World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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Characterization of Haemoglobin Variants among Patients at Bremang SDA Hospital: A One-Year Retrospective Study

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World Journal of Advanced Research and Reviews, 2026, 29(02), 1088-1097

Publication history: Received on 10 January 2026; revised on 17 February 2026; accepted on 19 February 2026

Article DOI: https://doi.org/10.30574/wjarr.2026.29.2.0384

Abstract

Background: Haemoglobin variants are a significant public health issue in sub-Saharan Africa due to their link with sickle cell disease (SCD) and related haemoglobinopathies. However, data from primary healthcare facilities remain scarce. This study explored the prevalence and distribution of haemoglobin variants among patients at Bremang Seventh Day Adventist Hospital in Suame Municipality, Ashanti Region, Ghana.

Methods: A retrospective cross-sectional study was conducted among 105 patients screened for sickle cell disease and haemoglobin variants. Blood samples were analyzed using the Gazelle Haemoglobin Variant Reader, which applies miniaturized electrophoresis technology. Data were processed with SPSS v20.1, employing descriptive statistics and chi-square tests to explore associations with demographic factors.

Results: Of 105 participants, 54.3% tested positive for sickling. Haemoglobin AS was most common (41.9%), followed by Haemoglobin AA (29.5%), Haemoglobin AC (8.6%), Haemoglobin SF (8.6%), Haemoglobin AF (5.7%), and Haemoglobin SC (4.8%). Females showed significantly higher sickling positivity (66.7%) than males (37.8%) ($p = 0.003$).

Conclusion: The findings reveal a high prevalence of sickle cell trait (Haemoglobin AS), notable sex differences, and persistence of fetal haemoglobin in younger patients. Routine screening, genetic counselling, and targeted education at primary healthcare facilities are essential to reduce the burden of haemoglobinopathies in Ghana

Keywords: Haemoglobin; Variants; Haemoglobinopathies; Sickle Cell; Suame

1. Introduction

Haemoglobin (Hb) is a vital protein in red blood cells responsible for oxygen transport [1,2]. More than a thousand human haemoglobin variations with single amino acid changes have been found, each with various degrees of physiological consequences [3,4]. Variations in haemoglobin structure, known as haemoglobin variants, occur due to genetic mutations in the globin genes. These variants include common forms such as Haemoglobin S (HbS), Haemoglobin C (HbC), Haemoglobin E (HbE), and Haemoglobin F (HbF) persistence, among others [4,5]. Some are

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clinically silent, while others are associated with significant morbidity, including sickle cell disease, thalassaemias, and other haemoglobinopathies [6].

The most prevalent pathogenic haemoglobin mutation worldwide, caused by a substitutional alteration, is HbS [7]. While HbD and HbE are found in Indian and Southeast Asian populations, respectively, HbS is the most common pathogenic haemoglobin type in Africa. It occurs when the amino acid glutamic acid is substituted with valine at position 6 of the β-globin chain of haemoglobin A, causing a single-point mutation, the sickle haemoglobin mutation, a structural variation of normal adult haemoglobin A [8]. Individuals who are carriers or heterozygotes (AS) receive the HbA allele from one parent and the HbS allele from the other [9]. Typically, homozygote (SS) people who receive both parents' HbS alleles have the disease genotype and sickle cell anaemia, which frequently results in both acute and long-term problems. The most severe types of Sickle Cell Disease (SCD) are found in people with HbSS and HbSβ° [10,11]

In sub-Saharan Africa, haemoglobinopathies remain a major public health concern, particularly sickle cell disease [12], which contributes significantly to childhood morbidity and mortality [13]. The prevalence and spectrum of haemoglobin variants among patients attending primary health facilities remain poorly characterized. A lack of such data hampers efforts to design preventive strategies, improve diagnostic services, and strengthen genetic counselling programs at the community level. Despite their burden, there is limited routine screening and documentation of haemoglobin variants at the primary healthcare level, where most patients first seek medical attention. Understanding the distribution and frequency of haemoglobin variants among patients at primary health facilities will aid in early screening, targeted health education, and policy formulation for genetic counselling and disease prevention. This study, therefore, aimed to characterize the Haemoglobin variants of patients who attended the Bremang Seventh Day Adventist (SDA) Hospital from January 2025 to December 2025.

2. Materials and Methods

2.1. Study Design and Setting

A retrospective, cross-sectional study was employed in this study. The study was conducted at the Laboratory Department of Bremang SDA Hospital in the Suame Municipality of Ashanti Region. The facility, which serves as the Municipal hospital, is situated in the Suame Municipality and is the only Quasi-government facility within the Municipality, hence a referral site for most facilities around the catchment area. Almost in the middle of the Ashanti Region, between Latitude 6.35°N and 6.40°S and Longitude 1.30°W and 1.35°E, is the Suame Municipal, founded in 2017. The municipality's northern, eastern, and southern borders are shared with the Afigya Kwabre South District, Old Tafo Municipality, and Kumasi Metropolis.

The Municipality has an estimated population of 250,365 people. The municipality is cosmopolitan, with almost all ethnic groups represented. The municipality is home to West Africa's largest enclave of artisanal engineers, which is popularly known as the “Suame Magazine’. It provides a significant source of income for the majority of individuals in the municipality and elsewhere.

https://www.linkees.com/placelist/gh/ashanti-region/suame-municipal-district/1

Figure 1 Map showing the Suame Municipality

2.2. Study Population and Sample Size

All patients, children and adults, male and female, who attended the facility from January 2025 to December 2025 and were requested to screen for sickling and the haemoglobin variants test were included in the study. A total of 105 individual patients were recruited for the study during the year under review.

2.3. Sample Analysis

The blood samples were analyzed using the Gazelle Hb Variant Reader (Hemex Dx Pvt Ltd, India). The technique uses a miniaturized electrophoresis technology to detect haemoglobin variants. It identifies and quantifies Hb A (normal), Hb S (sickle), Hb F (fetal), and Hb A2/C/E. The reader uses this information to provide interpretations for potential illnesses such as sickle cell disease and trait, as well as specific thalassaemias. A cartridge is put into the reader for analysis after a small quantity of whole blood and marker fluid (which acts as a control) is lysed and applied to it. The reader displays the results, including haemoglobin types and percentages, on the screen in around eight minutes. Gazelle uses a piece of cellulose acetate paper contained in a cartridge to separate the different forms of haemoglobin in a small amount of blood. The foundation of Gazelle's technology is haemoglobin electrophoresis, in which various haemoglobin types A, S, C, A2, E, and F have varying net negative charges in an alkaline solution and, as a result of an applied voltage, travel across the paper at varying speeds. On the paper, the various haemoglobin types are split into discernible bands for reading.

2.4. Data Analysis

The data, in the form of Microsoft Excel files, were entered into and analyzed using the Statistical Package for the Social Sciences (SPSS) version 20.1. Data were presented as descriptive statistics (frequencies, percentages) for prevalence and types of haemoglobin variants. Chi-square test or logistic regression was used to determine associations between haemoglobin variants and demographic factors.

3. Results

3.1. Demographic Characteristics of Respondents

Table 1 shows the demographic distribution of the study participants. The majority of respondents (56.2%) were within the age group of 18–35 years, followed by 24.8% aged 1–12 years. With respect to gender, females formed a higher proportion of the respondents (57.1%) compared to males (42.9%). Regarding marital status, most participants were single (82.9%), while 16.2% were married and only 1.0% widowed.

Table 1 Demographic Characteristics of Respondents

Demographics	Total(N=105)	Frequency (%)
Age Group		
1 to 11 months	5	4.8
1 to12	26	24.8
13 to 17	5	4.8
18 to 35	59	56.2
36 to 59	9	8.6
>59	1	1
Gender		
Female	60	57.1
Male	45	42.9
Marital Status		
Married	17	16.2
Single	87	82.9
Widowed	1	1

3.2. Sickling Status of Study Participants

Out of the 105 participants screened, 57 (54.29%) tested positive for sickling, while 48 (45.71%) tested negative. This indicates that the majority of respondents carried the sickle cell trait.

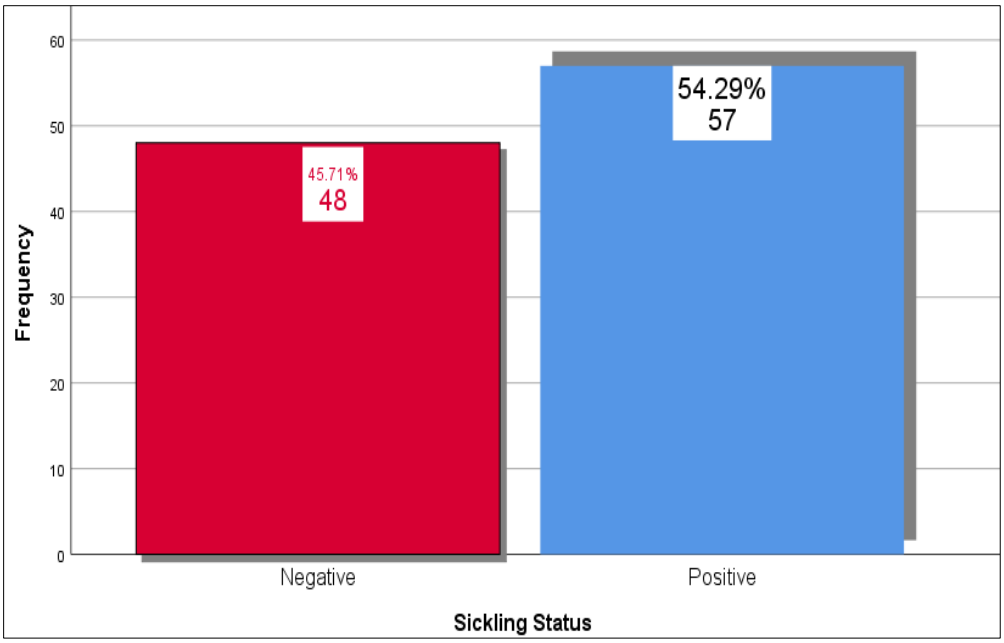

Figure 2 Figure showing the Sickling Status of Study Participants

3.3. Distribution of Hemoglobin Variants among Respondents

The distribution of hemoglobin variants among the study participants is shown in Table 2. The most common variant identified was HbAS, accounting for 41.9% of the respondents, followed by Hb AA with 29.5%. Other variants detected included HbAC (8.6%), HbSF (8.6%), HbAF (5.7%), and HbSC (4.8%).

Table 2 Distribution of Hemoglobin Variants among Respondents

Hb Variants	Total(N=105)	Frequency (%)
HbAA	31	29.5
HbAC	9	8.6
HbAE	6	5.7
HbAS	44	41.9
HbCC	1	1
HbSF	9	8.6
HbSC	5	4.8
HbSS	0	0

3.4. Distribution of Hemoglobin (Hb) Variants by Sex

Among males, the most common variant was HbAA (40.0%), followed by HbAS (22.2%) and HbSF (15.6%). In females, the predominant variant was HbAS (56.7%), followed by HbAA (21.7%) and HbAC (8.3%). Rare variants such as HbCC were found only in males (100%), while HbSS was absent in both sexes.

Table 3 Distribution of Hemoglobin (Hb) Variants by Sex

	Frequency (%)	
Hb Variants	**Male(N=45)**	**Female(N=60)**
HbAA	18(40.0)	13(21.7)
HbAC	4(8.9)	5(8.3)
HbAF	4(8.9)	2(3.3)
HbAS	10(22.2)	34(56.7)
HbCC	1(2.2)	0(0)
HbSF	7(15.6)	2(3.3)
HbSC	1(2.2)	4(6.7)
HbSS	0(0)	0(0.0)

3.5. Distribution of Hemoglobin (Hb) Variants by Age Group.

The distribution of hemoglobin variants across different age groups is shown in *Table 4*. In infants aged 1–11 months, HbAS (40%) was the most common variant; among children aged 1–12 years, HbAS (30.8%) was most prevalent. For adolescents aged 13–17 years, HbAS was the only variant observed (60%). In the 18–35-year age group, HbAS was the most frequent variant (42.4%).

Table 4 Distribution of Hemoglobin (Hb) Variants by Age Group

Genotype	**Frequency (%)**	**Phenotype**
HbAA	17(16.2)	Normal
HbAC	23(21.9)	Carrier of HbC
HbAF	6(5.7)	Normal with Fetal Hb
HbAS	44(41.9)	Sickle Cell Trait
HbCC	1(1)	HbC Disease
HbSC	5(4.8)	Sickle-HbC Disease
HbSF	9(8.6)	Fetal Hb
Total	105(100)	Total

3.6. Distribution of Genotypes and Corresponding Phenotypes among Study Participants.

Table 5 shows the distribution of genotypes and corresponding phenotypes among the study participants. It revealed that the most frequent genotype was HbAS (41.9%), corresponding to the sickle cell trait phenotype, followed by HbAC (21.9%), indicating carriers of HbC, and HbAA (16.2%), which represents a normal phenotype.

Table 5 Distribution of Genotypes and Corresponding Phenotypes among Study Participants

Age Group	HbAA	HbAC	HbAF	HbAS	HbCC	HbSF	HbSC	HbSS
1 to 11 months	1(20)	0(0)	1(20)	2(40)	0(0)	1(20)	0(0)	0(0)
1 to12	6(23.1)	0(0)	2(7.7)	8(30.8)	1(3.8)	7(26.9)	2(7.7)	0(0)
13 to 17	0(0)	2(40.0)	0(0)	3(60)	0(0)	0(0)	0(0)	0(0)
18 to 35	22(37.3)	7(11.9)	2(3.4)	25(42.4)	0(0)	0(0)	3(5.1)	0(0)
36 to 59	1(11.1)	0(0)	1(11.1)	6(66.7)	0(0)	1(11.1)	0(0)	0(0)
>59	1(100)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)

3.7. Association between Gender and Sickling Status

The relationship between gender and sickling status is shown in *Table 8*. Among males, 28 (62.0%) tested negative, while 17 (37.8%) tested positive for sickling. In contrast, among females, 20 (33.3%) were negative, whereas 40 (66.7%) were positive. The difference in sickling status between males and females was statistically significant (p = 0.003), indicating that females had a higher prevalence of sickling positivity compared to males.

Table 6 Association between Gender and Sickling Status

	Sickling Status		P-Value
Gender	**Negative**	**Positive**	
Male	28(62.0)	17(37.8)	**0.003**
Female	20(33.3)	40(66.7)	
Age Group			0.275
1month to 11 months	2(40)	3(60)	
1 to12	9(34.6)	17(65.4)	
13 to 17	2(40)	3(60)	
18 to 35	32(54.2)	27(45.8)	
36 to 59	2(22.2)	7(77.8)	
>59	1(100)	0(0.0)	
Marital status			0.198
Married	5(29.4)	12(70.6)	
Single	42(48.3)	45(51.7)	
Widowed	1(100)	0(0.0)	

4. Discussion

The demographic distribution of the study population reflects a predominantly youthful group, with over half of the participants falling within the 18–35-year age group. This age group typically represents the most economically and socially active population and is often the focus of health interventions, given its role in sustaining households and communities. Similar findings have been reported in studies conducted in Ghana, where the majority of respondents in community-based or facility-based health research were young adults [14,15]. Conversely, respondents above 59 years were few, reflecting the relatively low life expectancy in Ghana (currently estimated at 64 years for males and 67 years for females) [16]. With respect to gender, females were more represented than males. This is consistent with earlier studies in Ghana that observed higher female participation [17,18]. Women are more likely to utilize healthcare services, making them more available for inclusion in facility-based studies [19].

The absence of a significant relationship between sickling and age groups is consistent with the genetic nature of the sickle hemoglobin: the presence or absence of the sickling gene is determined at conception and does not change with age. Similar findings have been reported in Brazil, where age distributions of HbS carriers largely reflected sampling patterns rather than biological differences [20].

The lower prevalence of positive sickling status in the >59-year group may reflect survival bias. Individuals with severe sickle cell disease often experience higher morbidity and mortality, which can lead to under-representation of homozygous or compound heterozygous states in older populations. However, a statistically significant association was observed between gender and sickling status ($p = 0.003$). Females demonstrated a markedly higher prevalence of sickling positivity compared with males, which suggests that women were more likely to carry the sickling gene or an abnormal hemoglobin variant. Because inheritance of hemoglobin S is autosomal, true biological differences in gene frequency between males and females are unlikely. On the contrary, the findings of this current study contradict prior studies, which generally reported no significant sex-based variation in sickle trait prevalence when large community samples are examined [21,22]. The higher proportion among females in the current work may therefore reflect sampling characteristics. A large proportion of participants were women, possibly due to routine antenatal or premarital screening.

The relatively high prevalence of HbAS aligns with the well-documented burden of the sickle cell trait in Ghana, where carrier frequencies range from 20% to 40% depending on the region [21]. The findings demonstrate that a significant proportion of the population is carriers and therefore have the potential to transfer sickle cell genes to offspring, which has important implications for public health and genetic counseling. The presence of HbAC and HbSC among participants is also notable. HbAC is relatively common in West Africa and is usually asymptomatic, but it can contribute to hemoglobinopathies when inherited alongside other abnormal variants [23]. HbSC disease, although less severe than HbSS, is associated with clinical complications such as anaemia and vaso-occlusive crises, especially under stressful physiological conditions [21]. The frequency observed in this study is consistent with earlier reports in Ghana, which have shown HbC trait prevalence ranging between 6% and 15%. Interestingly, HbSF and HbAF were also identified, indicating the persistence of fetal hemoglobin in some individuals. The persistence of HbF into adolescence or adulthood has been reported in a minority of individuals and may provide protective effects against the severity of sickling disorders by inhibiting hemoglobin S polymerization [24]. This finding could be of clinical interest, particularly in populations at risk of sickle cell disease.

5. Conclusion

This study revealed a high prevalence of abnormal hemoglobin variants among the study population, with HbAS emerging as the most common genotype, followed by HbAA, HbAC, HbSF, and other less frequent variants. More than half of the sampled population tested positive for sickling, indicating that carriage of the sickle cell gene remains widespread in this community. It is recommended that counselling should emphasize informed reproductive choices, partner matching, and the genetic risks associated with Haemoglobin variants. The identification of HbAF and HbSF in infants and children underscores the importance of early-life testing.

Compliance with ethical standards

Acknowledgments

The authors would like to express our profound appreciation to the entire staff of the Laboratory Department of Bremang SDA Hospital and the Management members of the hospital.

Disclosure of conflict of interest

The authors declare no conflict of interest

Statement of ethical approval

Ethical clearance was sought from the Ghana Adventist Health Services Ethical Review Committee (GAHS/ERC/023/25). Approval was sought from the authorities of Bremang SDA Hospital. Anonymity and confidentiality of patients' information were strictly ensured.

Statement of informed consent

The researchers obtained informed consent from all individual participants who were included in the study.

Authors Contribution

All the authors listed made a substantial, direct, and intellectual contribution to this research and have given their approval for publication. All authors made contributions to this article and approved the submitted version.

Funding

We state categorically that this research received no external source of funding from any organization.

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