

The Heterogeneity and Prevalence of ABO and RH D Antigens in the Voluntary Blood Donors of Kenya

Rachel Githiomi^{1,2}, Kennedy Muna², Naomi Waiganjo³

¹Kenya National Blood Transfusion Service (KNBTS)

²Mount Kenya University (MKU)

³Technical University of Kenya (TUK)

Abstract: Blood groups (antigens) are proteins, glycoproteins or glycolipids inherited surface markers on the red blood cell membranes, which determine the blood phenotypes of human beings. There are 36 blood group systems with over 300 antigens. Among them, ABO and Rh are of clinical significance. For a safe transfusion, a blood donor and recipient should be ABO and Rh D compatible. The heterogeneity of ABO and RhD blood groups systems shows variations in different parts of the world. In Kenya, there is limited study done on ABO and Rh D blood groups heterogeneity among blood donors. The aim of this study was to determine the heterogeneity and prevalence of ABO and Rh D blood groups among voluntary blood donors in Kenya, which is fundamental for compelling management of blood bank stocks. The study sites were, Nairobi, Mombasa, Kisumu, Nakuru, Eldoret, Embu, Meru, Garrisa, Nyeri, Machakos, Thika, Voi, Malindi, Kericho, Kisii, Narok, Bungoma, Kitale, Lodwar and Busia. The presence of blood groups was determined by serological techniques both microtitre and tube methods. Commercial monoclonal antisera (anti-A, anti-B, anti-D and Antihuman globulin) were used. Descriptive statistics and Chi-square were applied in data analysis and results were presented in tables. The results showed that there was a statistical significance difference $p < 0.01$ between the positive and negative blood types in both the ABO and Rh D systems. Blood group O (51.75%); positive (46.75%), negative (3.5%), weak D (1.5%), followed by A (24.25%), positive (23.25%), negative (0.5%), weak D (0.25%). B (18.75%), positive (17.25%), negative (1%), weak D (0.25%) and the least is AB at 5.5%; positive (5.5%), negative (0%), weak D (0%). Among the RhD system, D positive was the most common (93%), followed by D negative (5%) and weak D was the least common (2%). This study recommends an extended study with a large sample size and to include heterogeneity of other blood groups of clinical significance.

Keywords: ABO, RHD, weak D, Microtitre, Anti Human Globulin (AHG) monoclonal antibodies, Heterogeneity, prevalence

List of Abbreviations and Acronyms

AHG	– Anti Human Globulin
D ^u	– Weakened form of Rh D antigen
ICT	– Indirect Coombs Test
EDTA	– Ethylenediaminetetraacetic acid
G/MLS	– Grams per decilitres
HDFN	– Haemolytic Disease of the Fetus and the New Born
HTR	– Haemolytic Transfusion Reaction
KNBTS	– Kenya National Blood Transfusion Service
RBCs	– Red Blood Cells

1. Introduction

Blood groups (antigens) are inherited surface markers on the red blood cells membrane. These antigens are proteins, glycoproteins or glycolipids on the red cell membrane surface; they determine blood phenotypes of human beings. Blood groups systems consist of single or more antigens which are governed by a solitary gene locus or by homologous genes (Daniel, 2002). They were first discovered in 1901 by Karl Landsteiner (Nobel Prize Winner) when he saw that plasma from a few people agglutinated red cells from others but failed to agglutinate others thus he named the blood as; A, B and O. Afterwards, Decastello and Sturli added a fourth group AB (Landsteiner, 1901; Daniels, 2002). Forty years later, Levine and Stetson depicted the Rh blood amass framework. This was while they were investigating a Haemolytic Transfusion Reaction (HTR) in a woman who reacted to a blood transfusion from her husband (Scott 2004; Levine *et al.*, 1939). ABO and Rh

blood group systems are of clinically significance in transfusion medicine because they are can cause Haemolytic Transfusion Reactions (HTRs) and Haemolytic disease of the fetus and the newborn plus transplant rejection (Daniels *et al.*, 2010). By 2016, up to 346 antigens have been described of which 306 are clustered within 36 blood group systems. The remaining 38 antigens are yet to be assigned to any known blood group systems (Story *et al.*, 2016).

Before 1950s human blood groups were known as pattern of inheritance that could only be detected serologically. As of 1950s, biochemical analysis aided in revealing the structure of carbohydrate and protein antigen, which resulted in describing the functions of some blood group antigens. Some of these surface markers are now known to have specific functions such as membrane transporters seen in Diego (anion transporter), Kidd (urea transporter), and the Colton (water channel), receptors expressed by Duffy, complement regulatory glycoproteins seen in Cromer and

Volume 6 Issue 9, September 2017

www.ijsr.net

Licensed Under Creative Commons Attribution CC BY

Knops, enzymatic function as observed with MN antigen. Functions of the Rh proteins and the Rh-associated glycoproteins RhAG proteins is not yet fully understood, but many assumptions have been made due to their structural characteristics of membrane transporters suggesting their involvement in ammonium transport or in maintaining the symmetry of the phospholipid in the red cell membrane. Many suggestions have been made to indicate that the Rh proteins are involved in CO₂ and O₂ transportation. However, all these assumptions are un-confirmed (Daniel, 2002; Daniel et al., 2010).

Most of the 36 defined blood groups systems exhibit the null phenotype, which is associated with lack of specific blood group antigen expression on the red cell membranes. The null phenotype is detected serologically by absence of agglutination with specific antisera. Molecular analysis has revealed that the null phenotypes is caused by mutations including; deletions, missense mutations, frame shift mutations, introns splice-site and promoter mutations which cause lack of antigen expression on the surface of the red cell. The null phenotypes are rare but clinically significant. Individuals with null phenotypes are at risk of immunization due to transfusion of incompatible blood or pregnancy via fetal maternal haemorrhage. Variation of antigen expression has also been reported which is caused by nucleotide duplications and hybrid gene as seen in weak or/and partial RhD (Daniels et al., 2010; Wagner et al., 2000; Wagner et al., 2007).

2. Materials and Methods ABO and RhD Typing

A total of 400 anonymous left over blood samples collected in EDTA vacutainers were randomly sampled from 20 registered KNBTS sites. The whole blood samples were typed serologically by use of commercially acquired monoclonal antisera at national blood grouping laboratory at KNBTS. Both microtitre and tube grouping methods were employed. Forward typing of the samples was done in the microtitre plate by mixing 1 drop of 2% red blood cells saline suspension that was prepared in normal saline with 1 drop of the appropriate antisera (anti-A, and anti-B).

Reverse grouping was done using the microtitre plate method by mixing 1 drop of plasma of the whole blood samples with 1 drop of known A,B, and O red blood cells. Rh typing was accomplished by mixing 1 drop of 3% red cell saline suspension with 1 drop of anti-D in the microtitre plates. All the microtitre plates and contents were loaded into the microtitre plate centrifuge and spun at 2000rpm for 1 minute. The microtitre plates contents were locked for 1 minute and examined using a magnifying glass mirror for agglutination. The Rh D negative blood samples were retyped using the tube method and confirmed for Du positive using indirect antihuman globulin test tube method.

3. Results

The results showed that there was a statistical significance difference $p < 0.01$ between the positive and negative blood

types in both the ABO and Rh D systems. Blood group A (24.25%), positive (23.25%), negative (0.5%), weak D (0.25%) as shown in tables 1, 2, & 3. B (18.75%); positive (17.25%), negative (1%), weak D (0.25%), (tables 4, 5, & 6). Blood group was O (51.75%); positive (46.75%), negative (3.5%), weak D (1.5%) tables; 7, 8 & 9). The least was AB (5.5%) and all were positive table 10 & 11. Among the RhD system, D positive was the most common (93%), followed by D negative (5%) and weak D was the least common (2%) tables 12 and 13.

Table 1: A phenotype Heterogeneity

Blood Type	Number	%
A	97	24.25
Total	400	100

Table 2: A phenotype variation across the ABO phenotypes

	A Phenotype	
	N	%
Total	97	100.0
Variation	2.87	100.0

Table 3: Differences between A Phenotype Categories

ABO blood group System		A blood group Categories		Total
		A Positive	A Negative	
Positive	N	95	0	95
	%	100	0	97.94
Negative	N	0	2	2
	%	0	100	2.06
Total		95	2	97
		100	100	100
Pearson χ^2 (1) = 97.0000 Pr < 0.001				

Table 4: Blood group B variation across the ABO Blood groups

	B	
	Number	%
Total	74	100.0
Variation	5.38	100.0

Table 5: Blood group B in percentages

Blood Type	Number	%
B	74	18.5
Total	400	100

Table 6: Blood type B categories variations

ABO blood group System		B blood group Categories		Total
		B Positive	B Negative	
Positive	N	70	0	70
	%	100	0	94.59
Negative	N	0	4	4
	%	0	100	5.41
Total		70	4	74
		100	100	100
Pearson χ^2 (1) = 74.0000 Pr < 0.001				

Table 7: Frequency of blood group O in percentages

Blood Type	Number	%
O	207	51.75
Total	400	100

Table 8: Blood group O variation

	O	
	Number	%
Total	207	100.0
Variation	2.98	100.0

Table 9: Blood group O categories Differences

ABO blood group System		O blood group Categories		Total
		O Positive	O Negative	
Positive	N	193	0	193
	%	100	0	93.24
Negative	N	0	14	14
	%	0	100	6.76
Total		193	14	207
		100	100	100

Pearson chi² (1) = 207.0000 Pr <0.001

Table10: Blood group AB distribution in Percentages

Blood Type	Number	%
AB	22	5.5
Total	400	100

Table11: AB phenotype Variation

	AB	
	N	%
Total	22	100.0
Variation	0.73	100.0

Table 12: RhD blood group Variation

RHD	Number	%
RHD Positive	372	93
RHD Negative	20	5
Weak D	8	2
Total	400	100

Table 13: RhD categories variation

RhD Positive	RhD Negative				Total
	Zero	One	Two	Three	
16	0	0	0	1	1
17	0	0	1	1	2
18	0	3	2	0	5
19	3	5	0	0	8
20	4	0	0	0	4
Total	7	8	3	2	20

Pearson chi² (12) = 30.6220 Pr = 0.002

4. Discussion

Knowledge of blood group ABO heterogeneity is very important in planning for recruitment of voluntary blood donors in a country. It is also essential in the management of blood stocks be it in the transfusing facilities or the national blood service activities. Typing donors and recipients blood for ABO antigens is essential in blood transfusion, genetic research, organ transplantation, settling paternity disputes, and in cases of immunisation complications (Ahuja, *et al.*, 2015; Rashaduz, *et al.*, 2015; Dennis, 2010).

The finding of this study analysis revealed that A phenotype heterogeneity was 97 (24.25%) in the donor population. Further, the analysis of the 97 samples indicated a variation of 2.87 across the ABO blood groups. There was a statistical significance difference (p<0.001) between the A positive

and A negative blood phenotypes in the ABO system. The outcome of other studies from different countries have also shown a wide difference in the A phenotype heterogeneity; In Kurd 37.2% (positive 29.99%, and negative 2.75%). Ethiopia A prevalence is 32.74%. (Alemu, *et al.*; 2016; Jaff, 2010). Different patterns of A phenotype have also been observed in other parts of the world (Agrawal, *et al.*, 2014; Ahuja, *et al.*, 2015; Rashaduz, *et al.*, 2015; Periyavan, *et al.*, 2010). In Delhi India, the A phenotype heterogeneity was recorded as 24.66% (Ahuja, *et al.*, 2015). The Delhi outcome was almost similar to the findings of this study of 24.25%. The frequency of the A phenotype in UK was recorded as 43% of which A positive was 36.6% and A negative was 6.5% respectively (Learoyd, *et al.*; 2009; Daniels, *et al.*; 2010). This is to mean that in the ABO system, individuals who are of A phenotype are either A positive or A negative.

The study outcome revealed that the variation of blood group A in the Kenyan donor population is 18.5% with a variation of 5.38 across the ABO blood groups. These results were further categorized into two; B positive which showed 17.5% and 1% B negative. There was a statistical significance difference p<0.001 between the B positive and B negative categories in the ABO blood group system.

According to studies from other countries, wide variations were also recorded in the B phenotype. In UK, blood group B was recorded as 9%. B positive 7.6 % and negative as 1.4% (Learoyd, *et al.*; 2009). In Ethiopia, record showed that B type was 20.9% (Alemu, *et al.*, 2016). Among the Kurd population, B blood group was 23.84% (Jaff, 2010). India recorded 32.26% of blood B type (Agrawal, *et al.*, 2014), 36.4% was recorded in Western Rajasthan (Behra, *et al.*, 2013), 34.15% in Bangladesh (Rashaduz, *et al.*, 2015), 32.73% in Delhi (Ahuja, *et al.*, 2015) and 29.95% in Bangalore (Periyavan, *et al.*, 2010). This was also shown by studies carried out in UK, Ethiopia, and Kurd (Learoyd, *et al.*, 2009; Daniel, *et al.*, 2010; Alemu, *et al.*, 2016; Jaff, 2010). Studies carried out in India showed that blood group B was the most common in that population (Agrawal, *et al.*, 2014; Behra, *et al.*, 2013; Rashaduz, *et al.*, 2015, Dennis, 2010; Ahuja, *et al.*, 2015; Periyavan, *et al.*, 2010).

The study outcome revealed that the frequency of blood group O was 51.75% (207/400) with a variation of 2.98 across the ABO blood groups. This outcome was further separated into O positive and O negative categories. The O positive was 193 (48.25%), negative were 14 (3.5%). The outcome also indicated that there was a statistical significance difference p<0.001 between the O positive and negative categories in the ABO blood system. The results showed a slight variation in the blood group O frequency when compared to other studies. Studies from other countries such as UK, Kurd, Ethiopia also showed different frequency patterns of blood group O. In UK, the frequency of phenotype O was 45%. Among the 45% O blood type, O positive was shown to be 38.25%, negative 6.75% (Learoyd, *et al.*, 2009; Daniel, *et al.*, 2010). In Kurd O phenotype frequency was 37.16% of which O positive was 34.03%, and O negative 3.13% (Jaff, 2010). Studies from India showed that O blood group frequency was 37.1% (Agrawal, *et al.*, 2014). The frequency of O phenotype among the Ethiopians was 42.1% (Alemu, *et al.*, 2016), and 30.42% in Delhi

(Ahuja, *et al.*, 2015). The study results revealed that blood group O was the most common blood phenotype in Kenya. This compares well with other studies carried out in UK, Ethiopia and Kurd.

The study outcome also indicated that AB type was 22 (5.5%) with a variation of 0.73 among then ABO blood groups. The study results grouped all the AB blood type in the AB positive category. Most studies carried out in different countries also recorded variation in the distribution of AB blood group. In UK, AB phenotype distribution was shown to be 3%, AB positive was 2.5%, and negative was 0.5% (Learoyd, *et al.*, 2009). Study outcome from Kurds indicated that AB was 6.35% in the donor population. Among Kurd population AB distribution pattern, 6.02% was AB positive and 0.33% negative (Jaff, 2010). In an Ethiopian study, AB distribution pattern was 4.3% (Alemu, *et al.*, 2016). In the Indian population, the AB blood phenotype distribution pattern ranges from 6.3% in Western Rajasthan (Behra, *et al.*, 2013) to 12.2% in Delhi (Ahuja, *et al.*, 2015)

The study has indicated that there was variation in the RhD system. RhD positive was 93%, negative was 5% and weak D was 2%. There was a statistical significance difference $p < 0.001$ between the D positive and D negative. Studies from UK indicated that 85% of the population was D positive and 15% D negative (Learoyd, *et al.*, 2009). In Ethiopia, 92.8% was of D positive and 7.3% negative (Alemu, *et al.*, and 2016). Study from Albania indicated that the Rh D positive was 89.0%, 10.86% negative and 0.14% weak D (Xhetani.M, *et al.*, 2013). In Indian, D antigen variation was shown to range from 91.7% -94.61% (Behra, *et al.*, 2013; Agrawal, *et al.*, 2014). The outcome of this study has shown that the Rh D antigens variation and prevalence differs in different parts of the world.

5. Conclusion

The study revealed that there is heterogeneity in the ABO and RhD blood groups.

6. Recommendation

There is need to expand this study to incorporate more samples and also to determine if the heterogeneity exhibited by the ABO and RhD phenotypes exists in other blood group antigens that may be of clinical significance.

7. Disclosure

The authors declare no conflict of interest relating to this study.

8. Acknowledgement

Kenya National Blood Transfusion Service and its entire staff, Mount Kenya University, Technical University, my family and all the voluntary blood donors in Kenya

References

- [1] Agrawal A, Tiwari AK, Mehta N, Bhattacharya P, Wankhede R, Tulsiani S, Kamath S (2014). ABO and Rh (D) group distribution and gene frequency; the first multicentric study in India. *Asian Journal of Transfusion Science*, 8(2), 121-125. <http://doi.org/10.4103/0973-6247.137452>.
- [2] Ahuja K, Satapathy RK, Singh V, Singh S (2015). Prevalence and distribution of ABO & RH-(D) antigens in Delhi-National Capital.
- [3] Alemu G, Mama M (2016). Assessing ABO/Rh blood group frequency and association with asymptomatic malaria among blood donor attending Arba Minch blood bank, south Ethiopia. <http://doi.org/10.1155/2016/80433768>.
- [4] Avent ND, Reid EM (2009). The Rh blood group system: a review. *Blood* 2000; 95: 375-387
- [5] Behra DR, Joshi D YR (2013). Distribution of ABO Blood Group and Rh (D) Factor in Western Rajasthan. *National Journal of Medical Research*, 3 (1), 73- 75.
- [6] Cid J, Lozano M, Fernández Avilós F, Carreras E, Pereira A, Mazzara R, Ordinas A (2006). Anti-D alloimmunisation after D-mismatched allogeneic hematopoietic stem cell transplantation in patients with hematologic diseases.
- [7] *Transfusion*, 46: 169-173. Doi:10.1111/j.1537-2995.2006.00698.x
- [8] Contreras M, De Silva M, Teasdale P, Mollison, PL (1987). The effect of naturally occurring Rh antibodies on the survival of serologically incompatible red cells. *British Journal of Haematology*, 65: 475-478. Doi:10.1111/j.1365-2141.1987.tb04153.x
- [9] Daniels G, *et al.* (2007). Fetal RhD genotyping. A more efficient use of anti-D immunoglobuline. *Transfusion Clinique et Biologie* 2007; 14: 568-571 Daniels, G. (2002). *Human blood groups*. 2nd edn. Oxford: Blackwell Science Ltd, Daniels, G. (2005). *The molecular genetics of blood group polymorphism*.
- [10] *Transplant immunology* 2005; 14: 143-153
- [11] Daniels G, Brommillo I (2010). *Essential Guide to Blood Groups* 2nd edn Willey-Blackwell Ltd,
- [12] Dean L (2005). *Blood Groups and Red Cell Antigens*. [Internet] Bethesda (MD): National Center for Biotechnology Information (US); 2005. Chapters 5 & 7: The red cell Antigens, ABO and the Rh blood groups. Accessed on 25/03/2016.
- [13] Dennis, ON (2010). *Modern Human Variation; Distribution of blood types*. Denomme GA, Wagner FF, Fernandes BJ, Li W, Flegel WA (2005) Partial D, weak D types, and novel RHD alleles among 33,864 multiethnic patients: implications for anti-D alloimmunisation and prevention. *Transfusion* 45: 1554-1560. doi:10.1111/j.1537-2995.2005.00586.x
- [14] Flegel WA (2007). The genetics of the Rhesus blood group system. Review in *Blood Transfusion*. 2007; 5(2): 50-57
- [15] Flegel WA, and Wagner FF (2002). Molecular biology of partial D and weak D: Implications for blood bank practice. *Clin Lab* 2002; 48(1-2): 53-9 International Society of Blood Transfusion (ISBT) (2008) Table of blood group systems <http://ibgrl.blood.co.uk/isbt>. 25/09/2016

- [16] Gu J, Sun A-Y, Wang X-D, Shao C-P, Li Z, Huang L-H, Sun G-M (2014). Analysis of density and epitopes of D antigen on the surface of erythrocytes from DEL phenotypic individuals carrying the RHD1227Aallele. *Blood Transfusion*, 12(2), 244-249. <http://doi.org/10.2450/2013.0091-13>
- [17] Jaff MS (2010). ABO and rhesus blood group distribution in Kurds. *Journal of Blood Medicine*, 1, 143-146.
- [18] Learoyd KR, Rogan P, Haines M (2009). An introduction to Blood transfusion Science and Blood Bank Practice; 5th Edition. British Blood Transfusion Society (BBTS). Printed in Great Britain; Manchester.
- [19] Lyko J, Gaertner H, Kaviti JN, Kariithi MW, Akoto B (1992). Blood group Systems ABO and Rh in the Kenyan Population. *Cracov*. 1992; 33(1-4):85-92.
- [20] Okrah CO, Amidu N, Sakyi SA (2008). Detection of Weak D (DU) Phenotype among Rh-D Negative Males and Females in Kumasi, Ghana *Journal of Science and Technology*, Vol. 28, No. 3, Dec., 2008 02/03/2015
- [21] Periyavan S, Sangeetha SK, Marimuthu P, Manjunath BK, Seema D M (2010). Distribution of ABO and Rhesus-D blood groups in and around Bangalore. *Asian Journal of Transfusion Science*, 4(1)41. <http://doi.org/10.4103/0973-6247.59391>
- [22] Scott ML (2004), ES05.01. The complexities of the Rh system. *Vox Sanguinis*, 87: 58-62. doi:10.1111/j.1741-6892.2004.00431
- [23] Technical Manual AABB 16th Edition 2011
- [24] *Vox Sanguinis* (2014) 107, 90-96 SHORT REPORT '2013 International Society of Blood Transfusion DOI: 10.1111/vox.12127
- [25] Wagner FF, Frohmajer A, Ladewig B, Nicole I, Cornelia B, Thomas LH, Manfred MH, Siegel and Flegel AW (2000). Weak D alleles express distinct phenotypes. 03/03/2015
- [26] Wagner FF, Eicher NI, Jørgensen JR, Lonicer CB, Flegel WA (2002). DNB: a partial D with anti-D present in central Europe. *Blood* 2002; Vol 100: 6; 2253-2256
- [27] Westhoff CM (2007). Rh complexities: serology and DNA genotyping. doi:10.1111/j.1537-2995.2007.01305.x.
- [28] Zaman R, Parvez, Jakaria MD, Sayeed M (2015). ABO and Rh-D blood group among the common people of Chittagong city corporation area of Bangladesh
- [29] Xhetani M, Seferi I, Førec C, Zoraqi G, Fichou Y (2014). Distribution of Rhesus blood group antigens and weak D alleles in the population of Albania. *Blood Transfusion*, 12(4), 565-569. <http://doi.org/10.2450/2014.0240-13>