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Gene frequencies of ABO and Rh (D) blood group alleles in Ilorin, North-Central Nigeria.

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Abstract

ABO and Rhesus blood group systems remain clinically the most significant blood group systems. Here we conducted a retrospective study of gene frequencies for the ABO and Rh (D) alleles in a population consisting of different ages in Ilorin, Kwara state, Nigeria over a period of ten years between 2000-2009. In the whole study population, 9,643 individuals were screened for both ABO and Rh blood groups. 5,605 (58.1%), 1,800 (18.7%), 1,699 (17.6%) and 539 (5.6%) were blood group O, A, B and AB respectively. 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. Gene frequencies of A, B and O were 0.13, 0.11 and 0.76 respectively. With respect to Rh, 9,209 (95.5%) (DD and Dd) and 434 (4.5%) (dd) were Rh positive and Rh negative respectively. The gene frequencies of D and d alleles were 0.78 and 0.22 respectively. This study revealed that the distribution and proportion of individuals belonging to each blood group did not differ significantly from those expected under the Hardy-Weinberg law ($p > 0.05$). Our results are true reflections of how the Nigerian population vary with respect to genetic traits.

Keywords: Blood groups, gene frequencies, Rhesus, alleles.

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Introduction

The ABO and Rh blood groups are among the useful genetic markers in human population studies. They are the most well known and medically significant blood types in blood transfusion.

The ABO system was the first genetic polymorphism to be defined in human beings and was first described by Karl Landsteiner in 1900 (Greenwell, 1997).

The Rhesus(Rh)D was in fact the fourth blood group system to be discovered and later ranked second to ABO system in terms of clinical importance.(Ahmed, et al., 2009).Both are of equal importance in clinical and forensic medicine.

More striking about the Rh blood system is the fact that the Rh antibody with some other blood systems such as Kell, Duffy, Kidd and MNSs have been implicated as the causes of severe haemolytic disease of the newborn (HDN) (Van der Schoot *et al*, 2003, Wagle and Deshpande (2010).ABO gene is located on the long arm of the ninth human chromosome (9q34.1) (Amundadottir, 2009) while the Rh D and Rhce genes encoding the Rh

proteins (d and cc/ee, respectively) are located on chromosome 1p34-p36 (Cartron, 1994).

The distribution of blood groups A, B, O and AB and Rh varies across the world population. Several reports have been documented on the distribution of ABO and Rh blood systems in Nigeria but majority have concentrated on the phenotypic rather than gene frequencies. This study is therefore necessary to provide information on the gene frequency distribution of ABO and Rhesus (D) among Nigerian population in Ilorin, North-central Nigeria.

Materials and methods

The study was carried out in Ilorin town (North – central Nigeria, longitude $4^{\circ}30'$ - $4^{\circ}45'$ N and latitude 8° - $38'$ E). Ilorin is an urban centre and the capital of Kwara state located in Nigeria's central savannah region with intense rainfalls from April to October and daily temperature between 23°C and 37°C . See Fig.1



Fig 1: Map of Nigeria showing Ilorin (in arrow) where this study was conducted.

Data for this study were collected from three different hospitals in Ilorin city. These are UML, U I H S and U.I.T.H.

Records for different ages ranging from infants to adults for 10 consecutive years, 2000 -2009 were collected. Approval with ref. no **UITH/CAT/189/12/719** was obtained for this study from the University of Ilorin Teaching Hospital Medical and Ethical committee. At the University Health Centre, we took part (with the help of the Chief Technologist) in blood typing of a few numbers of students who came for blood group analysis as part of their registration exercise for access to health services in 2009.

The ABO and Rh blood group tests was performed by using a sterilised needle to obtain a drop of blood from a sterilized finger from each student as part of their

registration exercise for access to the university health facilities . 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. We used Hardy -Weinberg equation to calculate both genotypic and allelic frequencies (Strickberger, 1976). Frequencies of Rh antigens were obtained using chi-square analysis. We expressed our results as a percentage. Goodness-of-fit statistics were also calculated for the figures observed compared to values expected using the Hardy-Weinberg equilibrium (Russell, 1998).

RESULTS AND DISCUSSION

This study investigated the gene frequencies of ABO and Rh(D) blood group systems among population in Ilorin .Our data revealed that the ABO blood group frequencies were found in the order O >A> B> AB (58.1%,18.7%,17.6% and 5.6%) respectively among the overall individuals sampled .

When compared with other reports from similar studies, our data is consistent with previous findings from other parts of the world including Nigeria. For example in Britain, 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 (Anees , 2007), findings reported from India also showed that the % frequencies were 18.85 , 32.50 , 9.90 and 38.75 % for A , B , AB and O blood groups respectively (see table 4).

In the Northern part of Nigeria , (Kulkarni *et al.*;1985) obtained frequencies of 46.6 , 23.05, 29.95 and 4.4% for blood group O, A , B and AB respectively and frequencies of 55.3, 25.3, 16.7 and 2.7% in the order O >A> B> AB were also obtained among 150 students of Cell Biology and Genetics at the University of Lagos ,Nigeria (Adeyemo and Soboyejo ,2006). (See table 4) In Ogbomoso, South-west Nigeria, (Bakare, *et al.*,2006) reported phenotypic frequencies of 50% for O;22.9% for A; 21.3% for B and 5.9% for AB among 7653 individuals sampled .

Among the Caucasians in the United States of America, the frequency of blood group O, A ,B and AB are 47.0 , 41.0 , 9.0 and 3.0 % respectively (Adeyemo and Soboyejo,2006) .

However,our findings seem to deviate from the results obtained by Khan and his colleagues on the genotype frequencies of blood group antigens from Bannu region in Pakistan where ABO blood group frequency occurred in the order B>A> O> AB (Khan *et al.*, 2009).It also seem not to agree with the results obtained from Swat district in Pakistan where the percentage frequencies were A=27.92% , B= 32.40 % , O = 29.10% and AB= 10.58% (Khattak *et al.*,2008).

In our study, we found allelic frequencies of ABO blood group to be O = 0.76, A to be 0.13 and B is 0.11 .They occurred in the order O>A>B (see Table 2). We observed similar pattern of allelic frequencies from those which have been earlier documented from previous studies among various segments of the world population including Nigeria (See table 4). For instance similar study by Bakare *et al.*, 2006 in Ogbomoso,South-west Nigeria, Omotade *et al.*, 1999 among a healthy infant population in Ibadan, Nigeria., (Yan *et al.*, 2005) on Chinese populations and (Hussain *et al.*,2001) among Balochistan in Pakistan all found the allelic frequencies to occur in O>A>B order.

On the predominance of blood group O over other blood groups in the population sampled, We are strongly of the opinion that O alleles may be predominant in Ilorin for the fact that it is a muslim dominated city where consanguineous marriages is still been practised.

We also agreed with the suggestion of Bakare *et al.*2006, that predominance of O allele may also be as a result of the fact that many As and Bs may have been heterozygous carrying O allele silently thereby maintaining O allele in the heterozygous population. However, it is our candid opinion that molecular characterization of O allele could assist in elucidating the possible causes of blood group O predominance in various populations.

With respect to Rhesus blood grouping system, we found that 95.5% of the population sampled were Rh (D) +ve while 4.5% were Rh (d)-ve. The allelic frequencies were 0.78 and 0.22 for D and d alleles respectively (see Table 3). Again our findings are consistent with report from previous similar studies among different sets of Nigerian population where the Rh(D) positive was found to be higher in the population sampled than the Rh (D) negative see (Kulkarni,*et al.*,1985,Ahmed and Obi ,1998 ; Omotade *et al* 1999; Ahmed *et al.*2004 ; Ahmed *et al.*2007; Jeremiah and Odumody,2005, Bakare, *et al.*, 2006, Akhigbe, *et al.*, 2009 ,Adeyemo and Soboyejo,2006) See table 5.Our results, however, differ

from the work reported by Yousaf and colleagues where the population sampled among Bahawalpur division of Pakistan population were all RhD positive see Yousaf *et al.*, (1988).

We have by these results presented in this study, provided information on the gene and allelic frequencies in the population of Ilorin, Kwara state of Nigeria hoping that it will serve as a reference for other studies. We believed this study will further contribute to existing knowledge in this field and help in planning for future clinical challenges especially when it relates to blood transfusion and genetic counselling.

Data from three different hospitals in Ilorin, Kwara state, Nigeria

Table 1. Phenotypic distribution of ABO and Rh blood group systems for the years 2000 – 2009 in Ilorin, Kwara state, Nigeria.

ABO SYSTEM					RHESUS SYSTEM				
Study sites/ yrs	O	A	B	AB	TOTAL	SEX	Rh+ve	Rh-ve	Total
Unity Medical Lab. (2000-2009)	1079 (52.8)	459 (22.5)	411 (20.1)	93 (4.6)	2042	Male	1136 (55.6)	36 (1.77)	1172 (57.4)
						Female	825 (40.4)	45 (2.2)	870 (42.6)
						Total	1961 (96.0)	81 (4.0)	2042
University of Ilorin Health Services (2005- 2009)	213 (56.5)	92 (24.4)	49 (13.0)	23 (6.1)	377	Male	152 (40.3)	27 (7.2)	179 (47.5)
						Female	175 (46.4)	23 (6.1)	198 (52.5)
						Total	327 (86.7)	50 (13.3)	377
University of Ilorin Teaching Hospital (U.I.T.H) (2006-2009)	4313 (59.7)	1249 (17.3)	1239 (17.2)	423 (5.9)	7224	Male	3307 (45.8)	83 (1.2)	3390 (47.0)
						Female	3614 (49.9)	220 (3.1)	3834 (53.0)
						Total	6921 (95.8)	303 (4.2)	7224
Gross Total	5605 (58.1)	1800 (18.7)	1699 (17.6)	539 (5.6)	9643	Male	4595 (47.7)	146 (1.5)	4741 (49.2)
						Female	4614 (47.8)	288 (3.0)	4902 (50.8)
						Total	9209 (95.5)	434 (4.5)	9643

Values in parentheses represent percentages of occurrence

Table 2: Gene frequencies of ABO and Rh blood group alleles for the years 2000- 2009 in Ilorin, Kwara State, Nigeria.

Study Sites/yrs	Gene (allele)	Frequency	Genotype	Frequency	Phenotype	Frequency
Unity Medical Laboratory (2000- 2009)	O	0.73	OO	0.5329	O	52.8
	A	0.15	AA	0.0225	A	22.5
	B	0.12	AO	0.2190	A	22.5
			BB	0.0144	B	20.1
			BO	0.1752	B	20.1
			AB	0.036	AB	4.6
	D	0.80	DD	0.64	Rh(D)+ve	96.0
	D	0.20	Dd	0.32	Rh(D)+ve	96.0
			Dd	0.04	Rh(d)-ve	4.0
University of Ilorin Health Services (2005- 2009)	O	0.75	OO	0.5625	O	56.5
	A	0.17	AA	0.0289	A	24.4
	B	0.08	AO	0.255	A	24.4
			BB	0.0064	B	13.0
			BO	0.12	B	13.0
			AB	0.0272	AB	6.1
	D	0.64	DD	0.41	Rh(D)+ve	86.7
	D	0.36	Dd	0.46	Rh(D)+ve	86.7
			Dd	0.13	Rh(d)-ve	13.3
University of Ilorin Teaching Hospital (U.I.T.H) (2006- 2009)	O	0.77	OO	0.5929	O	59.7
	A	0.12	AA	0.0144	A	17.3
	B	0.11	AO	0.1848	A	17.3
			BB	0.0121	B	17.2
			BO	0.1694	B	17.2
			AB	0.0264	AB	5.9
	D	0.80	DD	0.64	Rh(D)+ve	95.8
	D	0.20	Dd	0.32	Rh(D)+ve	95.8
			Dd	0.04	Rh(d)-ve	4.2
Gross total of the 3 sites	O	0.76	OO	0.5776	O	58.1
	A	0.13	AA	0.0169	A	18.7
	B	0.11	AO	0.1976	A	18.7
			BB	0.0121	B	17.6
			BO	0.1672	B	17.6
			AB	0.0286	AB	5.6
	D	0.78	DD	0.61	Rh(D)+ve	95.5
	D	0.22	Dd	0.34	Rh(D)+ve	95.5
			Dd	0.05	Rh(d)-ve	4.5

Table 3. Observed versus expected frequency of ABO and Rh Blood groups among individuals sampled in Kwara State, Nigeria.

ABO System Rh System

Blood group	Obs. Number	Obs. Freq. (%)	Expect. Freq. (%)	Expect. Number	Blood group	Obs. Number	Obs. Freq. (%)	Expect. Freq. (%)	Expect Number
O	5605	58.1	58.2	5592	Rh(D)+ ve	9209	95.5	96.0	9257
A	1800	18.7	19.0	1832	Rh(d) –ve	434	4.5	4.0	386
B	1699	17.6	18.0	1735					
AB	539	5.6	5.0	484					
Total	9643	100	100	9643		9643	100	100	9643

Goodness-of-fit X^2 for ABO =16.24, df =3, $P < 0.05$

Expect = Expected

X^2 = Chi –square

Goodness-of-fit X^2 for Rh = 6.22, df = 1, $P > 0.05$

Rh = Rhesus factor

Note:

Obs = Observed

Table 4: Frequency of blood groups (ABO) studied in different populations across the world.

Population	A	B	AB	O	References
	%	%	%	%	
Mandi Bahauddin .Pakistan	0.1583	0.2832	0.0448	0.5522	Anees <i>et al.</i> ,2007
Swat,Pakistan	0.2792	0.3240	0.1058	0.2910	Khattak <i>et al.</i> 2008
Britain	0.4170	0.0860	0.0300	0.4670	Khattak <i>et al.</i> 2008
Saudi Arabia	0.2400	0.1700	0.0400	0.5200	Khattak <i>et al.</i> ,2008
India	0.1885	0.3250	0.0990	0.3875	Khattak <i>et al.</i> ,2008
Turkey	0.1220	0.1213	0.0085	0.7398	Akbas <i>et al.</i> . 2003.
Hungary	0.2766	0.1218	0.0423	0.5593	Tuaszik,1995
Kuwait	0.1608	0.1400	0.0265	0.6678	Al-Bustan <i>et al.</i> 2002
Nairobi ,Kenya	0.1580	0.1261	0.0239	0.6900	Lyko <i>et al.</i> 1992
Sudan	0.1814	0.1235	0.0268	0.6683	Khalil <i>et al.</i> 1989
Gujrat .Pakistan	0.1740	0.2229	0.0435	0.5596	Anees and Mirza, 2005
Ogbomoso .Nigeria	0.2290	0.2130	0.0590	0.5000	Bakare <i>et al.</i> 2006
Benin,Nigeria	0.2372	0.2009	0.0297	0.5322	Enosolease and Bazuaye,2008
Ibadan ,Nigeria	0.2160	0.2140	0.0280	0.5420	Omotade, <i>et al.</i> 1999
Portharcourt (Nigeria)	0.2290	0.1710	0.0484	0.5516	Jeremiah ,2006
Lagos (Nigeria)	0.2530	0.1670	0.0270	0.5530	Adeyemo and Soboyejo ,2006
Adamawa(Nigeria)	0.1650	0.2130	0.1170	0.5060	Abdulazeez, <i>et al.</i> 2008
Nigeria	0.2443	0.2388	0.0275	0.4894	Falusi, <i>e t al.</i> 2006
Northern Nigeria	0.2305	0.2995	0.0440	0.4660	Kulkarni <i>et al.</i> 1985
Ilorin (Nigeria)	0.1870	0.1760	0.0560	0.5810	This study

Table 5: Allele Frequency of Rh blood groups studied in different populations across the world.

Population	Rh +	Rh -	References
Mandi Bahaiddin(Pakistan)	0.9140	0.0860	Anees <i>et al.</i> 2007
Britain	0.8300	0.1700	Khattak <i>et al.</i> 2008
U.S.A	0.8500	0.1500	Khattak <i>et al.</i> 2008
Kenya	0.8030	0.1970	Lyko <i>et al.</i> 1992
Saudi Arabia	0.9300	0.0700	Khattak <i>et al.</i> 2008
Germany	0.9500	0.0500	Akbas <i>et al.</i> 2003.
India	0.9445	0.0550	Khattak <i>et al.</i> 2008
Lagos(Nigeria)	0.9400	0.0600	Adeyemo and Soboyejo ,2006
Ogbomoso (Nigeria)	0.9670	0.0330	Bakare <i>et al.</i> 2006
Benin (Nigeria)	0.9388	0.0603	Enosolease and Bazuaye,2008
Adamawa (Nigeria)	0.9740	0.0260	Abdulazeez <i>et al.</i> 2008
Portharcourt (Nigeria)	0.9677	0.0323	Jeremiah , 2006
Ibadan (Nigeria)	0.9500	0.0480	Omotade, <i>et al.</i> 1999
Nigeria	0.9430	0.0570	Falusi, <i>et al.</i> 2006
Ilorin (Nigeria)	0.9550	0.0450	This study

Table 4 represents the percentage frequencies of ABO and Table 5 represents allelic frequency of Rh antigens .We have attempted to compare our study with few earlier studies done in some parts of the world populations. We observed that the frequency of blood O group was higher than that of the other blood groups and that Rh+ was predominant in all the population studied so far.

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REFERENCES.

Abdulazeez A.A, Alo E.B and Rebecca S.N (2008). Carriage rate of Human Immunodeficiency Virus (HIV) infection among different ABO and Rhesus blood groups in Adamawa state, Nigeria *Biomedical Research* 2008; 19 (1): 41-44

Adeyemo, A and Soboyejo, O. B. (2006). Frequency distribution of ABO, RH blood groups and blood genotypes among the cell biology and genetics students of University of Lagos, Nigeria *Afri J. of Biotechnol.* 5 (22), 2062-2065

Ahmed, S.G. and S.O. Obi (1998). The incidence of ABO and rhesus-D blood groups in northeast Nigeria. *Nig. J. Med.*, 7: 68-70.

Ahmed, S.G., B.A. Umar, A.T. Saidu and B. Jolayemi (2004). Pattern and clinical significance of ABO and rhesus-D red cell phenotypes among blood donors in Birnin Kudu, Nigeria. *Borno. Med. J.*, 1: 1-6.

Ahmed, S.G., M.B. Kangu and U.A.M. Abjah (2009). The role of du testing in scaling down the burden of Rhesus-D negative transfusion in Northern Nigeria. *Int. J. Third World Med.*, Vol. 8 Number 2

Ahmed, S.G., U.A. Ibrahim and A.W. Hassan (2007). Adequacy and pattern of blood donations in northeast Nigeria: The implications for blood safety. *Ann. Trop. Med. Parasitol.*, 101: 725-731. PMID: 18028734

Akbas, F., Aydin, M. and Cenani, A. 2003. AB0 blood subgroup allele frequencies in the Turkish population. *Anthropol. Anz.* 61:257-60.

Akhigbe, R.E., S.F. Ige, A.O. Afolabi, O.M. Azeez, G.J. Adegunlola and J.O. Bamidele (2009) . Prevalence of

haemoglobin variants ABO and rhesus blood groups in Ladoke Akintola University of Technology, Ogbomoso, Nigeria. *Trends Med. Res.*, 4: 24-29. DOI: 10.3923/tmr.2009.24.29

Al-Bustan, S., El-Zawahri, M., Al-Azmi, D. and Al-Bashir, A.A. (2002). Allele frequencies and molecular genotyping of the ABO blood group system in a Kuwaiti population. *Int. J. Hematol.* 75:147-53

Amundadottir L, Kraft P, Stolzenberg-Solomon RZ, Fuchs CS, Petersen GM, Arslan A.A et al.(2009).Genome-wide association study identifies variants in the ABO locus associated with susceptibility to pancreatic cancer. *Nature Genetics.* 2009; 41(9):986-90.

Anees M.and Shabir Mirza M. (2005).Distribution of ABO and Rh blood group alleles in Gujrat region of Punjab, Pakistan *Proc. Pakistan Acad. Sci.* 42(4):233-238.

Anees, M, Jawad A.and Hashmi,I (2007) . Distribution of ABO and Rh blood group alleles in Mandi Bahauddin district of Punjab, *Pakistan Proc. Pakistan Acad. Sci.* 44(4):289-294.

Bakare, A.A., M.A. Azeez and J.O. Agbolade (2006) . Gene frequencies of ABO and rhesus blood groups and haemoglobin variants in Ogbomosho, South-West Nigeria. *Afr. J. Biotechnol.*, 5: 224-229.

Cartron, J.P. (1994) . Defining the Rh blood group antigens. *Biochemistry and molecular genetics. Blood Rev.*, 8:199-212.

Enosolease M.E and G.N (2008). Distribution of ABO and Rh-D blood groups in the Benin area of Niger-Delta: Implication for regional blood transfusion *Asian J Transfus Sci.* 2008 January; 2(1): 3–5. doi: 10.4103/0973-6247.39502.

Falusi, A.G., Ademowo, O.G., Latunji, C.A., Okeke, A.C., Olatunji, P.O., Onyekwere, T.O, et al (2000). Distribution of ABO and Rh genes in Nigeria. *Afr. J. Med. Sci.* 29:23-6.

Greenwell, P. (1997): Blood group antigens: Molecules seeking a function. *Glycoconjugate J.* 14: 159-173.
Hussain A, Shiekh S.A, Haider M, Rasheed T, Malik M.R (2001).Frequency of ABO and Rh blood groups in population of Balouchistan (Pakistan). *Pak Armed Forces Med J*; 51:22–26

Khattak ,I. D , Khan ,T.M , Syed P, Shah, A.M , Khattak ,S.T, Ali ,A (2008) . Frequency of ABO and Rhesus blood groups in district Swat, *Pakistan J Ayub Med Coll Abbottabad* 2008; 20(4).

Jeremiah, Z.A. and Odumody,C (2005) . Rh antigens and phenotype frequencies of

the Ibibio, Efik, and Ibo ethnic nationalities in Calabar, Nigeria. *J. Blood Group Serol. Educ. Immunohematol.*, 21:21-24

Jeremiah Z.A. (2006). Abnormal haemoglobin variants, ABO and Rh blood groups among students of African descent in Port Harcourt, Nigeria, *African Health Sciences* 6 (3):177-181

Khalil, I.A., Phrykian, S. and Farr, A.D. (1989). Blood group distribution in Sudan. *Gene Geogr.* 3:7-10.

Khan, M.N., I. Khaliq, A. Bakhsh, M.S. Akhtar and M. Amin-ud-Din (2009). Distribution of ABO and Rh D blood groups in the population of Poonch District, Azad Jammu and Kashmir. *East Mediterr Health J.*, 15: 717-721.

Kulkarni, A.G., B. Peter, R. Ibazebo, B. Dash and A.F. Fleming, (1985). The ABO and Rhesus groups in the North of Nigeria. *Ann. Trop. Med. Parasitol.*, 79: 83-88.

Lyko, J., Gaertner, H., Kaviti, J. N., Karithi, M.W. and Akoto, B. 1992. The blood groups antigens ABO and Rh in Kenyans. *Hamdard Medicus*35:59-67.

Omotade, O.O., A.A. Adeyemo, C.M. Kayode, S.L. Falade and S. Ikpeme (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.

Russell, P.J. (1998). Population Genetics In: Genetics. 5th Edn., The Benjamin Cummings Publishing Company, Inc. USA. pp: 714-771.

Strickberger, M.W. (1976). Dominance relations and multiple alleles in diploid organisms. 2nd Edn., McMillan Publishing Company. Inc., NewYork, pp: 164-18

Talib, V.H. (1991). *Handbook of medical laboratory technology.* 2nd edition. CBS publishers. New Delhi,India., pp. 205-210.

Tuaszik, T. (1995). Hetrogeneti in the distribution of ABO blood groups in Hungary. *Gene Geogr.* 9:169-176.

Van der Schoot, C.E., G.H. Tax and R.J. Rijnders, (2003) . Prenatal typing of Rh and Kell blood group system antigens: The edge of a watershed. *Transfus Med. Rev.*, 17: 31-44.

Wagle, Sameer, and Prashant G. Deshpande. "Hemolytic Disease of Newborn." *eMedicine*. Eds. Itani Oussama, et al. 09 April. 2010. Medscape. 09 April. 2010 available at <http://emedicine.medscape.com/article/974349-diagnosis> Wagner, F.F., Kasulke, D., Kerowgan, M. And Flegel,

W.A. 1995. Frequencies of the blood groups ABO, Rhesus D category VI. Kell and of clinically relevant high frequency antigens in Southwestern Germany. *Infusions her Transfusions med.* 22:285-290

Yan, L., Zhu ,F., Fu Q. and He J. (2005). ABO, Rh, MNS, Duffy, Kidd,Yt, scianna, and colton blood group systems in indigenous Chinese. *Immunohematology*, 21:10-14.

Yousaf, M., Yousaf N.and Zahid,A. (1988). Pattern of ABO and Rh (D) blood groups distribution in Bahawalpur Division. *Pak. J. Med. Res.*, 27: 40-41.