GLOBAL JOURNAL OF MEDICAL SCIENCES VOL. 3, NO. 1 & 2, 2004: 17 - 22
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GENE FREQUENCIES OF ABO AND RHESUS BLOOD GROUPS AND HAEMOGLOBIN VARIANTS IN OGBOMOSO, SOUTH-WEST NIGERIA.

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(Received 11 June, 2003; Revision accepted 28 August, 2003)

ABSTRACT

The distribution and gene frequencies of ABO and Rhesus (Rh) blood groups and haemoglobin variants for samples of the Nigerian population at Ogbomoso, were determined. Data consisting of records of blood groups and haemoglobin types of different ages ranging from infants to adults for a period of 4 to 6 years (1995 – 2000) was collected from Baptist Medical Centre (BMC), Ladoke Akintola University of Technology Health Centre (LAUTHC) and Oyo State General Hospital (OSGH), all in Ogbomoso, Oyo State, Nigeria. Overall, a total number of 7653, 7053 and 14,845 individuals were typed for ABO and Rh blood groups; and haemoglobin genotypes, respectively. 3824 (50 %) were blood group O, 1750 (22.9 %) were blood group A, 1629 (21.3 %) were blood group B and 450 (5.9 %) were blood group AB. This distribution differs significantly ($P<0.05$) from those expected under the Hardy Weinberg law. The proportion of the individuals belonging to the various ABO blood groups also varied significantly ($P<0.05$) over the period of the study. Overall gene frequencies for the A, B and O alleles were 0.15, 0.15 and 0.70, respectively. For the Rh blood group 6823 (96.7 %) were Rh-positive(DD & Dd) while 230 (3.3 %) were Rh – negative(dd). The distribution and proportion of individuals belonging to each group did not differ significantly from those expected under the Hardy Weinberg law ($P>0.05$). The gene frequencies of D and d alleles were 0.82 and 0.18, respectively. Six haemoglobin genotypes were recorded in the order of AA (68.1 %) > AS (21.0 %) > AC (5.7 %) >SS (3.0 %) >SC (2.0 %) >CC (0.3 %). The gene frequencies were 0.81, 0.14 and 0.04 for A, S and C alleles, respectively. Our results are representative of the distribution of these genetic variants in Nigeria.

KEYWORDS : Gene frequency, Blood groups, Haemoglobin, Nigeria.

INTRODUCTION

The most famous blood groups are those of ABO and Rhesus(Rh) series. Both are routinely typed for in any blood bank or blood transfusion service. The Rh blood groups rank with ABO groups in clinical importance because of their relation to haemolytic disease of the newborn (HDN) and their importance in blood transfusion. The Rh is genetically complex but it is simply described in terms of a single pair of alleles, D and d. Rhesus positive (Rh+ve) persons are DD and Dd, and Rhesus negative (Rh-ve) ones are dd. The first discovery that the frequencies of the blood groups differed from one population to another was made in the early 20th century. Subsequent results from practically all countries of the world have corroborated this , and have also shown that frequency figures are valid only for the specific population from which they are derived (Mourant *et al.* , 1976).

The haemoglobin variants on the other hand, constitute the most thoroughly studied and most completely understood of all human genetic polymorphisms. The great majority of people everywhere have one major type of haemoglobin; the normal adult haemoglobin or HbA. About 400 different abnormal types are known, two thirds of which have an abnormal β – chain type. Most of the abnormal types are extremely rare. In West Africa, only four of them (HbS, C, K, Woolwich, and D(Queled O–Rabah) are sufficiently frequent to be of clinical or anthropological interest. The first two haemoglobin and the thalassemia are relatively common. Only HbS however, has a clinical importance due to the sickling phenomenon (Winter, 1987).

In West Africa, reports have been provided to show the distribution pattern of ABO and Rh blood groups and haemoglobin variants in a few countries including Nigeria. However, most of these studies only reported the observed phenotypes; but not the genotypic and allelic frequencies, and their occurrences among certain age range persons (Muller, 1927; Chalmers et al., 1952; Garlick and Barnicot, 1957; Yankah, 1965; Coker, 1976; Ahmed et al., 1993). This may not be desirable enough because gene frequencies among random population of people will give more accurate distribution pattern among the persons.

There has been no known data of the distribution pattern and frequency of ABO and Rh blood group and

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Table 1: Distribution of ABO and Rh blood group systems for the years 1995 – 2000

	ABO system					Rh system			
	O	A	B	AB	Total	Sex	Rh+ve	Rh-ve	Total
Baptist Medical Centre (1995-2000)	1604 (46.3)	818 (23.6)	857 (24.7)	187 (5.4)	3466	Male	463 (17)	40 (28)	503 (17.5)
						Female	2265 (83.0)	103 (72.0)	2368 (82.5)
						Total	2728 (95)	143 (5.0)	2871
Ladoke Akintol Univ. Of Tech. Health centre (1997-2000)	1815 (53.3)	742 (21.8)	612 (18.0)	235 (6.9)	3404	Male	2449 (72.9)	31 (70.5)	2480 (72.9)
						Female	911 (27.1)	13 (29.5)	924 (27.1)
						Total	3360 (98.7)	44 (1.3)	3404
Oyo State General Hospital (1995-2000)	405 (51.8)	190 (24.3)	160 (20.4)	28 (3.6)	783	Male	352 (47.9)	21 (48.8)	373 (47.9)
						Female	383 (52.1)	22 (51.2)	405 (52.1)
						Total	735 (94.5)	43 (5.5)	778
Gross Total	3824 (50.0)	1750 (22.9)	1629 (21.3)	450 (5.9)	7653		6823 (96.7)	230 (3.3)	7053

Values in parentheses represent percentages of occurrence
Heterogeneity tests : ABO groups : $X^2 = 66.47$, df = 2, $P<0.05$
Rh groups : $X^2 = 0.91$, df = 1, $P>0.05$

haemoglobin variants from Ogbomoso, the second largest city in Yorubaland and the fourth in Nigeria. This study aims at providing information on the distribution pattern of the phenotypes and genotypes, and the gene frequencies of these genetic variants in Ogbomoso; with a view to contributing to existing knowledge on the subject matter.

MATERIALS AND METHODS

Data were collected from 3 different hospitals in Ogbomoso (8^0N of the equator and 4^0 3^1E of the greenwhich meridian) Nigeria. These are Ladoke Akintola University of Technology Health Centre (LAUTHC), Oyo State General Hospital (OSGH) and Baptist Medical Center (BMC). Records for different ages ranging from infants to adults for 6 consecutive years, 1995 – 2000, were collected. At LAUTHC, we were deeply involved (with the assistance of the Chief Technologist) in blood typing of a few number of patients in 1999/2000. For each test, a drop of blood from a sterilized finger was used.

ABO and Rh blood group tests were carried out on a white porcelain tile and or microslide using blood grouping sera (Lome Laboratories Ltd., UK.; BIOTEC Laboratories Ltd., UK.). The haemoglobin type was determined using Hb – electrophoresis. The genotypic and allelic frequencies were computed based on Hardy-Weinberg formulations. Heterogeneity tests between years were calculated using the chi-square test (The Open University, 1983). Goodness - of - fit statistics were calculated for the figures observed compared to values expected using the Hardy-Weinberg equilibrum (Russell, 1998).

RESULTS

The different types and distribution of ABO and Rh blood group system recorded in 3 hospitals in Ogbomoso, from 1995 to 2000 are shown in Table 1. Overall , a total number of 7653 and 7053 individuals were typed for ABO and Rh blood groups respectively.

At BMC, 818 (23.6 %) were blood group A, 857 (24.7 %) were blood group B, 187 (5.4%) were blood group AB and 1604 (46.3 %) were blood group O (Table 1). The allelic frequency from this distribution were 0.68, 0.16 and 0.16 for alleles O, A and B, respectively (Table 2). For the Rh status, 2728 (95 %) were Rh +ve while 143 (5.0 %) were Rh -ve. The allelic frequencies were 0.78 and 0.22 for alleles D and d, respectively.

At LAUTHC, 742 (21.8 %) were blood group A, 612

(18.0 %) were blood group B, 235 (6.9 %) were blood group AB and 1815 (53.3 %) were blood group O (Table 1). The allelic frequencies were 0.73, 0.14 and 0.13 for O, A and B alleles, respectively (Table 2). On the Rhesus status, 3360 (98.7 %) were Rh -positive while 44 (1.3 %) were Rh- negative. These gave the allelic frequencies as 0.89 and 0.11 for alleles D and d, respectively.

At OSGH, a total of 783 and 778 individuals were typed for ABO and Rh blood groups, respectively. Of these, 190 (24.3 %) were blood group A, 160 (20.4%) were blood group B, 28 (3.6 %) were blood group AB and 405 (51.8 %) were blood group O; while 735 (94.5 %) and 43 (5.5 %) were Rh +ve and Rh -ve, respectively. The allelic frequency from these distribution were 0.72, 0.15 and 0.13 for O, A and B alleles, respectively ; and 0.77 and 0.23 for D and d alleles, respectively.

The data from the 3 hospitals combined shows that 22.9 % were blood group A, 21.3 % were blood group B, 5.9 % were blood group AB and 50.0 % were blood group O (Table 1). The overall allelic frequencies were 0.70, 0.15 and 0.15 for O, A and B alleles, respectively. On the Rhesus status, 96.7 % were Rh +ve while 3.3 % were Rh -ve. This gave the allelic frequencies as 0.82 and 0.18 for $\bar{D}$ and d alleles, respectively (Tables 1 and 2). The proportion of individuals belonging to the various ABO blood groups varied significantly over the period of the study (X^2=66.47, df=2, P<0.05); and the distribution also differed significantly from those expected under the Hardy Weinberg equilibrum { (Goodness-of-fit X^2= 47.25, df=3, P<0.05) Table 3}. However, the proportion (X^2=-0.91, df=1, P>0.05) and the distribution{(Goodness-of-fit X^2= 1.58, df=1, P>0.05) Table 3} of Rh blood group individuals is on the contrary.

Table 2 also presents the frequencies of the various genotypes in the ABO and Rh systems. In all, for example, the frequency of BB genotype was 0.0225 while that of BO genotype was 0.21. Thus, among those who are blood group B, 9.6 % were homozygous BB while about 90 % were heterozygous BO. Similar deductions can be made for blood group A, and for Rh +ve among DD and Dd individuals. The frequencies of the genotypes for Rh blood group were 0.67 for DD, 0.30 for Dd and 0.03 for dd.

Table 4 presents the phenotypic distribution and gene frequencies of the haemoglobin types in the study sites from 1995 to 2000. Three different haemoglobin types were recorded. They are Hb A, C and S and they

Table 2. Gene Frequencies of ABO and Rh blood group alleles for the years 1995 – 2000 in Ogbomoso, Nigeria

Study sites/yr	Gene (allele)	Frequency	Genotype	Frequency	Phenotype	Frequency (%)
	O	0.68	OO	0.4624	O	46.3
	A	0.16	AA	0.0256	A	
			AO	0.2176	A	23.6
Baptist Medical Centre (1995-2000)	B	0.16	BB	0.0256	B	
			BO	0.2176	B	24.7
	-	-	AB	0.0512	AB	5.4
	D	0.78	DD	0.61	Rh(D)+ve	
			Dd	0.34	Rh(D)+ve	95
	D	0.22	dd	0.05	Rh(d)-ve	5.0
	O	0.73	OO	0.5329	O	53.3
Ladoke Akintola Univ. of Tech. Health centre (1997-2000)	A	0.14	AA	0.0196	A	
			AO	0.2044	A	21.8
	B	0.13	BB	0.0169	B	
			BO	0.1898	B	18.0
	-	-	AB	0.0364	AB	6.9
	D	0.89	DD	0.79	Rh(D)+ve	
			Dd	0.20	Rh(D)+ve	98.7
	D	0.11	dd	0.12	Rh(d)-ve	1.3
	O	0.72	OO	0.5184	O	51.8
	A	0.15	AA	0.0225	A	
Oyo State General Hospital (1995-2000)			AO	0.216	A	24.3
	B	0.13	BB	0.0169	B	
			BO	0.1872	B	20.4
	-		AB	0.039	AB	3.6
	D	0.77	DD	0.59	Rh(D)+ve	
			Dd	0.35	Rh(D)+ve	94.5
	D	0.23	dd	0.05	Rh(d)-ve	5.5
	O	0.70	OO	0.49	O	50.0
	A	0.15	AA	0.0225	A	
			AO	0.21	A	22.9
	B	0.15	BB	0.0225	B	
Gross Total of the 3 sites			BO	0.21	B	21.3
	-	-	AB	0.045	AB	5.9
	D	0.82	DD	0.67	Rh(D)+ve	
			Dd	0.30	Rh(D)+ve	96.7
	D	0.18	dd	0.03	Rh(d)-ve	3.3

Table 3. Observed versus Expected Frequency of ABO and Rh Blood groups among individuals sampled in Ogbomoso, Nigeria

ABO System					Rh system				
Blood group	Obs. Number	Obs. Frequency(%)	Expect. Frequency (%)	Expect. Number	Blood group	Obs. Number	Obs. Frequency(%)	Expect. Frequency(%)	Expect. Number
O	3824	50.0	49.0	3750	Rh(D)+ve	6823	96.7	97.0	6841
A	1750	22.9	23.3	1779	Rh(D) -ve	230	3.3	3.3	212
B	1629	21.3	23.3	1779					
AB	450	5.9	4.50	344					
Total	7653	100.0	100.0	7652		7053	100.0	100.0	7053
Goodness-of-fit $X^2 = 47.25$, df = 3, $P<0.05$					Goodness-of-fit $X^2 = 1.58$, df = 1, $P>0.05$				

Obs. : Observed
Expect. : Expected
X^2 : Chi - square

occurred in 6 genotypic combinations as AA, AS, AC, SC, SS and CC. The overall order of occurrence is AA (68.1 %) > AS (21.0 %) > AC (5.7 %) > SS (3.0 %) > SC (2.0 %) > CC (0.3 %). The gene frequencies were 0.81, 0.14 and 0.04 for A, S and C alleles , respectively.

DISCUSSION

In this study, the gene frequencies of ABO and Rh blood groups and haemoglobin variants of individuals typed in Ogbomoso were considered.

Though the allelic frequencies of each blood group per year are similar, there was significant variation in the proportion of individuals belonging to the various ABO blood groups.

This was due to distinct variation in the number of observed and expected individuals at LAUTHC (Table 3). And also due to fewer records obtained for all the blood groups at OSGH, which might be a function of poor record keeping in the hospital. Data from the 3 hospitals showed that there were more O blood group in this survey. The allelic frequency of O (0.70) was also higher than those of A (0.15) and B (0.15). This is due to the fact that many of the individuals who are of blood groups A and B may have been heterozygous, carrying one O gene together with an A or B gene. Bernstein(1924) reported that the genetics of the ABO blood group system were dependent on a set of three allelic genes I^A, I^B and I^O. I^A and I^B are co-dominant in blood group AB and both are dominant to I^O.

The observed values and frequency figures are similar to those previously reported by other workers in Nigeria(Odaibo et al., 1974; Onwukeme, 1990; Njoku *et al.* 1996; Omotade et al,. 1999; Falusi *et al.*, 2000). They independently reported ABO blood group frequencies in the order O > A ≥ B > AB. This is in concert with the fact that Nigerian populations are characterised by high frequencies of the O allele and an average of about 14 % each of the A and B genes (Odeigah, 1990).

On the rhesus factor , the proportion of Rh -ve (3.3 %) is far lower than for Rh +ve (96.7 %) within the period of study. Likewise the gene frequencies of 0.82 and 0.18 for D and d alleles, respectively. Overall, 97 % (consisting of 67 % of DD individuals and 30 % of Dd individuals) were phenotypically Rh +ve while 3 % were Rh -ve. This is in agreement with what is expected from the Hardy Weinberg equilibrum. Our results are in contrast to that of Salmon *et al.* (1988) and Njoku *et al.* (1996) who reported rhesus positive values of 100 % for Eastern Highlands of Papua Guinea and Nigeria, respectively. It is also disimilar to that in Indians with a preponderance of the Rh(d) of 89.7 % over the Rh(D) gene of 10.3% (Thangaraj *et al.*, 1992). Our data are however, similar to findings among Africans, West Indians and Blacks living in Britain (Arneaud and Young,1955; Yankah, 1965; Worlledge et al., 1968; Leck 1969; Coker, 1976; Omotade et al., 1999; Falusi et al., 2000). It is also in concert with the fact that the frequency of Rh(d) is often low in parts of the world where malaria is

Table 4. Phenotypic distribution and Gene Frequencies of Haemoglobin Variants for the years 1995 – 2000 in Ogbomoso, Nigeria

Study sites/yr	Sex	Haemoglobin type						Total
		AA	AS	AC	SC	SS	CC	
Baptist Medical Centre (1995-2000)	Male	2600 (63.7)	538	263 (54.7)	124 (51.5)	290	14 (53.9)	3829 (61.3)
	Female	1479 (36.3)	(51.5)	218 (45.3)	117 (48.5)	(78.2)	12 (46.2)	2414 (38.7)
	Total	4079 (65.0)	507 (48.5)	481 (7.7)	241 (3.9)	81 (21.8)	26	6243
	Genotypic frequency	0.65	1045 (16.7)	0.08	0.04	371 (5.9)	(0.4)	
			0.17			0.06	0.004	
Allelic frequencies : f(A) = 0.78, f(S) = 0.16, f(C) = 0.062								
Ladoke Akintola Univ. of Tech. Health centre (1997-2000)	Male	3831 (72.1)	1413 (76.6)	265 (77.7)	31 (75.6)	12 (54.5)	05 (55.6)	5557
	Female	1485 (28.0)	432 (23.4)	76 (22.3)	10 (24.4)	10 (45.5)	04 (44.4)	(73.4)
	Total	5316 (70.2)	1845 (24.4)	341 (4.5)	41	22	09	2017
	Genotypic frequency	0.70	0.24	0.05	(0.5)	(0.3)	(0.1)	(26.6)
					0.005	0.003	0.001	7574
Allelic frequencies : f(A) = 0.85, f(S) = 0.13, f(C) = 0.03								
Oyo State General Hospital (1995-2000)	Male	294 (41.2)	120 (55.1)	12 (44.4)	07 (53.9)	24 (47.1)	03 (60.0)	460
	Female	420 (58.8)	98 (45.0)	15 (55.6)	06 (46.2)	27	02 (40.0)	(44.8)
	Total	714 (69.5)	218 (21.2)	27	13	(53.0)	05	568 (55.3)
	Genotypic frequency	0.70	0.21	(2.6)	(1.3)	51	(0.5)	1028
				0.03	0.01	(5.0)	0.005	
						0.05		
Allelic frequencies : f(A) = 0.81, f(S) = 0.16, f(C) = 0.02								
Gross total of the 3 sites		10109 (68.1)	3108 (21.0)	849 (5.7)	295 (2.0)	444 (3.0)	40 (0.3)	14845
	Genotypic frequency	0.68	0.21	0.06	0.02	0.03	0.003	
Allelic frequencies : f(A) = 0.81, f(S) = 0.14, f(C) = 0.04								

Values in parentheses represent percentages of occurrence

endemic(Emery, 1979; Falusi *et al.*, 2000).

The data for haemoglobin types is lowest at OSGH probably due to poor record keeping in the hospital. Of the 6 haemoglobin genotypes recorded in the 3 hospitals, HbAA has the highest proportion (68.1 %) while HbCC has the lowest (0.3 %) [Table 4]. The alleles A, S and C control these genotypes and they occurred at a frequency of 0.81, 0.14 and 0.04, respectively. These frequencies are similar to those previously reported for Ivorian, Ghanaian and Nigerian populations of West Africa (Cabannes *et al.*, 1987).

Of clinical interest are alleles S and C because they are abnormal, and in particular S due to the sickling phenomenon associated with it. Overall, both occurred , apart from in the heterozygous state with Hb A (i.e. AC and AS), at a relatively low proportion of 2.0 % in their heterozygous state (SC) and 3.0 % and 0.3 % in their homozygous state; SS and CC respectively (Table 4). Considering the data of each hospital separately, there were more HbSS at BMC and OSGH than at LAUTHC; and also more HbCC at BMC than at OSGH and LAUTHC. This might be due to records of several numbers of infants taken at BMC and OSGH. It is possible that in an institution of higher learning (such as where LAUTHC is situated) very few of individuals with HbSS would qualify for admission , their primary and secondary education having probably been disturbed by frequent illness. Also nearly all HbS homozygotes in Africa die in infancy of the disease called sicke cell anaemia (SCA)[Cabannes *et al.* , 1987]. The appreciable value of HbSS obtained in this study might be due to the fact that many now reside in urban communities with improved medical services.

The proportion and genotypic frequencies of the haemoglobin variants in our survey is in good agreement with Walters and Lehmann's (1956) and Garlick and Barnicot (1957) figures for a large sample of Yorubas of all ages and with Allison's (1956) for Yorubas resident in Accra.

This report clearly present the distribution and more importantly, the gene frequencies of the alleles controlling the ABO and Rh blood group system and haemoglobin variants for samples of the Nigerian population at Ogbomoso. Data obtained may serve as reference for other studies in this field. It may also be useful in the planning of blood transfusion programmes, since they are an integral part of the genetic profile of the Nigerian population.

ACKNOWLEDGEMENTS

The authors thank the chief Technologists: Mr. Aderinto of Ladoke Akintola University of Technology Health Centre, Mrs. Enahoro and Mrs. Edhwonu of Baptist Medical Centre and Mr. Adeleke of Oyo State General Hospital, all in Ogbomoso, Oyo State, Nigeria; for their technical assistance and available records. We also thank the authorities of these hospitals for granting access to these records.

REFERENCES

Ahmed, O. A., Agomo, P. U., Olukoya, D. K and Esan, G. J. F., 1993. The prevalence group antigens and antibodies in Lagos State Nigeria. Afr. J. Med. Sci. 22 : 49 – 53.

Allison, A. C., 1956. The sickle cell and haemoglobin C genes in some African populations. Ann. Hum. Genet., Lond., 21 : 67.

Arneaud, J. O. and Young. O., 1955. A preliminary survey of the distribution of ABO and Rhesus blood groups in Trinidad. Trop. Geogr. Med. , 7 : 375 – 378.

Bernstein, F., 1924. Ergebnisse einer biostatistichen zusammenfassenden Betrachtung uber die erblichen Blutstrukturen des Menschen, *Klin. Wschr.* , 3 : 1495 – 1497.

Cabannes, R. J. R., Fabritus, H., Sangare, A. and Kple-Faget, P., 1987. Haemoglobin variants : Distribution in West Africa. In : Haemoglobin variants ir Human population, Vol. II. W. P. Winter eds. CRC Press, Inc. Boca Raton, Florida, pp 11 – 28.

Chalmers, J. N. M., Ikin, A. E., and Mourant, A. E., 1952. The ABO, MNS and RH blood groups of the Nigerian. Ann. Hum. Genet. 17 : 168.

Coker, W. Z., 1976. Some Hereditary characteristics of first year Biology students at Legon. Ghana J. Sci., 16(2): 3 – 6.

Emery, A. E. H., 1979. Elements of Medical Genetics, Churchill Livingstone (5th Ed.). London.

Falusi, A. G., Ademowo, O. G., Latunji, C. A., Okeke, A. C., Latunji, P. O., Onyekwere, T. O., Jimmy, E. O., Raji, Y. O., Hedo, C. C., Otukonyong, E. E. and Itata, E. O. 2000. Distribution of ABO and RH Genes in Nigeria. Afr. J. Med. Med. Sci. , 29 : 23 – 26.

Garlick, J. P. and Barnicot, N. A., 1957. Blood groups and haemoglobin variants in Nigerian (Yoruba) schoolchildren. Ann. Hum. Genet., 21 : 420 – 425.

Leck, I., 1969. A note on the blood groups of Commonwealth immigrants to England. Br. J. Prev. Soc. Med. , 23 : 163 – 165.

Mourant, A. E. , Kopec, A. C. and Domane-Wska-Sobezak, K., 1976. The distribution of the Human blood groups and other Polymorphisms, Oxford University Press, London, pp. 1 – 138.

Muller, H. R., 1927. Blood groups among the Yoruba tribe of West African Negroes. Proc. Soc. Exp. Biol. NY. 24 : 437.

Njoku, O. U., Ononogbu, I. C., Alumunan, E. O. and Nwanjoh, I., 1996. Serum lipids, ABO blood group and sickle cell trait. Ind. J. Physiol. Pharmacol. 40(2) : 171 – 174.

Odaibo, F., Omada, J., and Fleming, A. F., 1974. Blood groups and Rhesus typing in donors in Kaduna. Nig. Med. J. 4 : 127.

Odeigah, P. G. C., 1990. Influence of blood group and secretor genes on susceptibility to duodenal ulcer. East Afr. Med. J. 67 : 487 – 500.

Omotade, O. O., Adeyemo, A. A., Kayode, C. M., Falade, S. I. and Ikpeme, S., 1999. Gene frequencies of ABO and RH(D) blood group alleles in a healthy infant population in Ibadan, Nigeria. West Afr. J. Med., 18(4) : 294 – 297.

Onwukeme, K. E., 1990. Blood group distribution in blood donors in Nigerian population. Nig. J. Physiol., Sci., 6 : 67 – 70.

Russell, P. J., 1998. Population Genetics In : *Genetics*, 5th Edition. The Benjamin/Cummings Publishing Company, Inc. USA. Pp. 714 – 771.

Salmon, D., Godlier, M., Halle, L., Lemonnier, P., Lorry, J. L., Rouger, P., Ruffie, J. and Salmon, C., 1988. Blood groups in Papua New Guinea Eastern Highlands, Gene Geogr. 2 : 89 – 98.

Thangaraj, K., Srikumari, C. R. and Ramesh, A., 1992. The genetic composition of an endogenous Adi – Dravidar population of Tami – Nadu. Gene Geogr. 6 : 27 – 30.

The Open University. 1983. *Statistics for Genetics*, Steven Rose Eds. The Open University Press. Great Britain, pp. 19 – 26.

Walters, J. H. G. and Lehman, H., 1956. Distribution of the S and C haemoglobin variants in two Nigerian communities. Trans. R. Soc. Trop. Med. Hyg. 50 : 204.

Winter, W. P., 1987. Haemoglobin variants in Human populations, Vol. II. CRC Press, Inc. Boca Raton, Florida, pp. 1 – 185.

Worlledge, S., Luzzatto, L., Ogiemudia, S. E., Luzzatto, P. and Edington, G. M., 1968. Rhesus immunization in Nigeria, *Vox sang*, 14 : 202 – 210.

Yankah, J. A. K., 1965. Observation on the frequency of the ABO and Rh blood groups in leprosy and non-leprosy people in Ghana. Lep. Rev., 36(2) : 73 – 74.