacity and delivery to the tissues has not been very well studied in the past. A growing number of studies have discussed the potential impact of donor characteristics on RBC storage lesions and post-transfusion outcomes, which led to the scrutiny of genetic and biological factors in blood donors that may contribute to variations in the quality of RBC units (Tamir Kanias *et al.,* 2017). Optimal selection of blood donors is critical for ensuring the safety of blood products.

Materials and Methods

The study is an ethically approved random, cross-sectional research comprising 120 apparently healthy male prospective blood donors within the age of 21-55 years residents in Ilorin metropolis, Kwara state using the serial recruitment method.

A total number of 120 male donors were recruited as blood donors, family donors (n=30) and non-family donors (n=90). Non-family remunerated donors were

P-ISSN: 2811-1516

E-ISSN: 2811-1524

grouped into three (3) based on the frequency of donation per year as mild (n=30), moderate (n=30) and high frequency (n=30) donors.

Blood donors screening

Satellite double blood bag having a capacity of 450 ± 10 mls containing Citrate Phosphate Dextrose Adenine (CPDA-1) solution with a shelve life of 35 days for whole blood storage at 2-6^0 C was used to store the collected blood.

Bleeding of donors

Four hundred and fifty milliliters (450 mls) of blood was drawn from each of the 120 apparently healthy donors (age range from 21-55 years) into a double blood bag containing CPDA-1 anticoagulant. Blood was collected with adequate safety precautions to avoid contamination and infection. 100 mls of well-mixed blood was transferred into the satellite bag, detached and stored in the blood bank at 2-6^0 C for 35 days.

Sample collection

The effect of storage was analyzed at 0, 7, 14, 21, 28 and 35 days of storage by withdrawing 10 mls blood each time from the satellite blood bag. The blood samples collected were analyzed for hematological parameters before being centrifuged at 5000 rpm for five minutes to obtain the plasma which was stored at -20 C for further biochemical investigations. The sample analyzed on day 0 served as baseline control.

Laboratory Procedures

Full Blood Count (FBC)

The blood samples were analyzed for full blood count (FBC) immediately and repeated at intervals of 7 days throughout the 35 days of storage using the hematology auto-analyzer MODEL: SYSMEX KX21. Procedures were performed according to the standard operating manuals.

Plasma Ferritin Assay, 2, 3- Disphosphoglycerate and Human Erythropoietin- EPO were done using ELISA methods.

Electrolytes were estimated, using Ion Selective Electrode (ISE) (Springer, 2012)

Results

Table 1: Haemoglobin, Haematocrit and Red Blood Cells

Categories	Baseline	Week 1	Week 2	Week 3	Week 4	Week 5
Family	13.5±0.7	12.5±.3	12.4±1.0	12.3±0.9	12.3±0.8	12.3±0.7
			Haemoglobin			
Remunerated	12.6±1.4	11.5±1.5	11.4±1.4	11.4±1.4	11.3±1.5	11.3±1.6
t-test	3.376	3.264	3.613	3.296	3.483	3.312
P-value	**0.001**	**0.014**	**0.004**	**0.013**	**0.007**	**0.012**
			Haematocrit			
Family	0.44±0.03	0.41±0.03	0.40±0.04	0.40±0.03	0.39±0.04	0.39±0.03
Remunerated	0.40±0.04	0.37±0.03	0.35±0.02	0.35±0.04	0.34±0.03	0.34±0.02
t-test	5.021	5.325	8.997	6.276	7.244	10.372
P-value	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**
			Red Blood Cells-RBC			
Family	5.1±0.5	4.6±0.4	4.5±0.5	4.4±0.6	4.4±0.5	4.3±0.5
Remunerated	4.4±0.5	3.9±0.5	3.9±0.6	3.8±0.5	3.8±0.6	3.7±0.5
t-test	6.641	6.956	4.932	5.407	4.932	5.692
P-value	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**

Table 1 above shows the Hemoglobin, Hematocrit and Red Blood Cells (RBC) among different categories of donors throughout the storage of whole blood units under standard blood bank conditions. Values obtained with independent samples t-test and expressed as Mean ± Standard deviation, bold p-value indicates statistical significance at $p < 0.05$.

P-ISSN: 2811-1516
E-ISSN: 2811-1524

Table 2: Red Blood Cells Indices, Ferritin and Erythropoietin-EPO

Categories	Baseline	Week 1	Week 2	Week 3	Week 4	Week 5
Mean Cell Volume-MCV						
Family	84.2±4.9	82.2±6.7	80.1±6.3	78.4 ±5.7	78.2±6.1	78.9±6.3
Remunerated	81.7±5.6	79.6±5.7	78.1±4.3	76.5±4.2	75.9±5.2	75.2±5.6
t-test	2.181	2.069	1.949	1.953	2.007	3.037
P-value	**0.031**	**0.041**	**0.054**	**0.053**	**0.047**	**0.003**
Mean Cell Haemoglobin-MCH						
Family	25.5±2.3	23.4±3.1	22.9±2.2	22.6±1.5	22.6±1.3	22,5±1.4
Remunerated	24.5±2.2	22.3±2.4	22.0±2.1	22.0±1.4	21.9±1.7	21.9±1.3
t-test	2.132	2.015	2.009	1.997	2.061	2.148
P-value	**0.035**	**0.046**	**0.047**	**0.048**	**0.042**	**0.034**
Mean Cell Haemoglobin Concentration-MCHC						
Family	30.8±1.6	29.9±2.3	29.7±1.7	29.6±1.6	29.9±1.1	30.0±1.2
Remunerated	30.0±1.5	28.5±2.3	28.5±2.0	28.7±1.5	29.0±1.8	29.3±1.4
t-test	2.488	2.887	2.948	2.799	2.579	2.453
P-value	**0.014**	**0.005**	**0.004**	**0.006**	**0.011**	**0.016**
Ferritin						
Family	43.6±2.2	43.6±2.2	43.6±2.2	43.7±2.1	45.9±2.0	47.9±2.2
Remunerated	28.3±11.2	29.0±11.1	29.3±10.7	30.5±10.0	32.4±10.1	34.5±9.9
t-test	7.401	7.118	7.238	7.208	7.284	7.414
P-value	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**
Erythropoietin-EPO						
Family	4.4±0.6	4.3±0.8	3.8±0.6	3.2±0.6	2.3±0.5	1.2±0.5
Remunerated	6.3±1.2	5.7±1.0	5.4±1.2	4.6±1.1	3.5±1.0	2.2±0.7
t-test	-9.094	-6.956	-7.002	-6.637	-6.302	-6.693
P-value	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**

Table 2 above shows the Red Blood Cells Indices, Ferritin and Erythropoietin-EPO among different categories of donors throughout the storage of whole blood units under standard blood bank conditions. Values obtained with independent samples t-test and expressed as Mean ± Standard deviation, bold p-value indicates statistical significance at $p < 0.05$.

Table 3: White Blood Cells-WBC and Platelets

Categories	Baseline	Week 1	Week 2	Week 3	Week 4	Week 5
White Blood Cells						
Family	5.3±0.7	4.2±1.0	3.9±1.0	3.7±1.1	3.5±1.1	3.6±1.0
Remunerated	6.0±1.3	4.8±1.1	4.5±1.2	4.3±1.3	4.0±1.2	4.1±1.2
t-test	-2.811	-2.644	-2.466	-2.270	-2.016	-2.055
P-value	**0.006**	**0.009**	**0.015**	**0.025**	**0.046**	**0.042**
Platelets-PLT						
Family	238.6±75.1	190.2±37.4	171.9±37.8	168.7±37.8	166.2±34.7	169.5±76.0
Remunerated	228.8±61.2	194.0±49.5	180.9±48.8	173.4±46.0	177.2±46.2	179.7±54.4
t-test	0.716	-0.385	-0.921	-0.505	-1.195	-0.801
P-value	0.475	0.701	0.359	0.614	0.234	0.425

Table 3: above shows the White blood cells and Platelet Counts among different categories of donors throughout the storage of whole blood units under standard blood bank conditions. Values obtained with independent samples t-test and expressed as Mean ± Standard deviation, bold p-value indicates statistical significance at $p < 0.05$.

P-ISSN: 2811-1516

E-ISSN: 2811-1524

Table 4: 2, 3, Diphosphoglycerate (2, 3 DPG), Sodium and Potassium

Categories	Baseline	Week 1	Week 2	Week 3	Week 4	Week 5
Family	29.4±1.4	28.1± 1.3	26.7±1.1	21.8±1.5	15.9±1.1	10.7±0.9
Remunerated	43.4±11.3	42.4±11.1	40.4±10.8	32.9±8.2	24.0±5.9	15.7±4.0
t-test	-6.750	-6.992	-6.915	-7.294	-7.430	-6.798
P-value	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**	**0.001**
			Sodium (Na^+)			
Family	143.5±1.2	140.5±1.9	137.3±2.8	126.8±0.9	121.3±1.3	116.6±1.5
Remunerated	150.7±8.6	149.4±8.9	145.1±9.2	137.0±9.4	129±11.4	122.3±14.3
t-test	-4.558	-5.422	-4.562	-5.918	-3.681	-2.173
P-value	**0.001**	**0.001**	**0.001**	**0.001**	**0.004**	**0.032**
			Potassium (K^+)			
Family	4.1±0.5	7.2±0.7	10.2±1.1	13.0±1.6	16.7±1.3	20.6±1.6
Remunerated	4.3±0.6	8.0±2.3	10.5±2.9	13.3±3.8	16.7±4.5	20.2±5.6
t-test	-1.644	-1.872	-0.552	-0.419	0.000	0.385
P-value	0.103	0.064	0.582	0.676	1.000	0.701

Table 4: above shows the potassium (K^+) among different categories of donors throughout the storage of whole blood units under standard blood bank conditions. Values obtained with independent samples t-test and expressed as Mean ± Standard deviation, bold p-value indicates statistical significance at $p < 0.05$.

Discussion

In this current study, out of a total number of 120 adult male recruited as blood donors, family donors were 30 and remunerated donors were 90. In the recruited family donors, majority were above 40 years of age; had secondary education, government employee; feed majorly on carbohydrates and were none alcohol drinkers, none cigarette smokers with history of donating more than four years before the study and less than four times donation frequency per year. These findings on family donors aligned with previous studies (Lownik *et al.*, 2012). This study corroborates why the International Society of Blood Transfusion and WHO regarded blood donation as voluntary in all circumstances and financial benefit must never be a motive.

Contrarily, remunerated, blood donors were majorly young individuals of age between 31-40 years having primary education, self or unemployed, moderate alcohol drinkers and moderate cigarette smokers donating more than four years before the study and more than four times a year. These observations probably can be due to the increasing rate of poverty, joblessness and bad social life. This study is in support of the evidence from previous studies that alcohol and cigarette consumption have associated risks of addiction which in turn have adverse effects on the metabolic quality of blood from remunerated high-frequency blood donors.

In the assessment of haemogram biomarkers in the studied groups, Hb, Hematocrit and RBCs in family donors from baseline to week 5 were found to be higher than remunerated blood donors and progressively decreasing during cold storage. The decrease that showed statistically significant p-value< 0.05 along the weeks. These imply family donors have high values in these parameters all through the weeks of storage compared with remunerated donors with unacceptably low values as donation frequencies increase. Hence, neither the socio-economic status nor the frequency of donation of the family replacement donor would adversely affect their hemoglobin, hematocrit and RBCs count. In contrast, commercial donors are usually of low socio-economic status who are in most cases involved in drug abuse with consequent nutritional neglect. Hence, commercial donors often suffer from nutrient depletion and iron deficiency anemia. This result agreed with the study reported by (Amballi *et al.*, 2020). Also, several studies have reported anemia in blood donors (Rajab *et al.*, 2005) with higher frequencies in Africa than in Western countries (Tayou Tagny *et al.*, 2006), (Erhabor *et al.*, 2007). Erharbor *et al*. in a similar study reported that hemoglobin levels are lower in remunerated blood donors than replacement donors in Nigeria (Gomez-Simon *et al.*, 2007). Anemia is the most common reason for donor ineligibility (Ukaejiofor *et al.*, 1979). White Blood Cells counts in the stored blood from baseline values to week-5 for family donors were found to be lower than that of remunerated donors, with progressive decrease that in

P-ISSN: 2811-1516

E-ISSN: 2811-1524

overall showed statistical significance p-value<0.05 thereby aligned with the mean values that were previously reported among healthy Nigerians (Dale, 1991). However, the mean values of total WBC count of the commercial donors were significantly higher than that of family replacement donors. This result may suggest that the higher total WBC count seen among the commercial donors may be due to elevated neutrophil count, which may be due to excessive blood loss resulting from high frequency of blood donation since hemorrhage is an important cause of elevation in neutrophil count (Hsieh *et al.,* 2007). In addition, commercial donors are often involved in drug and substance abuse including cigarette smoking, which is known to be associated with elevation in neutrophil count (Essien *et al.,* 2004). Platelets in the stored blood at baseline values for family donors were found to be higher than in remunerated donors, but moderately higher in remunerated donor from week 1 to week 5 with a progressive decrease that showed no statistically significant p-value when compared with family donors. The mean values of platelet count seen among the family replacement donors were comparatively similar and consistent with normal values that were previously reported among healthy Nigerians (Schafer, 2004). In addition, in this study high frequent remunerated donor had very low ferritin content among others which is indicative of iron deficiency, which is also known to cause thrombocytosis (Ahmed *et al.,* 2010).

Mean Cell Volume, Mean Cell Hemoglobin and Mean Cell Hemoglobin Concentration in the stored blood at baseline values for family category was found to be higher when compared with remunerated donors with progressive decrease that showed statistically significant p-value<0.05 all through from week-1 to 5 when compared with family category. This study was in agreement with report of (Benedict *et al.,* 2012) which stated that the mean values of red cell indices (MCV, MCH, MCHC) for the commercial donors were lower than that of family replacement donors but, in contrast, the differences were not statistically significant (p>0.05) for all three indices. The relatively lower mean values of red cell indices among the commercial donors would further suggest the existence of a negative iron balance in this donor category. Also, the concomitant reduction in the red cell indices further suggests that the anemia most likely resulted from too frequent blood donation (Finch and Huebers, 1982). In assessing haemopoietic biomarkers in the studied groups, ferritin in family donors from baseline to week-5 was higher than in remunerated non-family donors, and progressively increased during cold storage. This increase showed statistical significance (p-value < 0.05) from baseline to week 5 when compared with family category of blood donors. This means that high frequent donation has resulted to decrease in ferritin levels. This is so because the physiologic importance of the storage iron is that, it provides a rapidly available supply in the event of blood loss (Szymczyk-Nuzka and WoÅ, 2003). Findings in this study support previous research (Badami K, and Taylor, 2008) who reported that an increase in the donation frequency was followed by a significant decrease in serum ferritin concentration.

Erythropoietin (EPO) in family donors from baseline to week 5 was lower than other remunerated donors of the non-family group and progressively decreased during cold storage. This decrease showed statistical significance (p-value < 0.05) all through from baseline to week-5 when compared with family category of donors. The erythropoietin (EPO) mediates the remarkable regenerative capacity of the bone marrow to compensate for blood loss or reduced oxygen tension (Aziz *et al.,* 2014). These findings agreed with the previous study by (Hess, 2006) which found that EPO was significantly higher and the ferritin was significantly lower in regular donors than in the first-time donors.

In assessing the biochemical changes in the studied groups, both sodium and potassium in family donors from baseline to week-5 were lower than remunerated non-family donors and Na^+ was progressively decreasing while K^+ was progressively increasing during cold storage. The decrease showed statistically significant p-value < 0.05 in Na^+ all through. While the increase in K^+ showed no statistically significant p-value when compared with the family category. The high concentration of sodium (hypernatremia) reported is likely to be dehydration that occurred, as a result of high donation frequency without adequate fluid intake coupled with too much fluid loss. Potassium loss is recognized to be secondary to the changes in metabolic activity and decreasing pH with cooling (Opoku-Okrah *et al.,* 2015). Findings in this study corroborate the earlier reported increase and reduction in plasma potassium and sodium respectively in stored blood by Opoku-Okrah *et al* (Freiser, 1986).

2, 3, Diphosphoglycerate (2, 3, DPG) in the stored blood is lower in family donors than remunerated non-family donors and progressively decreased during cold storage, this decrease showed statistically significant p-value < 0.05 from baseline to week-5 when compared with the family category.

P-ISSN: 2811-1516

E-ISSN: 2811-1524

Conclusion

This study revealed acceptable normal high values in haemogram, erythropoietin and ferritin in family donors while non-family remunerated donors had mild to moderate anemia, high total WBC count, higher platelet count, a very low ferritin content, low red cell indices (MCV, MCH, and MCHC), high EPO, hypernatremia, low potassium and high 2, 3. Diphosphoglycerate (2, 3, DPG) reflects iron deficiency anemia and electrolyte imbalance.

Acknowledgement

We acknowledged the efforts of the entire staff (both Technical and Clinical) of the department of Hematology and Blood Transfusion Science, University of Ilorin Teaching Hospital, Nigeria; The Director, Medical Laboratory Services, Kwara State General Hospital, Ilorin, Nigeria. Special regards to the prospective blood donors who consented to partake in this work. We are also grateful to the Kwara State Ministry of Health for ethical approval given to this work.

References

Adediran, I., Fesogun, R., Oyekunle, A. (2005). Haematological parameters in prospective Nigerian blood donors rejected on account of anaemia and/ or microfilaria infestation. *Nigeria Journal of Medicine;* **14**:45-50.

Ahmed, S., Kagu, M., & Abjah, U. (2010). Haematological parameters of blood donors in north east Nigeria and the implication on quality of blood products. *Africa Sanguine*; Volume **13**, no. 1.

Amballi, A., Olooto, W., Olaniyi, O., Onayemi, A., Adebowale, D., & Fatai, A. (2020). Assessment of biochemical and haematological changes that occur in blood stored with CPDA-1 as an anticoagulant in a tertiary hospital in Nigeria. *Journal of Medical Biomedical Research*; (**19**):13-22

Aziz, F., Abdullah, U., & Rahim, N. (2014). Correlation of Serum Erythropoietin and Ferritin Levels with the Frequency of Blood Donation. *Journal of Blood Disorders Transfusion*; **5**:232

Badami, K., and Taylor, K. (2008). Iron status and risk-profiling for deficiency in New Zealand blood donors. See comment in PubMed Commons below *New Zealand Medical Journal*; **121**: 50-60.

Benedict, N., Augustina, A., & Nosakhare, B. (2012). Blood Donation in Nigeria: Standard of the Donated Blood. *Journal of Lab Physicians*; **4**:94-7

Bennett-Guerrero, E., Veldman, T., Doctor, A., Telen, M., Ortel, T., Reid, T., Mulherin, M., Zhu, H., Buck, R., & Califf, R. (2007). Evolution of adverse changes in stored RBCs. Proc Natl Acad Sci USA.; **104**:17063-17068

Blasi, B., D'Alessandro, A., Ramundo, N., Zolla, L. (2012). Red blood cell storage and cell morphology. Transfusion Medicine. **22**:90-96

Caroline Sut, Sofiane Tariket, Ming Li, Olivier Garraud, Sandrine Laradi, Hind Hamzeh, Cognasse Jerard, Thierry Burnouf, & Fabrice Cognasse. (2017). Duration of red blood cell storage and inflammatory marker generation. *Blood Transfusion*; **15**(2):145–152

D'Alessandro, A., Liumbruno, G., Grazzini, G., & Zolla, L. (2010). Red blood cell storage: the story so far. *Blood Transfusion*; 8:82-8

Dale, D. (1991). Neutrophilia. In: Hematology, 4th ed (Williams WJ, Beutler E, Erslev AJ, Lichtman M. eds.) New York: McGraw-Hill; pp. 816-834.

Dumont, L., & AuBuchon, J. (2008). Evaluation of proposed FDA criteria for the evaluation of radiolabeled red cell recovery trials. *Transfusion*; **48**:1053–60

Erhabor, O., Ok, O., Awah, I., Uko, K., & Charles, A. (2007). The prevalence of Plasmodium parasitaemia among donors in the Niger delta of Nigeria. *Tropical Doct;* **37**:32-4

Essien, E., Usanga, E., & Ayeni, O. (1973). The Normal Platelet Count and Platelet Factor-3 Availability in Some Nigerian Population Groups. *Scandinavian Journal of Haematology*; **10**: 378-383

Finch, C., and Huebers, H. (1982). Perspective in iron metabolism. *New England Journal of Medicine* **306**: 1520-1528.

Freiser, H. (1986). Coated wire ion-selective electrodes. Principles and practice. *Journal of the Chemical Society*, Faraday Transactions 1: Physical

P-ISSN: 2811-1516

E-ISSN: 2811-1524

Chemistry in Condensed Phases; **82**(4), 1217.

Gomez-Simon, A., Navarro-Nuwez, L., Perez-Ceballos, E., Lozano, M., Candela, M., & Cascales, A. (2007). Evaluation of four rapid methods for haemoglobin screening of whole blood donors in mobile collection settings. *Transfusion Apheresis Science*; **36**:235-42

Hendrickson Jeanne, & Hillyer Christopher. (2009). Noninfectious Serious Hazards of Transfusion. *Anesthesia & Analgesia*; **108**(3):759-769

Hess, J., Sparrow, R., & Van der Meer. (2009). Red blood cell hemolysis during blood bank storage: using national quality management data to answer basic scientific questions. *Transfusion*; **49**:2599–2603.

Hess, J. (2006). An update on solutions for red cell storage. *Vox Sang*.; **91**:13–19.

Hess, J. (2010). Red cell changes during storage. Transfusion Apheresis Science; **43**:51-59

Hsieh, M., Everhart, J., Byrd-Holt, D., Tisdale, J., & Rodgers, G. (2007). Prevalence of neutropenia in the U.S. population: age, sex, smoking status, and ethnic differences. *Annals Internal Medicine*; **146**: 486-492

Kanias, T. & Gladwin, M. (2012). Nitric oxide, hemolysis, and the red blood cell storage lesion: interactions between transfusion, donor, and recipient. *Transfusion*; **52**(7):1388-1392

Kim-Shapiro, D., Lee, J., & Gladwin, M. (2011). Storage lesion: Role of red blood cell breakdown. *Transfusion*; **51**:844–851

Lownik, E., Riley, E., Konstenius, T., Riley, W., & McCullough, J. (2012). Knowledge, attitudes and practices surveys of blood donation in developing countries. *Vox Sang*. Jul; **103**(1):64-74

McAteer, M., Dumont, L., & Cancelas, J. (2010). Multi-institutional randomized control study of haemolysis in stored red cell units prepared manually or by an automated system. *Vox Sang.*; **99**:34-43.

Opoku-Okrah, C., Acquah, B., & Dogbe, E. (2015). Changes in potassium and sodium concentrations in stored blood. *Pan African Medical Journal*; **20**: 236-241

Rajab, J., Muchina, W., Orinda, D., & Scott, C. (2005). Blood donor haematology parameters in two regions of Kenya. *East Africa Medical Journal*; **82**:123-7.

Rubin, O., Crettaz, D., & Canellini, G. (2008). Microparticles in stored red blood cells: an approach using flow cytometry and proteomic tools. *Vox Sang*.; **95**:288–97

Schafer, A. (2004). Thrombocytosis. *New England Journal of Medicine*; **350**: 1211-1219.

Silliman, C., Clay, K., & Thurman, G. (1994). Partial characterization of lipids that develop during the routine storage of blood and prime the neutrophil NADPH oxidase. *Journal of Lab Clinical Medicine*; **124**:684–694.

Szymczyk-Nuzka M and WoÅ‚owiec D. (2003). Iron stores in regular blood donors. See comment in PubMed Commons below *Pol Arch Med Wewn*.; **110**: 1415-1421.

Tamir Kanias, Marion, C., Lanteri Grier, Page YuelongGuo, Stacy M, Endres Mars, Sheila Keating, Alan Mast, Ritchard, G., Cable Darrell, Triulzi Joseph, Kiss Edward, Murphy Steve, Kleinman Michael, & Mark Gladwin. (2017). Ethnicity, sex, and age are determinants of red blood cell storage and stress hemolysis: results of the REDS-III RBC-Omics study. *Blood advances*; Volume **1**, Number 15

Tayou Tagny, Monny Lobe, & Mbanya D. (2006). Evaluation of two methods for haemoglobin measurement in Cameroonian blood donors. *Transfusion Clinical Biology*; (**13**):331-4.

Ukaejiofor, E., Isaac-Sodeye, W., Adigun, E., & Ipadeola, A. (1979). Normal haematological values in adult Nigerians. *Nigerian Medical Journal*; **9**:117-119

Vamvakas, E., & Blajchman, M. (2007). Transfusion-related immunomodulation (TRIM): an update. *Blood Revelation*; **21**:327–48.