Hemoglobin Phenotype Variants Among Voluntary Blood Donors at Lagos State Blood Transfusion Service.

Abstract

Introduction:A class of hereditary blood illnesses known as hemoglobinopathies continues to pose a serious threat to world health, especially in areas with high prevalence, such as sub-Saharan Africa. To ensure transfusion safety and address the particular public health issues of hemoglobinopathies, it is crucial to comprehend the distribution of hemoglobin phenotypic variants among voluntary blood donors.

Aim/Objective: The purpose of this study is to determine the distribution and prevalence of hemoglobin phenotypic variations among willing blood donors at the Lagos State Blood Transfusion Service (LSBTS), one of Nigeria's largest blood suppliers.

Method:A cross-sectional descriptive study was carried out at LSBTS in Lagos, Nigeria, with 200 volunteer donors. At random, participants were chosen from 20 blood donation camps. Statistical analyses were conducted using SPSS version 25, hemoglobin electrophoresis was used to determine phenotypes, and structured questionnaires were used to gather demographic and health data.

Results: The hemoglobin phenotypes of 75% of the 200 donors were AA, 23% AS, and 2% AC. The majority (71.5%) were between the ages of 26 and 45 and were male. Demographic characteristics including age, sex, or hemoglobin levels did not significantly correlate with hemoglobin variations ($p>0.05$). The ethnic distribution revealed that Yoruba donors made up the majority (55.5%).

Conclusion: The safety of most blood donations is suggested by the high incidence of hemoglobin AA. To guarantee transfusion safety, thorough pre-donation screening is necessary, as evidenced by the existence of AS and AC variations.

Keywords: Haemoglobin variants, blood donors, haemoglobinopathies, transfusion safety, Lagos State, public health.

1.0 Introduction

Hemoglobinopathies and thalassemiaare serious hereditary conditions caused by genetic abnormalities in the globin genes that change the structure or synthesis of hemoglobin. Examples of these disorders include sickle cell disease (SCD) and thalassemia. The synthesis of aberrant hemoglobin S (HbS) is the outcome of a mutation in the β-globin gene, which causes sickle cell anemia, a common form of sickle cell disease. This mutation causes HbS to polymerize under low oxygen conditions, resulting in stiff, sickle-shaped red blood cells. This can cause hemolysis, vaso-occlusive crises, and other serious clinical symptoms like stroke and acute chest syndrome [1][2].

The symptoms of thalassemia, on the other hand, range from minor anemia to severe growth delays and organ damage. The condition is defined by decreased or nonexistent globin chain formation, which results in inefficient erythropoiesis and hemolysis [1][3]. In places like South Asia, the Mediterranean, and sub-Saharan Africa, both conditions are very common [1]. Blood transfusions, hydroxyurea, and pain management are traditional treatments for sickle cell disease (SCD); however, new developments in gene therapy present encouraging alternatives. By substituting a healthy gene for the damaged one, gene therapy seeks to improve patients' quality of life and maybe lessen the need for blood transfusions [4][5].

This strategy, which makes use of methods like gene editing and hematopoietic stem cell transplantation, is a major breakthrough in the treatment of sickle cell disease (SCD) and may provide a cure for those who are afflicted [5]. With 2–3% of the population suffering from sickle cell disease (SCD) and a prevalence of sickle cell trait (HbAS) of about 24%, Nigeria faces a serious public health concern. Although hemoglobin variations make compatibility and safety in transfusions more difficult, the Lagos State Blood Transfusion Service (LSBTS) is essential for guaranteeing safe blood transfusions [6][7].

Regular hemoglobin variation screening, such that done with the HemoTypeSC device, has demonstrated great sensitivity and specificity, which makes it a good choice for screening newborns in large quantities [8][9]. Only 22% of tertiary institutions have complete SCD facilities, indicating that efficient screening and care techniques are still underutilized despite the high incidence of SCD [6]. In this situation with limited resources, it is imperative to implement systematic screening techniques to optimize patient outcomes and transfusion safety [10][9]. The distribution of hemoglobin phenotypic variations among LSBTS voluntary blood donors is examined in this study. It seeks to offer useful information to support genetic counseling programs, enhance transfusion procedures, and guide public health policies.

2. Materials and Method

2.1 Study Design and Setting

A descriptive cross-sectional study was carried out at the LSBTS facility in Gbagada, Lagos, Nigeria. Assuring a sufficient and secure supply of blood for medical facilities throughout Lagos State is the responsibility of the LSBTS, a government organization.

2.2 Study Design

The study assessed the prevalence and distribution of haemoglobin phenotype variants among voluntary donors aged 18–65 years who met the inclusion criteria. Data collection was carried out during June 2024, with participants selected from 20 blood donation camps.

2.3 Sample Size Determination

The sample size was determined using Fisher's formula, based on a 2023 haemoglobin variant prevalence of 13.8% in Lagos State. With an adjustment for a 10% non-response rate, a total of 200 donors were recruited to ensure sufficient statistical power.

$$n = \frac{Z^2(Pq)}{e^2}$$

where n = minimum sample size

Z = Z-score (1.96 for a 95% confidence level),

P = Prevalence of haemoglobin phenotype variants in Nigeria

e = error margin tolerated at 5% = 0.05

q = 1 - p

Based on Lagos state blood transfusion service data, the 2023 prevalence was 13.8% (LSBTS, 2023)

P = 13.8% = 0.138

q = 1 – p

= 1 – 0.138

= 0.862

$$n = \frac{(1.96)^2(0.138 \times 0.862)}{(0.05)^2}$$

$$n = \frac{3.8416 \, x \, 0.118956}{0.0025}$$

$$n = \frac{0.45698}{0.0025} = 182.79$$

The minimum sample size was 183 and was adjusted to 200 to account for non-response rate of 10 %.

2.4 Study Subjects

2.4.1 Inclusion Criteria

- Voluntary donors aged 18–65 years.
- Haemoglobin level ≥12.5 g/dL.
- Weight >50 kg.
- Donors who provided written informed consent.

2.4.2 Exclusion Criteria

- Donors with haemoglobin levels <12.5 g/dL or weight <50 kg.
- History of infectious diseases such as HIV, HBV, or HCV.
- Known haemoglobinopathies or at-risk behaviors.
- Refusal to provide consent.

2.5 Materials and Equipment

Blood samples were collected in EDTA tubes and analyzed using cellulose acetate electrophoresis to determine haemoglobin phenotypes.

2.6 Ethical Consideration

Ethical approval was obtained from the Lagos State Health Research and Ethics Committee. Written informed consent was secured from all participants, and data confidentiality was maintained throughout the study.

2.7 Clinical Laboratory Investigation

2.7.1 Sample Collection and Analysis

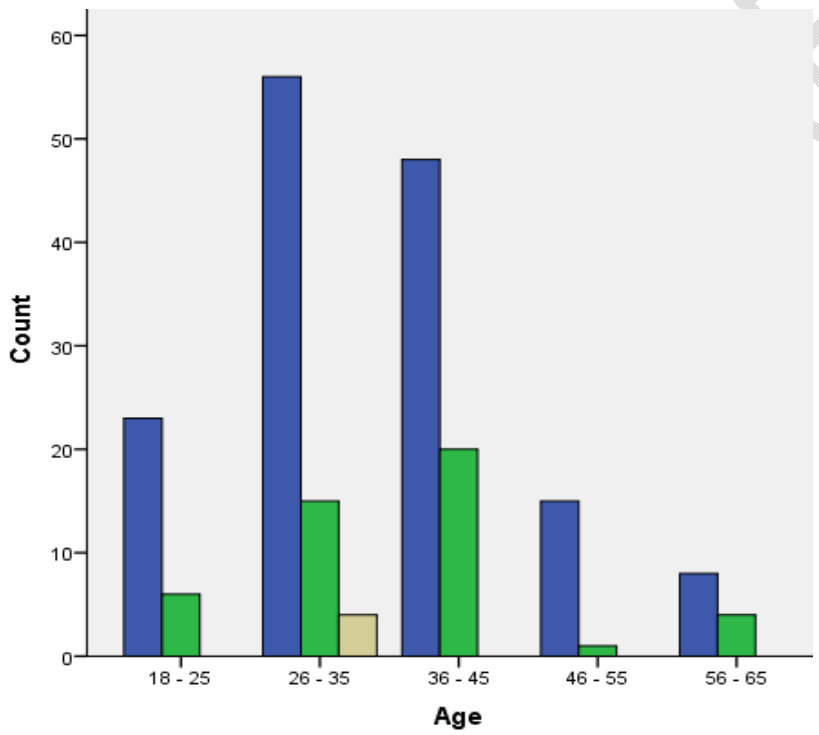
Approximately 2 mL of blood was collected from each donor using aseptic techniques. Haemoglobin electrophoresis was performed at pH 8.6 to identify phenotypes based on band patterns.

2.8 Statistical Analysis

Data were analyzed using SPSS version 25. Descriptive statistics summarized demographic and clinical characteristics, while chi-square tests evaluated associations between variables. A p-value <0.05 was considered statistically significant.

3.0 Results

Fig 1 :Relationship between Age and Haemoglobin Variants



Sociodemographic Information of Participants

The majority of participants were aged between 26–45 years, with 37.5% in the 26–35 range and 34% in the 36–45 range. Males represented 71.5% of the sample, indicating a male-dominant participation. Private sector workers were the largest occupational group (56.5%), followed by students (13.5%) and medical scientists (10%). Ethnically, 55.5% identified as Yoruba, followed by 21% Igbo, with the remaining participants from various other groups. Most were from the South West region (53%), with South East (20%) and South South (10.5%) also

represented. Marital status was nearly evenly split between married (50%) and single (49.5%) participants.

3.2 Relationship between Number of Previous Blood Donation and Haemoglobin Variants

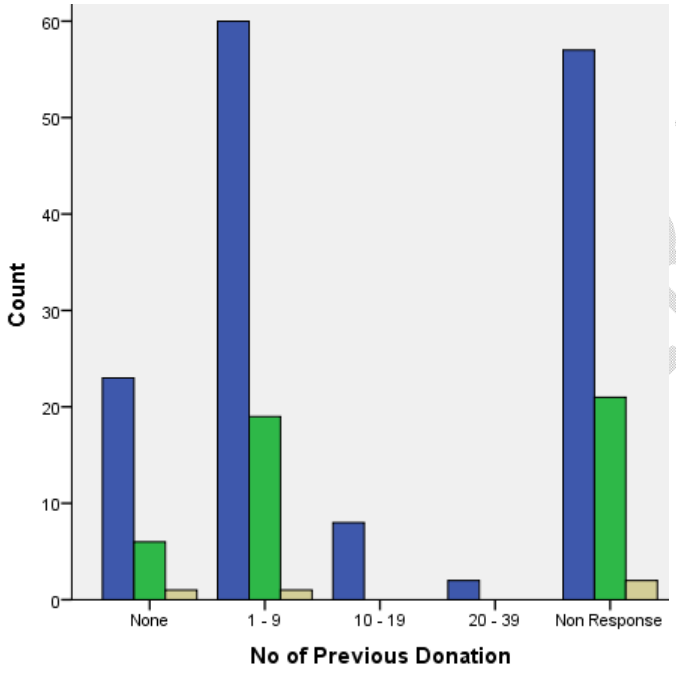


Figure 2. Number of Previous Blood Donation and Haemoglobin Variants

Blood Donation Patterns

About 55% of participants had donated blood before, with 40% having donated 1–9 times. The most recent donations were primarily in 2023 (21.5%), indicating a recent increase. Nearly all participants (78.5%) had no history of donor deferral, though those deferred mentioned reasons like low blood count or underweight. All participants were voluntary donors, with most learning about donation from non-specified sources (37%) and the LSBTC advocacy team (27%). Preferred reminders for future donations were email (36%) and SMS (34.5%).

3.3 Physical and Haemoglobin Characteristics

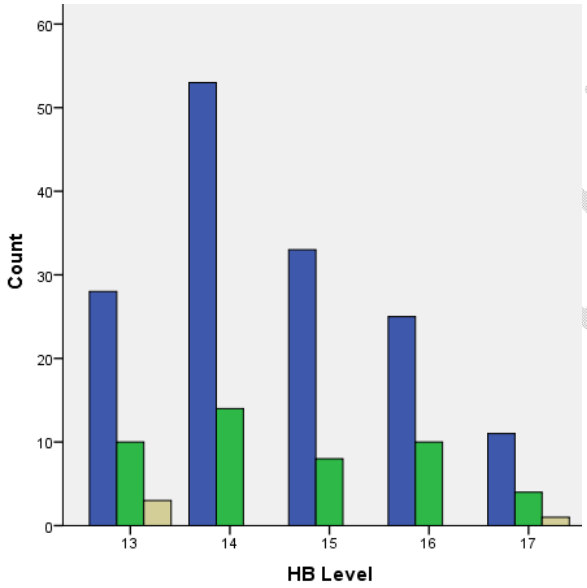


Figure 3. HB levelsamong the participants

The majority had haemoglobin levels between 13–17 g/dL, with the most frequent level at 14 g/dL (33.5%). The pulse rate and weight distributions were wide, centering around 70 bpm and common weights of 65 kg and 85 kg. Haemoglobin variants showed that 75% of donors were AA, 23% were AS, and 2% were AC.

3.4 Relationship between Haemoglobin Level and Haemoglobin Variants

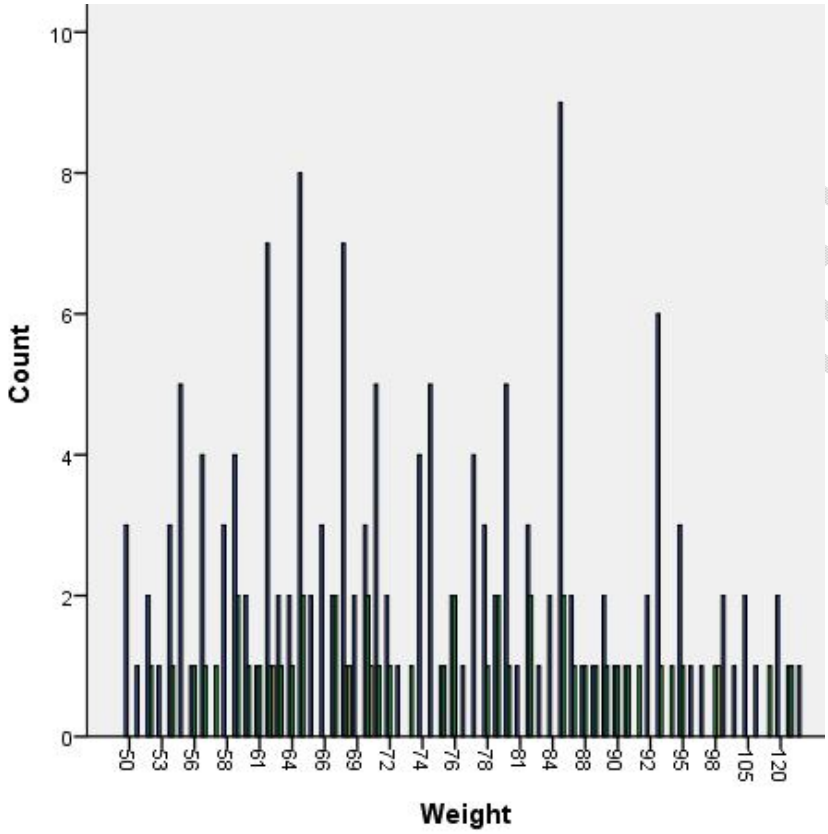


Figure 4.Haemoglobin Level and Haemoglobin Variants

Relationship between Weight and Haemoglobin Variants

Associations with Haemoglobin Variants

Chi-square tests indicated no significant associations between haemoglobin variants and factors such as weight (χ^2=91.871, p=0.986), pulse rate (χ^2=51.375, p=0.778), or haemoglobin levels (χ^2=11.685, p=0.166). Further analyses of demographic and background factors, including age, sex, occupation, ethnicity, and marital status, also revealed no significant associations with haemoglobin variants, with all p-values exceeding 0.05.

4.0 Discussion

According to this study, the majority of voluntary blood donors at LSBTS had hemoglobin phenotype AA, which is in line with results from other African populations. The majority of donors are probably safe for transfusion given the high incidence of HbAA (75%). To reduce the risks of asymptomatic malaria parasitemia (AMP) and transfusion-transmitted malaria (TTM), strict pre-donation screening is essential, as evidenced by the presence of HbAS (23%) and HbAC (2%), respectively [11][12]. Research has indicated that the sickle cell trait (HbAS) provides some protection against malaria, however HbAA is associated with an increased risk of AMP. In areas where malaria is widespread, this dual dynamic suggests that donors with HbAA may unintentionally provide a higher risk for TTM, underscoring the significance of thorough screening procedures to protect donor safety and recipient health [12].

The idea of a generally safe blood supply for transfusions is supported by the high prevalence of hemoglobin phenotype AA, which is prevalent among voluntary blood donors at LSBTS. This conclusion is consistent with studies from other African communities. Prior research [13][12] has also shown that HbAA is prevalent in African donor communities. However, proactive steps are required to detect and manage potential concerns associated with HbAS and HbAC due to their documented prevalence. Although HbAS protects against severe malaria, it may make donor selection more difficult in areas where the disease is endemic [12].

According to the demographic analysis, the majority of donors were men (71.5%), which is in line with worldwide patterns where men make up the majority of organ and plasma donors [14][15]. This is consistent with research indicating that men participate in blood donation at higher rates and make up around 63.3% of dead organ donors. This trend is influenced by a number of factors, including eligibility requirements, health awareness, and decreased deferral rates. The effectiveness of effective health programs aimed at this group is reflected in the age distribution of contributors, which is primarily between 26 and 45 years old [16]. The necessity of deliberate health promotion programs to maintain contribution rates is highlighted by the fact that younger persons are frequently more health-conscious and inclined to give [17][18].

According to an analysis of ethnic distribution, the majority of donors were Yoruba, which is consistent with the demographic makeup of Lagos. This result is in line with the population and cultural dynamics of the area, where Yoruba people make up the majority ethnic group. Haemoglobin variations did not significantly correlate with demographic characteristics like age, sex, occupation, or ethnicity, despite this ethnic predominance. Instead of focusing on outside demographic factors, our findings highlight the genetic foundations of hemoglobinopathies.

The consistent distribution of hemoglobin variations across various demographic groups has also been observed in similar investigations, such as those conducted by Kani et al. (2021) and Ezeonu et al. (2019), supporting the genetic foundation of these disorders.

These results highlight how crucial it is to incorporate genetic counseling into public health initiatives, especially in areas where hemoglobinopathies are more prevalent. Genetic counseling can reduce the dangers associated with hemoglobinopathies, raise awareness, and guide potential donors. In order to maximize blood donation practices and guarantee transfusion safety, public health interventions should also concentrate on strong screening procedures, health education initiatives, and focused recruitment tactics.

5.0 Conclusion

This study demonstrates that among voluntary blood donors in Lagos, hemoglobin AA (75%) predominates, with notable percentages of HbAS (23%) and HbAC (2%). The prevalence of HbAS and HbAC emphasizes the significance of thorough pre-donation screening to reduce transfusion risks, even though HbAA guarantees a typically safe blood supply. Because HbAS contributes to both transfusion problems and malaria resistance, it presents particular difficulties in regions where malaria is endemic.

These results highlight how genetic counseling can be incorporated into public health campaigns to inform donors about hemoglobin variations and their consequences. To improve screening accuracy, sophisticated diagnostic technologies like molecular methods should be used. Additionally, although health education initiatives raise awareness and encourage involvement, focused recruitment tactics might broaden the pool of potential donors. The burden of hemoglobinopathy in Lagos can be reduced by combining strict screening, genetic counseling, and contemporary diagnostics to improve transfusion safety and public health results.

6.0 Recommendations

Targeted donor recruitment techniques should involve underrepresented populations through public awareness campaigns and community engagement in order to improve transfusion safety and treat hemoglobinopathies. To guarantee compatibility and lower the danger of transfusion, routine screening for hemoglobin variants must be applied globally. Donor education initiatives should promote informed involvement by highlighting the importance of hemoglobin screening. Legislators ought to back programs that encourage genetic counseling and more extensive public health measures. In order to track trends in hemoglobin variants throughout Nigeria and provide information for improving methods and results, more research—including longitudinal studies—is also necessary. Together, these initiatives can guarantee a blood supply system that is safer and more inclusive.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that 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.

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