

# Distribution of blood groups in the Iranian general population

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We report the first study of antigen and phenotype prevalence within various blood group systems in the Iranian general population. In this retrospective study, samples from 3475 individuals referred to the Immunohematology Reference Laboratory of the Iranian Blood Transfusion Organization, Tehran, Iran, for paternity testing from 1998 to 2008 were additionally tested for red blood cell (RBC) antigens in the Rh, Kell, Kidd, Duffy, MNS, Lutheran, P1PK, and Xg blood group systems. The antigen testing was performed by the tube method, and the phenotype prevalences were expressed as percentages. Of 3475 (1857 male and 1618 female) blood samples, 1268 samples were typed as group O (36.49%), 1115 as group A (32.09%), 823 as group B (23.68%), and 269 as group AB (7.74%). In our sample population, 3152 (90.71%) samples were D+ and 323 (9.29%) were D-. Analysis of Rh antigen typing results showed e (3359; 96.66%) to be most prevalent in the Iranian population, followed by D (3152; 90.71%), C (2677; 77.04%), c (2557; 73.58%), and E (1059; 30.47%). In the Kell blood group system, 3293 (94.76%) samples were typed as K-k+. For the Kidd and Duffy blood group systems, the following were the most common phenotypes: Jk(a+b+) (1703; 49%), Jk(a+b-) (1006; 28.95%), Fy(a+b+) (1495; 43.02%), and Fy(a+b-) (1005; 28.92%). In the MNS blood group system, the following were the most common phenotypes: M+N+ (1668; 48%), M+N- (1310; 37.70%), S+s+ (1564; 45%), and S-s+ (1392; 40.06%). In the Lutheran and P1PK blood group systems, Lu(a-b+) and P1+ phenotypes were observed in 3292 (94.73%) and 1966 (56.58%) samples, respectively. The Xg antigen was present in 1953 (56.20%) samples versus 1522 (43.80%) samples identified as Xg(a-). Knowledge of the prevalence of RBC antigen phenotypes in a population can be useful in databank creation for providing antigen-negative compatible blood to patients with multiple alloantibodies. *Immunohematology* 2016;32:135-139.

**Key Words:** blood group systems, red blood cell antigens, phenotype prevalence, MNS, ABO, Rh, Kell, Kidd, Duffy

The nine major blood group systems include ABO, Rh, Kell, Kidd, Duffy, MNS, P1PK, Lewis, and Lutheran.<sup>1,2</sup> Identifying blood group antigens is very important in blood transfusion and organ transplantation to minimize major transfusion reactions.<sup>3,4</sup> Determining the prevalence of red blood cell (RBC) antigens of various blood groups in first-time voluntary blood donors would help us obtain insight into blood group distribution in a geographic population. This information can also help us lay the foundation for starting a databank of antigen-negative blood, which would aid in the prevention of

transfusion reactions in alloimmunized patients.<sup>5</sup> There are some studies limited to ABO and Rh blood groups,<sup>6-10</sup> but other than one older study of blood group distribution,<sup>11</sup> no current data are available on RBC antigens and phenotype prevalence in Iran. The present study is the first comprehensive report of the prevalence of various RBC antigens and phenotypes of various blood groups in the Iranian general population.

## Materials and Methods

This retrospective study was carried out using the data from 3475 individuals referred for paternity testing during a period of 10 years (from 1998 to 2008) to the Immunohematology Reference Laboratory (IRL) of the Iranian Blood Transfusion Organization (IBTO), Tehran, Iran, to derive information on the population prevalence of antigens and phenotypes in ABO, Rh, and seven other major blood group systems.

## Ethical Considerations

This study was approved by the ethics committee of IBTO and its health services. Individuals were asked to sign an informed consent form before blood samples were obtained. All the terms of the Helsinki Declaration were met, and the personal information remained anonymous.

## Sample Size

The sample size included all blood samples from individuals referred to the national forensic laboratory in Tehran, Iran, and the IRL of IBTO. During these 10 years, blood samples were collected and tested independently in two centers.

## Blood Samples

### TESTING FOR ABO AND RH ANTIGENS

Six milliliters of peripheral blood was drawn from each person into a vial containing ethylenediaminetetraacetic acid (EDTA) anticoagulant. Blood samples were collected under aseptic conditions from an antecubital vein for determination of blood group antigens. Initial ABO blood grouping was

determined by the tube method using commercially prepared antisera provided by Iranian Blood Research and Fractionation [IBRF], Tehran, Iran. The presence of D was determined serologically using reagents from IBRF. Weak-D testing was performed on samples initially tested as D-. Repeat ABO and D testing for blood group confirmation was performed by the conventional tube method as per our standard operating procedure using monoclonal reagents from different commercial companies: anti-A (Bio-Rad, Munich, Germany), anti-B (Bio-Rad), and anti-D (CE-Immumodiagnostika, Heidelberg, Germany). Testing for the presence of the weak-D phenotype was done on all samples typed as D- as per manufacturer's instructions. The tube method using a 2–5 percent RBC suspension and monoclonal Rh antisera (anti-C, anti-c, anti-E, and anti-e, Diamed AG, Cressier sur Morat, Switzerland) as per the manufacturer's instructions was performed for the common Rh antigens (C, E, c, e). A reaction range of 1+ to 4+ agglutination indicated the presence of the corresponding antigen. The absence of agglutination was confirmed macroscopically per the manufacturer's instructions indicating the antigen's absence.

#### TESTING FOR KELL, KIDD, DUFFY, MNSs, LUTHERAN, P1, AND Xg ANTIGENS

Cells with either the presence or absence of the antigens to be tested were selected from an in-house screening cell panel that was validated with commercial panel cells (Diace, Diamed AG). These cells were used as positive and negative controls to ensure expected reactivity of antisera to be used in the testing.

#### INTERPRETATION OF TUBE TESTING RESULTS:

**Positive:** Various-sized clumps of RBCs on the bottom of the tube, graded from 1+ to 4+, indicated the presence of the corresponding antigen.

**Negative:** A smooth RBC suspension after re-suspension of cells on the bottom of the tube indicated the absence of the corresponding antigen.

#### Statistical Analysis

RBC antigen and phenotype prevalence within the various blood group systems was calculated by totaling the number of individuals positive for a particular antigen or phenotype divided by the total number of individuals screened. Results are expressed as a percentage.

## Results

The prevalence of different blood group antigens and phenotypes in a total of 3475 (1857 male and 1618 female) individual samples was compared.

### ABO and Rh Blood Group Systems

The breakdown of results for ABO blood grouping was 1268 (36.49%) typed as group O followed by 1115 (32.09%) as group A, 823 (23.68%) as group B, and 269 (7.74%) as group AB. D phenotype prevalence analysis showed 3152 (90.71%) D+ individuals and 323 (9.27%) D- individuals. In total, among D+ individuals, group O (1148; 33.06%) was found to be most prevalent followed by groups A (1014; 29.19%), B (743; 21.41%), and AB (247; 7.11%). Among D- individuals, blood groups O (128; 3.7%) and A (107; 3.10%) were the most common, followed by groups B (75; 2.17%) and AB (13; 0.62%). Testing for Rh antigens found Rh5(e) (3359; 96.66%) to be most prevalent of the common Rh antigens in this Iranian population, followed by Rh1(D) (3152; 90.70%), Rh2(C) (2677; 77.04%), Rh4(c) (2557; 73.58%), and Rh3(E) (1059; 30.47%). Nine probable Rh phenotype combinations were found to be present in our D+ population; the most common phenotype was DCE/dce (R<sub>1</sub>r; 873; 27.70%) (Tables 1 and 2).

### Other Blood Group Systems

In the Kell blood group system, 3293 (94.76%) samples were typed as K-k+. The Kp(a+b-) phenotype was rarely found. In the Kidd and Duffy blood group systems, Jk(a+b+) (1670; 48.06%) and Fy(a+b+) (1466; 42.19%) were the most common phenotypes observed. Jk(a-b-) and Fy(a-b-) were found as rare phenotypes in the Kidd and Duffy blood group systems, respectively. M+N+ (1660; 47.77%) and S+s+ (1569; 45.15%) were the most common phenotypes observed in the

**Table 1.** Prevalence of D+ phenotypes in the Iranian study population (N = 3152)

Antigens present	Phenotype		Prevalence (%)
	Fisher-Race	Modified Weiner	
D Cc e	DCE/dce	R <sub>1</sub> r	27.70
D C e	DCE/DCe	R <sub>1</sub> R <sub>1</sub>	22.38
D Cc Ee	DCE/DcE	R <sub>1</sub> R <sub>2</sub>	14.59
D c Ee	DcE/dce	R <sub>2</sub> r	10.35
D c E	DcE/DcE	R <sub>2</sub> R <sub>2</sub>	2.30
D c e	Dce/dce	R <sub>0</sub> r	1.78
D C Ee	DCE/DCe	R <sub>2</sub> R <sub>1</sub>	0.08
D Cc E	DCE/DcE	R <sub>2</sub> R <sub>2</sub>	0.01
D C E	DCE/DCE	R <sub>2</sub> R <sub>2</sub>	0.008

**Table 2.** Prevalence of D- phenotypes in the Iranian study population ( $N = 323$ )

Antigens present	Phenotype		Prevalence (%)
	Fisher-Race (assumed)	Modified Weiner	
c e	dce/dce	rr	9.59
Cc e	dCe/dce	r'r	1.95
c Ee	dcE/dce	r''r	0.45
Cc Ee	dCe/dcE	r'r''	0.05
C e	dCe/dCe	r'r'	0.04
c E	dcE/dcE	r''r''	0.001
C Ee	dCE/dCe	r'y'r'	Rare
CE	dCE/dCE	r'y'r'y	Rare
Cc E	dCE/dcE	r'y'r''	Rare
Cc Ee	dCE/dce	r'y'r	Rare

MNS blood group system. In the Lutheran and P1PK blood group systems, Lu(a-b+) and P1+ phenotypes were observed in 3292 (94.73%) and 1966 (56.58%) samples, respectively. The rare phenotype Lu(a-b-) was observed in none (0%) of the samples. The Xg antigen was identified in 1953 samples (56.20%), versus 1522 (43.80%) samples that typed as Xg(a-) (Table 3).

## Discussion

In our study, blood group O was the most prevalent, followed by groups A, B, and AB. According to some studies, in the United States, group O is the most prevalent, followed by groups A, B, and AB.<sup>12</sup> Klein and Anstee<sup>13</sup> showed that the most common blood groups in Australians were O and A. These results are in line with our findings. According to a previous Iranian study, blood group O was the most common.<sup>14</sup> The prevalence is different between that study and ours (41% vs. 36%). In contrast, in some other studies of populations in other countries,<sup>3,15-18</sup> blood group B was most prevalent. According to Tomilin et al.,<sup>19</sup> blood group A was the most prevalent group in the Russian Federation.

In our study, the targeted population showed D- prevalence of 9 percent, as compared with 17 percent in Britain and 4.29 percent in India.<sup>20,21</sup> This result suggests that the expected rate of Rh isoimmunization would be lower in our population than that encountered in the British population. Studies have reported that in the United States, 85 percent of the population were found to be D+.<sup>22</sup> The prevalence of D- individuals varies from 20 percent to 40 percent in Basque populations to 0 percent to 1 percent in Japanese, Chinese, Burmese, Melanesian, Mauri, American Indian, and Eskimo populations.<sup>3</sup>

**Table 3.** Prevalence of phenotypes in various blood group systems in the Iranian study population ( $N = 3475$ )

System	Phenotype	Prevalence (%)
Kell	Kp(a-b+)	99
	K-k+	95
	K+k+	4.8
	Kp(a+b+)	0.8
	K+k-	0.2
Kidd	Kp(a+b-)	Rare
	Jk(a+b+)	49
	Jk(a+b-)	29
	Jk(a-b+)	22
Duffy	Jk(a-b-)	Rare
	Fy(a+b+)	43
	Fy(a+b-)	29
	Fy(a-b+)	28
MNS	Fy(a-b-)	1
	M+N+	48
	M+N-	38
	M-N+	14
	S+s+	45
	S-s+	40
	S+s-	15
S-s-	0	
Lutheran	Lu(a-b+)	91
	Lu(a+b+)	6
	Lu(a+b-)	3
	Lu(a-b-)	0
P1PK	P1+	67
	P1-	33
Xg	Xg(a+)	58
	Xg(a-)	42

The worldwide prevalence of D differs between ethnic groups—from 85 percent in white populations to 92 percent in black populations.<sup>23,24</sup> In the present study, we found the prevalence of D to be 91 percent.

We report for the first time the prevalence of other common antigens in the Rh system, including C, c, E, and e, in a general Iranian population. We found e to be the most prevalent Rh antigen in this population. DCE/dce ( $R_1r$ ) was the most common phenotype in the D+ population versus dce/dce (rr) in that of the D-. In previous studies on Thai and Chinese individuals, CDE/ $CDe$  ( $R_1R_1$ ) has been reported to be of the highest prevalence.<sup>25</sup> Nanu and Thapliyal also found DCE/ $CDe$  ( $R_1R_1$ ) to be the most common phenotype in that population.<sup>26</sup> The prevalence of cde/cde (rr) varies among different ethnic groups. It was reported in 35 percent of white individuals, 26 percent of black individuals, and in only 3 percent of individuals of Asian descent.<sup>27-30</sup>

In the Kell system, the most common phenotype in our population was found to be K-k+ (95%), which is found in 100 percent of peoples from Southeast Asia.<sup>27</sup> The prevalence of K+k- in this study was 0.2 percent. None of the individuals of the Thakral et al. study<sup>5</sup> were found to be K+k-. The rarest phenotype in our study was Kp(a+b-), whereas Kp(a+b+) was found to be rare in the Thakral et al. study population.<sup>5</sup> This shows that a rare phenotype in a certain population does not necessarily imply rarity of that phenotype in another population.

In the Duffy system, Fy(a+b+) and Fy(a-b-) were the most common and the rarest phenotypes, respectively. According to Agarwal et al.,<sup>15</sup> Fy(a-b-) was rare in Indian and white populations, although it was common in a black population. In virtually all Indian studies, Fy(a+b+) was the most common phenotype in the white population.<sup>15</sup> *Plasmodium vivax* is endemic to India, and therefore we expect India to have a high prevalence of the Fy(a-b-) phenotype because the Duffy antigen has been proposed to be the receptor for entry of *P. vivax* into red blood cells.<sup>31</sup> Lack of this phenotype in studies from India could be attributable to fewer *P. vivax* infections. In Iran, thanks to preventive measures and treatment protocols, malaria has been eradicated, and this may account for the low prevalence of the Fy(a-b-) phenotype in our population.

Jk(a+b+) was the most common Kidd phenotype in our study. Nathalang et al.<sup>27</sup> reported similar findings in Asian and Thai populations. Moreover, Jk(a-b-) has rarely been found.

In our study, the M+N+ phenotype was the most common in the MNS blood group system. In the Nanu and Thapliyal study, the M+N- phenotype was reported to be the most common.<sup>26</sup>

S+s+ was the most common phenotype in our study. In other studies, S-s+ has been reported as the most common phenotype.<sup>5,15</sup> Further, the M+N+S+s+ phenotype was reported to be the most common by Nanu and Thapliyal, as well as in people of European descent and in African Americans.<sup>26,32,33</sup> In our population study, M+N+S+s+ was found to be the most common phenotype. It is possible that in areas where heterozygous phenotypes are most prominent, less alloimmunization occurs. In these areas, the value of a donor database might be in question.

In the Lutheran system, Lu(a-b+) was the most common phenotype found in our study, which is true for most of the populations around the world.<sup>15</sup> In our study, there also was no one with the Lu(a-b-) phenotype. Lu(a-b-) was reported as a very rare phenotype in the study by Thakral et al.<sup>5</sup>

In the P1PK system, P1+ was the most common phenotype in our study. Musa et al.<sup>34</sup> demonstrated that

Malays and Chinese populations had high prevalence of the P1- phenotype, whereas the Indian population had higher prevalence of P1+. A lower prevalence of the P1- phenotype was reported among Thai individuals.<sup>35</sup>

In our study, the Xg(a+) phenotype was found as the most common phenotype in the Xg blood system. The distribution of the Xg antigen in our sample population is comparable with that reported in the Daniels study.<sup>36</sup>

## Conclusions

We reported on the distribution of various blood group antigens and phenotypes among a general Iranian population. The study has a vital impact on the management of blood bank and transfusion services in this area. Knowledge of blood group antigen distribution is also important for clinical studies, for worldwide reliable geographical information, and for forensic research in various populations.

## References

- Daniels G, Castilho L, Flegel W, Fletcher A, Garratty G, Levine C, et al. International Society of Blood Transfusion Committee on Terminology for Red Blood Cell Surface Antigens: Macao report. *Vox Sang* 2009;96:153-6.
- Smart E, Armstrong B. Blood group systems. *ISBT Sci Ser* 2008;3:68-92.
- Khattak ID, Khan TM, Khan P, Shah S, Khattak ST, Ali A. Frequency of ABO and Rhesus blood groups in District Swat, Pakistan. *J Ayub Med Coll Abbottabad* 2008;20:127-9.
- Khurshid B, Naz M, Hassan M, Mabood S. Frequency of ABO and Rh (D) blood groups in district Swabi NWFP (Pakistan). *J Sc Tech Univ Peshawar* 1992;16:5-6.
- Thakral B, Saluja K, Sharma RR, Marwaha N. Phenotype frequencies of blood group systems (Rh, Kell, Kidd, Duffy, MNS, P, Lewis, and Lutheran) in north Indian blood donors. *Transfus Apher Sci* 2010;43:17-22.
- Pourfathollah A, Oody A, Honarkaran N. Geographical distribution of ABO and Rh (D) blood groups among Iranian blood donors in the year 1361 (1982) as compared with that of the year 1380 (2001). *Sci J Iran Blood Transfus Organ* 2004;1:11-7.
- Boskabady M, Shademan A, Ghamami G, Mazloom R. Distribution of blood groups among population in the city of Mashhad (North East of Iran). *Pak J Med Sci* 2005;21:194-8.
- Paridar M, Shoushtari MM, Kiani B, Nori B, Shahjehani M, Khosravi A, et al. Distribution of ABO blood groups and rhesus factor in a large scale study of different cities and ethnicities in Khuzestan province, Iran. *Egyptian J Med Hum Genet* 2016;17:105-9.
- Ghobadian Z, Sayemiri K, Zeinali M, Sajjadi SM. Distribution of ABO and Rh blood groups in a major ethnic group of the West Iran, the Kurdish population. *Asian J Med Sci* 2014;5:26-9.
- Nojavan M, Shamsasenjan K, Movassaghpour AA, Akbarzadehlaleh P, Torabi SE, Ghojzadeh M. Allelic

- prevalence of ABO blood group genes in Iranian Azari population. *BioImpacts* 2012;2:207.
11. Farhud D, Eftekhari A. Blood groups distribution in Iran. *Iranian J Public Health* 1994;23:1–10.
  12. Frances T. Blood groups (ABO groups). Common laboratory and diagnostic tests. 3rd ed. Philadelphia, PA: Lippincott, 2002:19–5.
  13. Klein HG, Anstee DL, eds. ABO, H, LE, P1PK, GLOB, I and FORS blood group systems. In: Mollison's blood transfusion in clinical medicine. 12th ed. Oxford, UK: John Wiley & Sons, 2014:119.
  14. Marzban M, Kamali M, Hosseinbasi T. Blood groups of the people of Ahwaz, Iran. *Anthropologischer Anzeiger* 1988;46:83–9.
  15. Agarwal N, Thapliyal RM, Chatterjee K. Blood group phenotype frequencies in blood donors from a tertiary care hospital in north India. *Blood Res* 2013;48:51–4.
  16. Rahman M, Lodhi Y. Frequency of ABO and Rhesus blood groups in blood donors in Punjab. *Pak J Med Sci* 2004;20:315–8.
  17. Khan MS, Subhan F, Tahir F, Kazi BM, Dil AS, Sultan S, et al. Prevalence of blood groups and Rh factor in Bannu region NWFP (Pakistan). *Pak J Med Res* 2004;43:8–10.
  18. Hamed A, Hussain W, Ahmed J, Rabbi F, Qureshi J. Prevalence of phenotypes and genes of ABO and rhesus (Rh) blood groups in Faisalabad, Pakistan. *Pak J Biol Sci* 2002;5:722–4.
  19. Tomilin V, Gurtovaia S. [The incidence of finding ABO system antigens in the population of the Russian Federation]. *Sud Med Ekspert* 1999;42:16–8.
  20. Chandra T, Gupta A. Frequency of ABO and rhesus blood groups in blood donors. *Asian J Transfus Sci* 2012;6:52.
  21. Klein HG, Anstee DL, eds. The Rh blood group system (including LW and RHAG). In: Blood transfusion in clinical medicine. 12th ed. Oxford, UK: John Wiley & Sons, 2014:170.
  22. Bashwari L, Al-Mulhim AA, Ahmad MS, Ahmed MA. Frequency of ABO blood groups in the Eastern region of Saudi Arabia. *Saudi Med J* 2001;22:1008–12.
  23. Banks RE, Stanley AJ, Cairns DA, Barrett JH, Clarke P, Thompson D, et al. Influences of blood sample processing on low-molecular-weight proteome identified by surface-enhanced laser desorption/ionization mass spectrometry. *Clin Chem* 2005;51:1637–49.
  24. Harmening DM. Modern blood banking and transfusion practices. Philadelphia, PA: FA Davis, 2012.
  25. Daniels G, Bromilow I. Essential guide to blood groups. Hoboken, NJ: John Wiley & Sons, 2011.
  26. Nanu A, Thapliyal R. Blood group gene frequency in a selected north Indian population. *Indian J Med Res* 1997;106:242–6.
  27. Nathalang O, Kuvanont S, Punyaprasiddhi P, Tasaniyanonda C, Sriphaisal T. A preliminary study of the distribution of blood group systems in Thai blood donors determined by the gel test. *Southeast Asian J Trop Med Public Health* 2001;32:204–7.
  28. Javed A, Maseer A, Nisar A, Khan G, Showkat A. The BO and Rh blood groups in Kashmiri population. *Indian J Pract Doctor* 2006;3:200–6.
  29. Reid ME, Lomas-Francis C, Olsson ML. The blood group antigen factsbook. Cambridge, MA: Academic Press, 2012.
  30. Chandanayingyong D, Bejrachandra S, Metaseta P, Pongsataporn S. Further study of Rh, Kell, Duffy, P, MN, Lewis and Gerbiech blood groups of the Thais. *Southeast Asian J Trop Med Public Health* 1979;10:209–11.
  31. Langhi DM Jr, Bordin JO. Duffy blood group and malaria. *Hematology* 2006;11:389–98.
  32. Cleghorn T. MNSs gene frequencies in English blood donors. *Nature* 1960;187:701.
  33. Race RR, Sanger R. Blood groups in man. Oxford: Blackwell Scientific Publications, 1965.
  34. Musa RH, Ahmed SA, Hashim H, Ayob Y, Asidin NH, Choo PY, et al. Red cell phenotyping of blood from donors at the National Blood Center of Malaysia. *Asian J Transfus Sci* 2012;6:3.
  35. Panigrahi I, Marwaha RK. Common queries in thalassemia care. *Indian Pediatr* 2006;43:513.
  36. Daniels G. Human blood groups. Hoboken, NJ: John Wiley & Sons, 2008.

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