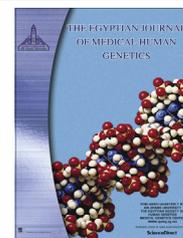




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ORIGINAL ARTICLE

A retrospective study on fourteen year hemoglobin genotype variants recorded at five government hospitals in Akure, Ondo State, Southwestern Nigeria



Akeem Akinboro *, Ebenezer Kayode Komolafe, Musibau Adewuyi Azeez

Department of Pure and Applied Biology, Ladoko Akintola University of Technology, Ogbomosho, Nigeria

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KEYWORDS

Hemoglobin;
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Abstract *Background:* Hospital data are a useful source of information about health status of people in a geographical location.

Aim of the study: An attempt was made to extend demographic data about hemoglobin variants and their prevalence in Southwestern Nigeria to Akure the capital city of Ondo state.

Subjects and methods: This study analyzed fourteen year (2000–2013) hemoglobin (Hb) genotypes records from five state government hospitals in Akure, Ondo State, Southwestern, Nigeria. In the fourteen year record, a total of 56,218 hemoglobin genotypes were subjected to analyses in terms of a variety of hemoglobin genotypes and their prevalence in the area. The gene frequency was also calculated for this trait among the residents in Akure metropolis.

Results and conclusion: Six hemoglobin genotypes were identified as HbAA, HbAS, HbAC, HbSS, HbSC and HbCC. The overall average values of their prevalence in decreasing order were HbAA (88.11%) > HbAS (10.23%) > HbAC (0.78%) > HbSS (0.72%), HbSC (0.15%) and HbCC (0.01%). There was a steady increase in the number of people who visited the hospitals for hemoglobin genotype determination throughout the years covered in this investigation, as the proportion of abnormal hemoglobin genotypes to the normal HbAA tremendously increased in the last four years (2010–2013). This suggests the possibility of many other residents in the capital city of Ondo state carrying the abnormal forms of hemoglobin genotype, and calling for more efforts in the area of genetic counseling. The gene frequencies of A, S, and C were 0.91, 0.08 and 0.01, respectively. The prevalence of HbAA in this study has been the highest reported in the Southwest and Nigeria as a whole.

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Abbreviations: Hb, hemoglobin; β , beta

* Corresponding author. Tel.: +234 8134727845.

E-mail address: aakinboro@lautech.edu.ng (A. Akinboro).

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1. Introduction

Abnormal hemoglobin (Hb) genotype otherwise known as hemoglobinopathies is the most common human genetic problem affecting 7% of the world's population. The World Health Organization is concerned about the alarming rate at which it spreads in more than 70% of the countries of the world [1]. The most affected populations are from low and middle income countries especially Asian and African countries where 250,000–300,000 children are born with variant hemoglobin genotypes, either in heterozygous with the normal HbA or in homozygous form each year. However many cases have also been found in the United States of America, the Caribbean, and Northern Europe [2]. Although, the normal hemoglobin HbAA genotype is the most frequently recorded of these genotypes [3,4], nevertheless, variants of HbAA are of importance because of their various associated pathological problems. The number of Hb variants has been increasing since the discovery of HbS in 1949 [5], over 600 variants of HbA are known today. HbS is most commonly studied of all the hemoglobin variants being the most pronounced with clinical complications. About 85 million people are carriers of different Hb variants in Sub-Saharan Africa, 90 million in South East Asia, and 48 million in the West Pacific region [6]. Two third of the variant Hb genotypes carries their mutations on β globin gene located on chromosome 11, consequently producing a change of amino acid in the polypeptide chain [7,8]. Studies on Hb genotypes are usually undertaken in order to elucidate new variants of the normal HbA, and ultimately to prevent them from further spread among human population preferably in a homozygous form. A number of methods have been used for the detection of abnormal hemoglobin genotypes ranging from simple paper electrophoresis to a combination of Cation-Exchange High Performance Liquid Chromatography (CE-HPLC) with either capillary electrophoresis or isoelectric focusing [4]. In Nigeria, several reports are available on the distribution of ABO blood groups, rhesus factors and hemoglobin genotypes among different populations across the geopolitical zones in the country. Patterns of inheritance of ABO and rhesus factor, phenylthiocarbamide taste sensitivity and Hb alleles among the human population in Ogbomoso and Lagos, (Southwest) [3,9], in Uyo, Delta and Imo states (East) [10–12], in Sokoto and Kastina states (North) [6,13] in Nigeria have been reported. Over the years, there is no report on various forms of Hb genotypes and their distribution among the human population in Akure, the capital city of Ondo state in the Southwestern Nigeria. Therefore, this study was aimed at elucidating the various forms of hemoglobin genotypes among the residents in Akure, Ondo state, and the distribution of these genotypes among them, as well as their attitudes toward hemoglobin genotype determination over the years (2000–2013) covered in this study.

2. Subjects and methods

Retrospectively, records of the hemoglobin genotypes of patients who visited five government hospitals in Akure, the capital city of Ondo state, were collected for a period of fourteen years (2000–2013). The hospitals included the state specialist hospital Akure, Mother and Child hospital Akure, Comprehensive Health Centre Isolo Akure, Comprehensive

Health Center Arakale (Youth Center) Akure, and Comprehensive Health Center Oba Ile, Akure. A letter of introduction and statement of purpose was written and directed to the Chief Medical Director of each hospital seeking the permission of the management to collect the needed data. Thereafter, hemoglobin records for the past fourteen years were released to us for the purpose of this study. These hemoglobin data were generated from the results of blood tests carried out in the acceptable standard procedure for Medical laboratory's investigations. Ethically and professionally, the blood test was performed by the medical laboratory scientists in these hospitals on the patients who visited the hospitals between 2000 and 2013. Various forms of hemoglobin genotypes observed in the patients' blood samples were recorded annually.

The frequency of the alleles 'A', 'S' and 'C' was calculated using the Hardy–Weinberg equilibrium formula:

$$p + q + r = 1 \quad (1)$$

where p represents allele 'A', q represents allele 'S', and r represents allele 'C'.

Data were summarized into percentage of different genotypes, as well as normal HbAA and mutant allele(s) in the genotype; HbAS, HbAC, HbSS, HbSC, and HbCC.

3. Results

The fourteen year (2000–2013) records of hemoglobin genotypes show highest prevalence of HbAA, followed by HbAS and the least occurred among the genotypes was HbCC (Table 1). The prevalence of HbAA was above 70% of the total hemoglobin genotypes recorded in each year. The most frequent among the abnormal hemoglobin genotypes was HbAS recorded at the range of 2.10–22.78%. The HbSS genotype occurred at <1% in most years except in 2010, 2011 and 2012 when the prevalence values were 1.47%, 1.15% and 1.20%, respectively. HbSC was not recorded at all in 2000 and 2001, likewise HbCC in 2000, 2001, 2006, 2007, 2008 and 2009 of the years considered in this study. However, where they were observed, they occurred between 0.02% and 0.32%.

Table 1 Percentage of different hemoglobin genotypes recorded at five different hospitals in Akure Ondo State.

Year	HbAA (%)	HbAS (%)	HbAC (%)	HbSS (%)	HbSC (%)	HbCC (%)
2000	96.83	2.10	0.46	0.61	0.00	0.00
2001	96.46	2.34	0.53	0.67	0.00	0.00
2002	95.85	2.53	0.57	0.91	0.10	0.05
2003	96.09	2.63	0.45	0.77	0.05	0.00
2004	95.52	3.25	0.49	0.66	0.08	0.00
2005	96.77	2.60	0.19	0.33	0.08	0.03
2006	93.35	5.15	0.39	0.92	0.18	0.00
2007	88.88	10.12	0.70	0.29	0.02	0.00
2008	88.88	10.29	0.66	0.09	0.09	0.00
2009	85.25	13.49	0.58	0.41	0.27	0.00
2010	74.00	22.78	1.42	1.47	0.30	0.02
2011	74.70	22.10	1.72	1.15	0.32	0.02
2012	75.55	21.59	1.33	1.20	0.27	0.05
2013	75.35	22.26	1.41	0.67	0.27	0.03
Average	88.11	10.23	0.78	0.72	0.15	0.01

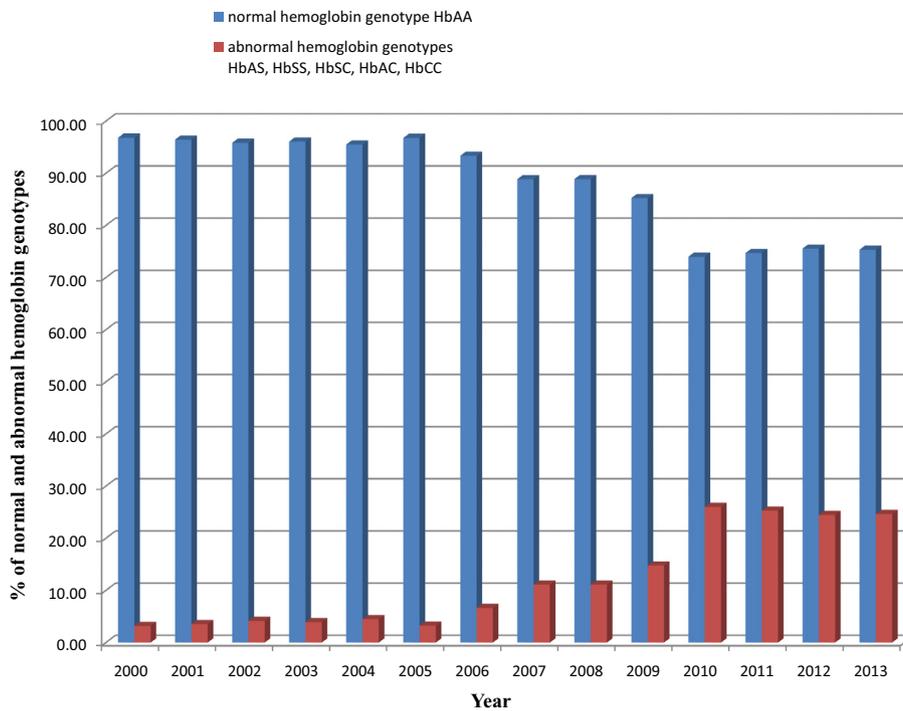


Figure 1 Percentage of normal hemoglobin genotype AA compared to other variant hemoglobin genotypes (AS, AC, SS, SC, CC) recorded at five government hospitals in Akure between 2000 and 2013. % Normal hemoglobin HbAA. % Abnormal hemoglobin Hb genotypes (HbAS, HbAC, HbSS, HbSC and HbCC).

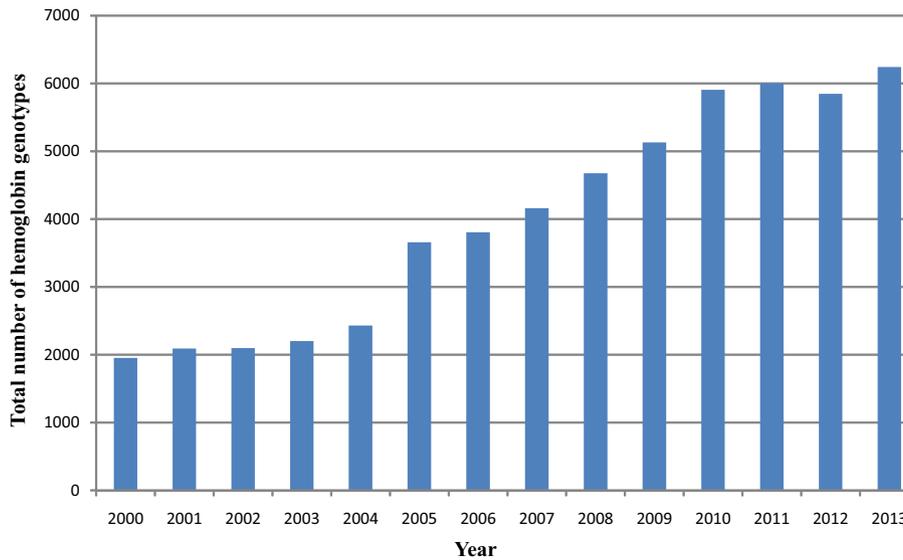


Figure 2 Annual hemoglobin genotypes recorded between 2000 and 2013 at five government hospitals in Akure Ondo State.

HbAC genotype had its highest percentage of occurrence in 2010, 2011, 2012, and 2013 at 1.42%, 1.72%, 1.33% and 1.42%, respectively.

Comparing the prevalence of the abnormal hemoglobin genotypes HbAS, HbAC, HbSC, HbSS, HbCC with the normal hemoglobin genotype HbAA, there was a progressive increase in the occurrence of the abnormal hemoglobin genotypes throughout the studied years, with their highest occurrence in 2010 (Fig. 1). The first seven years (2000–2006)

recorded < 10% of abnormal genotypes, 2007–2009 had > 10% while in 2010–2013 the occurrence of abnormal genotypes was > 20%. The average values of prevalence of the observed hemoglobin genotypes were 88.11%, 10.23%, 0.78%, 0.72%, 0.15% and 0.01% for HbAA, HbAS, HbAC, HbSS, HbSC and HbCC, respectively.

The allelic frequencies showing the proportion of the hemoglobin genes at equilibrium were calculated to be 0.91, 0.08 and 0.01 for f(A), f(S) and f(C), respectively.

There was a steady increase in the number of hemoglobin genotypes recorded throughout the fourteen years' data. The highest number of 6243 hemoglobin genotypes was recorded in 2013, and the least number was 1954 recorded in the year 2000 for the five government hospitals (Fig. 2).

4. Discussion

Hemoglobin genotype determines the oxygen carrying capacity of the erythrocytes. Normal hemoglobin (HbAA) has greater affinity for oxygen and delivers same to the cells for energy (ATP) production. Any other variants of the normal hemoglobin HbAA are usually deficient in their oxygen carrying capacity. There were 5 mutant hemoglobin variants observed in this study compared to three hemoglobin variants (HbAS, HbAC and HbSS) observed among Ika ethnic nationality of Delta State and student of Usmanu Danfodiyo University Sokoto [1,11]. Likewise, we had one hemoglobin variant (HbCC) more than the four hemoglobin variants observed among the students of Imo state university, as well as students of College of Health Science and Technology, Port Harcourt and some residents of Sokoto, Sokoto State, Nigeria [6,12,14].

The occurrence of hemoglobin genotype HbCC in this study could be due to the higher number of hemoglobin genotypes recorded in the fourteen years, in addition to probable heterogeneous nature of the residents of Akure metropolis. Akure is an urban town inhabited largely by the Yorubas with the representation of other ethnic groups as a result of migration. This might have led to interbreeding resulting in the admixture of genes [15]. The more the number of people of different ethnic background screened, the higher the tendency of getting new variants of hemoglobin genotype. However, its least percentage compared to other hemoglobin genotype variants justifies its rare occurrence among human population.

The range of prevalence of HbAA throughout the fourteen year records was between 74.0% and 96.83% which is perfectly in line with the previous findings which reported the range of 74–97% for Kenyans in the East Africa [16]. In overall, the prevalence of HbAA at 88.11% is higher than the previously reported data for some populations of Nigerians in the Southwest, Northwest, East and South–south [3,6,9,11,12]. The high proportion of residents of Akure metropolis carrying HbAA genotype calls for some levels of preventive measures against mosquito bite which might be common in this area because of its location in the tropical rain forest zone. This is necessary in order to prevent them from attack by plasmodium parasite (*Plasmodium falciparum*) that causes malaria since individuals having HbAA are more susceptible to malarial infection. The prevalence of HbAS and HbAC above other abnormal hemoglobin genotypes HbSS, HbSC and HbCC in this study could be justified by the presence of one normal allele coding for a normal polypeptide β globin chain which confers on the hemoglobin better affinity for oxygen, hence, individual carriers of these abnormal hemoglobin genotypes still live a normal live, unlike in the case of HbSS and HbCC. This is in accord with the report of prevalence of HbAS and HbAC [1], but at variance with higher prevalence of HbSS than HbAC previously reported [11].

Although, 2000–2006 records of hemoglobin genotypes showed higher prevalence of HbSS than HbAC, however, this was reversed as from 2007 to 2013 when the prevalence of

HbAC was higher than HbSS among the residents of Akure metropolis. There was a consistent increase in the number of people who presented themselves for hemoglobin genotype test between 2000 and 2013. This could have been due to the positive change in the attitudes of the residents of Akure metropolis to the campaign for hemoglobin genotype determination before marriage. This attitude is expected to help in either preventing further spread of the lethal abnormal hemoglobin genotypes or/and in taking prompt action toward the management of its associated crisis whenever it occurs.

In overall, the allelic frequencies of A, S, and C obtained in this study are lower, except for the allelic frequency of A, compared with the allelic frequencies of hemoglobin genotypes of some Ogbomoso residents [3]. The increase in the proportion of abnormal hemoglobin genotypes to the normal HbAA at 1:3 observed in 2010–2013 suggests that a substantial number of residents of Akure metropolis are likely to be carriers of abnormal hemoglobin genotypes. This portends danger for future generations in this area inheriting abnormal hemoglobin gene(s) especially in the homozygous form. Although, heterozygotes of HbAS are better resistant to malarial infection by plasmodium. Nevertheless, our findings have unequivocally shown that concerted efforts in the area of genetic counseling are urgently required in Akure city in order to prevent further increase in the prevalence of abnormal hemoglobin genotypes among human population in this area. It is our advice that government should enforce 'show your hemoglobin genotype status' by individuals requesting for governmental services at all levels, as one of the prerequisites for granting their requests.

5. Conclusion

The analysis of fourteen years' hemoglobin genotypes recorded at five government hospitals in Akure capital city of Ondo state revealed prevalence of HbAA (88.11%) > HbAS (10.23%) > HbAC (0.78%) > HbSS (0.72%) > HbSC (0.15) > HbCC (0.01). This study reported the manifestation of a rare HbCC genotype, but at a very low frequency among the residents of Akure. There was a steady increase in the awareness of the residents about the determination of their hemoglobin genotype which could have been driven by either willingness (through genetic counseling efforts) or based on medical advice for diagnosis. The proportion of mutant hemoglobin alleles to the normal one was on the increase in the last four years of our investigation, this calls for attention of government at all levels, and non governmental agencies to intensify efforts on the awareness campaign for hemoglobin genotype determination in the state and throughout the country.

Conflict of interest

Authors declared no conflict of interest in all forms.

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