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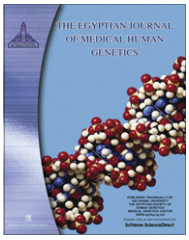

ORIGINAL ARTICLE

Gene frequencies of ABO and Rh(D) blood group alleles in Lagos, South-West Nigeria

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KEYWORDS

Blood groups;
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Abstract *Background:* It has been well documented that the ABO and Rhesus remain clinically the most significant blood group systems. There is limited information on the gene frequency of the ABO and Rhesus blood groups from Lagos, South-West Nigeria. Data from this study will be of immense use to the geneticists, biologists, blood transfusion services policy maker and clinicians.
Aim of this study: This study aims to provide descriptive information on the genetic composition and variation of population in Lagos State, Nigeria, with respect to blood group and Rhesus factor contributing to the existing knowledge.
Subjects and methods: This study investigated the gene frequencies for the ABO and Rh(D) alleles in a population consisting of different ages in Lagos, Nigeria, over a period spanning 12 years (1998–2009). The 23,832 and 23,764 individuals were typed for ABO and Rh blood groups, respectively. We analyzed the genotypic and allelic frequencies based on Hardy–Weinberg equations. Chi-square goodness-of-fit statistic was calculated to compare observed and expected frequencies and to investigate heterogeneity between years.

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Results: 5504 (23.1%), 5072 (21.3%), 647 (2.7%) and 12,609 (52.9%) were blood groups A, B, AB and O, respectively. Over the period of this study, we observed an overall trend of ABO blood group was O > B > A > AB in both males and females. We also observed that blood group O was the most encountered phenotype while group AB was the least phenotype encountered among the studied population in both genders. This distribution differs significantly ($p < 0.05$) from those expected under the Hardy–Weinberg law. With regard to the Rh blood group, individuals with Rh positive (DD and Dd) were 0.69 and 0.28. Rh negative (dd) was 0.03. This also showed that Rh(D) positive was the most phenotype observed in this study. This distribution do not differ significantly ($p > 0.05$) from those expected under the Hardy–Weinberg law.

Conclusion: Our results demonstrate that there exist genetic variability and polymorphism as regards ABO and Rh blood group among the population sampled. These findings would be useful to geneticists and clinicians when planning to address future health challenges relating blood transfusion and marriage counseling.

1. Introduction

The ABO and Rhesus (Rh) both remain the most important and famous blood group systems clinically. The ABO blood group system was first discovered in 1900 by Landsteiner [1,2]. The Rh system was later described by both Landsteiner and Weiner in 1940 by their joint work [2]. Both are equally important in clinical and forensic medicine. Since the discovery, attention of scientists have been greatly focused on these two blood group systems because of the fact that they are highly polymorphic and immunogenic especially in human. ABO gene is located on the long arm of the ninth human chromosome (9q34.1) [3] while the Rh(D) gene encoding the Rh protein is located on chromosome 1p34–p36 [4]. The Rh blood system is important because the Rh antibody causes severe hemolytic disease of the newborn (HDN) [5,6]. There are several reliable reports from different parts of the world that have lent credence to the fact that people vary genetically with respect to ABO and Rh blood group systems and increasing number of the variants of the ABO alleles is still emerging. DNA sequence of the normal A and B alleles have shed more light on our understanding of the ABO blood grouping [7]. Although the contribution of ABO blood group system to protection against malaria has not drawn much attention, it has been reported that blood group O may confer resistance to severe *falciparum* malaria through the mechanism of reduced resetting [8]. The gene cloning of Rh system in the early 1990s has tremendously advanced our understanding of the Rh alleles and further studies are still in progress as new alleles begin to be elucidated [9]. There has been an increasing incidence of association of ABO blood group with several types of genetic diseases including cancers [1]. For instance early independent studies showed association of rectal, cervical, leukemia, pancreatic, breast, ovarian, gastric cancers among individuals with blood groups A, AB, or B more likely to have elevated risk of pancreatic cancer than individual belonging to blood group O [10–12]. However, further work is still required to define the exact mechanisms by which ABO blood group or other type genetic variants may influence cancer risk in human.

There is limited information available on the gene frequencies of the ABO and Rhesus blood among the residents of Lagos, South-West Nigeria. This scarcity of knowledge is at variant with the cosmopolitan and mega city status of Lagos population as it continues to grow on a daily basis. Our aim, therefore, is to provide information on the distribution pattern of the phenotypes and genotypes of these genetic variants in people living in Lagos, Nigeria.

2. Materials and methods

The study was carried out in Lagos, an urban city situated in the southwest of Nigeria. Lagos is the commercial nerve center and the former capital of Nigeria. It is characterized with intense rainfalls from April to October and daily temperature between 23 and 37 °C (Fig. 1).

Approval of the authority was obtained for this study from the Medical and Ethical Committee for access to health records. Health records of people of different ages ranging from infants to adults spanning 11 years (1998–2009) consecutively were retrospectively collected from three different health service centers within Lagos metropolis, namely Lagos Island Laboratory and Health Services (LILHS), Lagos State University Teaching Hospital (LUTH) and Isolo General Hospital (IGH).

ABO and Rh blood group tests were carried out by using a sterilized needle to obtain a drop of blood from a sterilized finger from each participant. It was then placed on a clean white tile in three places. A drop of each of the antisera, anti-A, anti-B and anti-D obtained from Helena Laboratories, Beaumont, Texas, was added and mixed with each blood sample, with the aid of glass rods. Blood groups were determined on the basis of agglutination.

3. Statistical method

Allele frequencies were calculated under the assumption of Hardy–Weinberg equilibrium and expressed as percentages. Chi-square test was used to compare observed allelic and genotypic frequency distributions of the blood group and Rh antigens to that expected under the Hardy–Weinberg.

4. Results

As shown in Table 1, we observed that the ABO blood group frequencies occurred in the following order O > A > B > AB (52.9% > 23.1% > 21.3% > 2.7%), respectively, among the

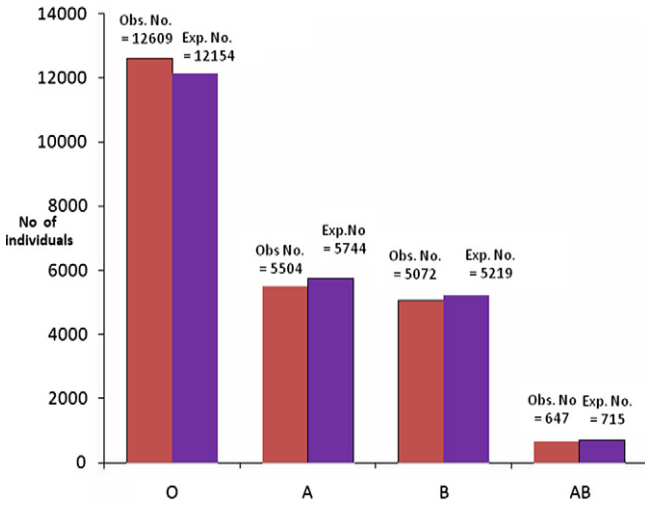

Figure 1 Observed (Obs.) vs expected (Exp.) frequencies of the ABO blood group among individuals sampled in Lagos State, Nigeria.

overall individuals sampled. O blood group has the highest overall percentage frequency (52.9%). AB blood group has the least overall percentage frequency (2.7%). Our results revealed a marginal difference between the overall percentage frequencies of blood groups A and B (23.1% and 21.3%, respectively). In all the three sample sites, the percentage frequency of B group was higher than that of A group in female. As regards the Rhesus blood group system, we found that 97.0% of the sampled population were Rh(D)+ve while 3.0% were Rh(d)−ve (Table 1). Comparatively, we observed higher proportions of Rh+ve in males than females.

Table 2 shows the overall allele frequencies for the ABO and Rh antigens in the studied population. For the ABO blood group the allele frequencies were as follows: (A), (B) and (O) 0.14, 0.13 and 0.73, respectively. This occurred in the order O > A > B. The phenotype frequencies were O = 53.3%, A = 22.4%, B = 20.7% and AB = 3.6%. The allele frequency of blood group O was the highest in all the sampled population. For the Rh blood group, the genotypic frequencies were DD = 0.69, Dd = 0.28 and dd = 0.03 while the phenotype frequencies were D = 97.0% and d = 3.0%. There was higher proportion of Rh(D)+ve individuals than the Rh−ve in the studied population.

Figs. 1 and 2 represent comparison between observed and expected values for both ABO blood group and Rh factor in the tested population, respectively. The observed and expected values were A (23.1%, 24.1%), B (21.3%, 21.9%), AB (2.7%, 3.0%) and O (52.9%, 51.0%). The observed frequency for Rh positive was 97.0% and the expected was 96.7% while the observed frequency for Rh negative was 3.0% and the expected value was 3.3%.

Goodness-of-fit χ^2 for Rh = 7.03, $df = 1$, $P > 0.05$ (statistically insignificant), where Obs = observed; Exp. = expected; χ^2 = Chi-square, Rh = Rhesus factor; +ve (D) = positive, −ve (d) = negative.

Figs. 1 and 2 represent the observed proportions of ABO and Rh individuals in the studied population when compared with expected proportions. We found that the distribution and proportion of individuals having ABO blood antigens differ from those expected under Hardy–Weinberg equilibrium (goodness-of-fit χ^2 for ABO = 37.57, df = 3, P < 0.05) and therefore statistically significant. The distribution and proportion of individuals having Rh blood antigens did not differ from those expected under Hardy–Weinberg equilibrium (goodness-of-fit χ^2 for Rh = 7.03, df = 1, P > 0.05) which is statistically insignificant.

Table 3 represents the phenotypic frequencies of ABO blood group in different populations of the world while Table 4 shows the allelic frequencies of Rh antigens in some parts of the population across the world.

We observed that the frequency of blood O group was higher than that of the other blood groups and that Rh positive was predominant in most of the populations reported in the literature so far.

5. Discussion

We studied the gene frequencies for the ABO and Rh(D) alleles in a population consisting of different ages in Lagos, Nigeria, over a period of 11 years (1998–2009). The 23,832 and 23,764 individuals were typed for ABO and Rh blood groups, respectively. When the data from the three hospitals were compared,

Table 1 Phenotypic distribution of ABO and Rh blood group systems for the years 1998–2009 in Lagos State, Nigeria.

Health facilities (period)	ABO system					Sex	Rhesus system		
	O	A	B	AB	Total		Rh+ve	Rh–ve	Total
LILHS (1998–2009)	4833 (51.8)[a]	2201 (23.5)	2045 (21.9)	253 (2.7)	9332	Male	4570 (49.3)	136 (1.47)	4706 (50.8)
						Female	4413 (47.6)	144 (1.55)	4557 (44.2)
						Total	8983 (97.0)	280 (3.02)	9263 (100.0)
LUTH (1998–2009)	4223 (52.5)	1860 (23.1)	1741 (21.7)	217 (2.7)	8041	Male	4350 (54.1)	137 (1.70)	4487 (55.8)
						Female	3459 (43.0)	100 (1.24)	3559 (44.2)
						Total	7809 (97.1)	237 (2.94)	8046 (100.0)
IGH (1998–2009)	3553 (55.0)	1443 (22.3)	1286 (19.9)	177 (2.7)	6459	Male	3279 (50.8)	97 (1.50)	3376 (52.3)
						Female	2982 (46.2)	97 (1.50)	3079 (47.7)
						Total	6261 (97.0)	194 (3.0)	6455 (100.0)
Gross total	12,609 (52.9)	5504 (23.1)	5072 (21.3)	647 (2.7)	23,832	Male	12,199 (51.3)	370 (1.56)	12,569 (52.9)
						Female	10,854 (45.7)	341 (1.43)	11,195 (47.1)
						Total	23,053 (97.0)	711 (3.0)	23,764 (100.0)

[a] Values in parenthesis represent percentages of occurrence.

Table 2 Gene frequencies of ABO and Rh blood group alleles for the years 1998–2009 Lagos State, Nigeria.

Study sites (period)	Blood group system	Gene (allele)	Frequency	Genotype	Frequency	Phenotype	Frequency
LILHS (1998–2009)	ABO	O	0.72	OO	0.5200	O	52.0
		A	0.14	AA	0.0196	A	
				AO	0.2016	A	22.2
		B		BB	0.0196	B	
			0.14	BO	0.2016	B	22.2
				AB	0.0392	AB	3.9
	Rhesus	D	0.83	DD	0.69	Rh(D) + ve	
				Dd	0.28	Rh(D) + ve	97.0
		d	0.17	dd	0.03	Rh(d)−ve	3.0
LUTH (1998–2009)	ABO	O	0.73	OO	0.5329	O	53.3
		A	0.13	AA	0.0169	A	
				AO	0.1898	A	20.7
		B	0.14	BB	0.0196	B	
				BO	0.2044	B	22.4
				AB	0.0364	AB	3.6
	Rhesus	D	0.83	DD	0.69	Rh(D) + ve	
				Dd	0.28	Rh(D) + ve	97.1
		d	0.17	dd	0.03	Rh(d)−ve	2.94
IGH (1998–2009)	ABO	O	0.74	OO	0.5329	O	54.8
		A	0.13	AA	0.0196	A	
				AO	0.1924	A	20.9
		B	0.13	BB	0.0169	B	20.9
				BO	0.1924	B	3.4
				AB	0.0338	AB	
	Rhesus	D	0.83	DD	0.69	Rh(D) + ve	97.0
		d	0.17	Dd	0.28	Rh(D) + ve	3.0
				dd	0.03	Rh(d)−ve	
Gross total	ABO	O	0.73	OO	0.5329	O	53.3
		A	0.14	AA	0.0196	A	22.4
				AO	0.2044	A	
		B	0.13	BB	0.0169	B	20.7
				BO	0.1898	B	3.6
				AB	0.0364	AB	
	Rhesus	D	0.83	DD	0.69	Rh(D) + ve	
		d		Dd	0.28	Rh(D) + ve	97.0
			0.17	dd	0.03	Rh(d)−ve	3.0

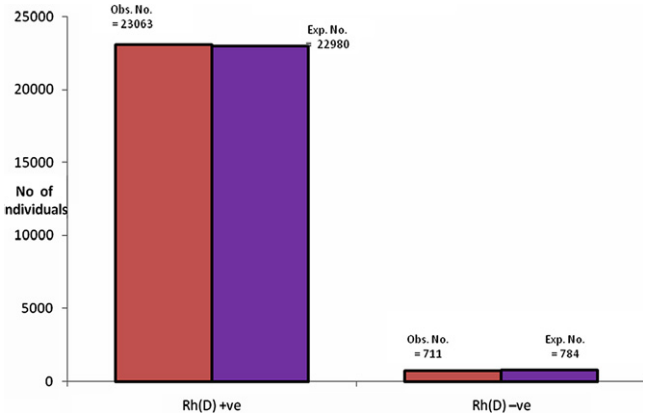

Figure 2 Observed (Obs.) vs expected (Exp.) frequencies of Rh Blood groups among individuals sampled in Lagos State, Nigeria.

we observed a similar pattern in the distribution of individuals with ABO blood antigen. On the phenotypic frequencies of ABO blood group, our data from this study are consistent with previous findings on the same subject matter from various segments of the world population including Nigeria. For instance similar study in Britain revealed the percentage frequencies of the ABO blood group were 41.7%, 8.6%, 3.0% and 46.7% for A, B, AB and O blood groups, respectively, while in India ABO blood group phenotypic frequencies were 18.85%, 32.50%, 9.90% and 38.75% for A, B, AB and O blood groups, respectively (Table 3).

In the northern part of Nigeria, Kulkarni and colleagues reported phenotypic frequencies of 46.6%, 23.05%, 29.95% and 4.4% for blood groups O, A, B and AB, respectively [28]. Adeyemo and Soboyejo also obtained phenotypic frequencies of 55.3%, 25.3%, 16.7% and 2.7% in the order O > A > B > AB [30]. Bakare and colleagues reported phenotypic frequencies of 50% for O, 22.9% for A, 21.3% for B and 5.9% for AB among 7653 individuals sampled in Ogbomoso, South-West, Nigeria [23]. When we analyzed our data and compared them with previous available findings, we observed a consistent pattern of distribution of blood group O, A, B, AB occurring in the order O > A > B > AB [22–25,29,30,32] (Table 3). We observed that themost available data from Nigeria and some parts of the world reported the

Table 3 Frequency of blood groups (ABO) studied in different populations across the world.

Population	A (%)	B (%)	AB (%)	O (%)	References
Asia					
Mandi Bahauddin (Pakistan)	0.1583	0.2832	0.0448	0.5522	[13]
Swat (Pakistan)	0.2792	0.3240	0.1058	0.2910	[14]
India	0.1885	0.3250	0.0990	0.3875	[14]
Gujrat (Pakistan)	0.1740	0.2229	0.0435	0.5596	[15]
Europe					
Britain	0.4170	0.0860	0.0300	0.4670	[14]
Hungary	0.2766	0.1218	0.0423	0.5593	[16]
Turkey	0.1220	0.1213	0.0085	0.7398	[17]
Middle East					
Kuwait	0.1608	0.1406	0.0265	0.6678	[18]
Saudi Arabia	0.2400	0.1700	0.0400	0.5200	[14]
Africa					
Nairobi (Kenya)	0.1580	0.1261	0.0239	0.6900	[19]
Sudan	0.1814	0.1235	0.0268	0.6683	[20]
Guinea	0.2254	0.2386	0.0472	0.4888	[21]
Nigeria	0.2443	0.2388	0.0275	0.4894	[22]
Ogbomoso (Nigeria)	0.2290	0.2130	0.0590	0.5000	[23]
Benin (Nigeria)	0.2372	0.2009	0.0297	0.5322	[24]
Ibadan (Nigeria)	0.2160	0.2140	0.0280	0.5420	[25]
Port-Harcourt (Nigeria)	0.2290	0.1710	0.0484	0.5516	[26]
Adamawa (Nigeria)	0.1650	0.2130	0.1170	0.5060	[27]
Northern Nigeria	0.2305	0.2995	0.0440	0.4660	[28]
Ilorin (Nigeria)	0.1870	0.1760	0.0560	0.5810	[29]
Lagos (Nigeria)	0.2310	0.2130	0.0270	0.5290	This study

Table 4 Frequency of Rh blood groups studied in different populations across the world.

Population	Rh+ (%)	Rh− (%)	References
Asia			
Mandi Bahauddin (Pakistan)	0.9140	0.0860	[13]
India	0.9445	0.0550	[14]
Europe			
Britain	0.8300	0.1700	[14]
Germany	0.9500	0.0500	[17]
North America			
USA	0.8500	0.1500	[14]
Middle East			
Saudi Arabia	0.9300	0.0700	[14]
Africa			
Nigeria	0.9430	0.0570	[22]
Lagos (Nigeria)	0.9400	0.0600	[30]
Ogbomoso (Nigeria)	0.9670	0.0330	[23]
Benin (Nigeria)	0.9388	0.0603	[24]
Adamawa (Nigeria)	0.9740	0.0260	[27]
Port Harcourt (Nigeria)	0.9677	0.0323	[26]
Ibadan (Nigeria)	0.9500	0.0480	[25]
Ilorin (Nigeria)	0.9550	0.0450	[29]
Lagos (Nigeria)	0.9700	0.0300	This study

proportions of A, B, AB and O in the order O > B > A > AB [21,27,28,31].

Our data deviate from previous studies in some parts of Pakistan where blood group B was dominant in the population and the phenotypic frequencies were in the order B > A > O > AB [14,33,34]. We observed that in most findings reported to date, there was a marginal difference between the proportions of individuals with blood groups A and B. Although this was not true in some cases as Khaliq and colleagues reported a marginal difference between blood groups B and O in a population of Hazara, Pakistan with percentage phenotypic frequencies of A (24%), B(32%), AB(11%) and O(33%) [35]. This is not consistent with our own data. In the same vein, our data deviate from those of Yousaf and colleagues who also reported a marginal difference especially for phenotypes B and O in a population of Bahawalpur, Pakistan with phenotypic frequencies of A (21%), B (36%), AB (6%) and O (37%) [36]. In a study conducted among American Indians by Mourant and colleagues, there was no individual with blood group AB in the population sampled with the following phenotypic frequencies proportion A (3.9%), B(1.1%), AB(0%) and O(95%) [37].

From our findings (Tables 1 and 2), it is evident that the proportion and gene frequencies of individuals belonging to blood group O in the studied population was most predominant. This is consistent with previous reports from the studies conducted among Nigeria population and African countries [22–29] (Table 4). The implication of this finding is that blood type O is the most readily available blood group in the Nigerian population which is more advantageous for the population in the event of blood transfusion. The higher proportion of blood group O in the studied population is an advantage because Nigeria is a malaria endemic country and so therefore individuals belonging to blood group O may be protected from severe malaria attack due to the mechanism of reduced resetting [8]. Previous studies have also shown that the frequency of blood group A was significantly higher among people suffering from pancreatic cancer [11]. This also indi-

cates that one out of five of the studied population is probably at elevated risk of pancreatic and other types of cancer.

For instance early independent studies showed association of rectal, cervical, leukemia, pancreatic, breast, ovarian, gastric cancers among individuals with blood groups A, AB, or B more likely to have elevated risk of pancreatic cancer than individual belonging to blood group O [10–12].

With regard to Rhesus D antigens, we found the phenotypic proportions to be (97%) for Rh positive which consist of DD (69%), Dd (28%) and (3%) for Rh negative in the overall population (Table 2). Our findings are consistent with the available data from previous studies among Nigerian populations where the Rh(D) + ve was found to be higher in the population sampled than the Rh(d) –ve [23,25,28,30,37–42] (Table 4). We observed that our results, however, differ from the study conducted by Yousaf and colleagues among Bahawalpur division of Pakistan population where the subjects were exclusively Rh(D) positive [36]. In all the data that we came across, there was a higher proportion of individual with Rh(D) positive. We need to also stress that we did not come across any previous studies on this subject matter where there was a higher proportion of Rh(D) negative in the sampled population at all.

We have by the data presented herein, provided information on the gene and allelic frequencies in the population of Lagos State of Nigeria hoping that it will serve as a reference for other studies. We believe this study will further contribute to existing knowledge in this genetic field and help in planning for future clinical challenges especially when it relates to blood transfusion and genetic counseling.

This report clearly presents the distribution and the gene frequencies of the allele controlling the ABO and Rh blood group system for samples of the Nigerian population in Lagos State.

6. Conclusion

We believe that data from this study have provided information on the genetic variability and polymorphism of the blood group and rhesus antigens among the population in Lagos, Nigeria. This information would be useful to the geneticists and to the clinicians especially in the planning of blood transfusion programmes since they play integral role of the genetic profile of the Nigerian population.

Source of support

Nil.

Conflict of interest

The authors declare no competing financial interests.

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