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Frequencies of major blood group antigens and phenotypes among blood donors in Al-Jouf, Saudi Arabia.

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ABSTRACT

Background: Blood group antigens are a representation of some personal traits.

Objectives: To determine the frequency of ABO, Rhesus and Kell blood group phenotypes among blood donors in the Al-Jouf region, Saudi Arabia.

Materials and methods: 980 donors were included in retrospective study design. Data was collected from blood donor records from July 2022 to January 2023 at Al-Jouf Central Blood Bank. ABO, Rhesus phenotypes (D, C, E, e, c), and K antigen have been detected in the blood bank using the fully automated Bio-Rad IH-500.

Results: Regarding the ABO system, the O phenotype was the most common among the donors (approximately 45.7%), and followed by A (25.4%) and B (24.9%), while the AB group had the lowest number (4%). Analysis of Rhesus blood group phenotypes demonstrated that 89.3% of donors were Rh D positive and 10.7% were Rh D negative. Other Rhesus antigens were found in variable percentages; the e antigen was the most prevalent among donors (99.2%),followed by the c and C antigens (72.7% and 69.2%, respectively), and the E antigen was the least prevalent (22.8%). Only 0.3% of donors were positive for Cw. Accordingly, the DCce phenotype (24.9%) was the most common Rh phenotype among donors, followed by DCe and Dce (22.8% and 20.2%,respectively). CE and CEe phenotypes had the lowest prevalence among donors(0.1%). Out of 980 donors, 178 donor (18.2%) had the Kell antigen (K).

Conclusion: The most prevalent blood group among donors was O Rh D+ while the most prevalent Rhesus antigen was the e antigen. The most common Rhesus phenotype among donors was DCce. Reporting Rh phenotypes and Kell antigen (K) is extremely important from a clinical standpoint, especially during pregnancy and blood transfusions as it can improve maternal and fetal care and enhance safer blood transfusion.

Introduction

So far, 346 Red Blood Cell (RBC) antigens (Ags) have been found across 36 blood group systems. In the transfusion and transplant fields, the ABO blood group is still the most important, followed by Rhesus (Rh) and Kell.[1] According to reports, the frequency of D antigen in Saudi Arabia ranges from 84% to 91%.[2-5]

Approximately fifty distinct Rh group antigens have been found to date, with D, C, c, E, and e being the most clinically significant, creating IgG antibodies when transfusing incompatible blood or following abortion, and causing hemolytic disease of the newborn (HDN).[6,7] This happens in varied degrees of severity, with D Ag being the most immunogenic compared to antigens from Rhesus and other systems.[88] Similarly, Oladeinde and

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colleagues found that D Ag accounts for half of all cases of maternal alloimmunization with higher immunogenicity,[9] followed by c, E, C, and e antigens, and that all of these antigens mediate hemolytic transfusion reactions (HTR), particularly delayed reactions in addition to HDN. [10, 11] RhCE and RhD encode eight distinct haplotypes of the Rh system, denoted as Dce, dce, DCe, dCe, DcE, dcE, DCE, and dCE, or in shorter nomenclature: R0, r, R1, r', R2, r'', Rz, and ry. [4,12]

The Kell blood group system is regarded clinically significant after the ABO and Rh systems in transfusion medicine due to its immunogenic features. This system comprises numerous antigens (Ags), with the most common being K and k (previously known as Kell and Cellano, respectively), Kp^a, and Kp^b, all of which have immunogenic features. In most ethnicities, the k antigen is more frequent than the K antigen; 98% of Blacks and 91% of Caucasians have the K-k+ phenotype.[10,11,13] The absence of any of these antigens may elicit an immunological response following blood transfusion or abortion, resulting in the development of alloantibodies that cause hemolytic transfusion responses (HTR) and hemolytic disease of the newborn (HDN).[14]

The first Kell system antibodies found were anti-K1 (Kelleher) and anti-K2 (Cellano).[15] The clinically most relevant antigen is K (KEL1). Anti-K antibodies are second to anti-D antibodies the most frequently encountered antibodies in severe HDFN. K0 (the null phenotype), which was identified alongside Kp^a, is one of the other antigens of the Kell system. While Kp^b (K4) has high frequency mutations, Kp^a (K3) was shown to have low frequency mutations.[16]

The prevalence of the k antigen in Saudi Arabia has been reported to be greater than 99%.[14,17,18] The heterozygous form (K, k) was found to be around 17% in the Riyadh region, which is significantly varied than its prevalence in other ethnic groups,[19] such as Indians (3.5%),[20] Africans (24%),[21] and Caucasians (9%).[22]

Most cases of abnormal hemoglobin (Hb), particularly sickle and thalassemic individuals, were detected that 12-18% with alloimmunization due to blood type incompatibility.[23-25] Compared to the RhD antigen, the K antigen is approximately 8-10 times less immunogenic.[26]

In general, the incidence of red cell alloimmunization due to blood group incompatibility ranges between 2% and 10%, but it can reach 60% in specific groups of multi-transfused individuals. Phenotyping of the ABO, Rhesus, and Kell systems can decrease or prevent probable subsequent hemolytic transfusion reactions.[27]

Accurate phenotyping can improve maternal and fetal care, patient outcomes and enhance safer blood transfusion practices. Identifying the most frequent blood phenotypes aids to understand genetic variation in the region and provide prediction of allele distribution within a community.

Our study aimed to determine the frequency of red blood cell antigens and phenotypes of ABO, Rh, and Kell systems, among donors in Sakaka city, Al-Jouf, Saudi Arabia.

Materials and methods

A retrospective analysis was undertaken on blood donors at the Al-Jouf Central Blood Bank in Saudi Arabia. A total of 980 records of donors who had matched the criteria of donation and had been accepted by the blood bank were included in the study excluded repeated donors. Concerning demographic and laboratory information of ABO, Rh, and Kell system, data from July 2022 to January 2023 was collected from the blood bank electronic database.

Fully automated system technique:Bio-Rad IH-500 analyzer has been used in the blood bank to detect blood group antigens. The ID-Card DiaClon ABO/D+ Reverse Grouping (Bio-Rad,Switzerland) was used to perform both forward and reverse ABO grouping as well as Rh D. The presence or absence of the C (RH2), Cw (RH8), c (RH4), E (RH3), e (RH5), and K (KEL1) antigens was examined using the ID-Card DiaClon Rh- Subgroups+ Cw+ K.

The findings of blood groups, including ABO, Rhesus phenotypes (D, C, E, e, c), and Kell antigen (K) were analyzed using the Statistical Package for Social Sciences version 23 to find descriptive statistics as frequencies for blood groups and means±SD for age and weight.

Results

Donor demographics are listed in Table 1. Near to half of the donors were O blood group while the lowest percentage of donors was found in the AB blood group Table 2.

As shown in Table 3, the D-antigen, which is represented by 875 donors (89.3%), was more common in donors of the O blood type and less common in donors of the A, B, and AB blood groups. According to Table 4, surveillance of the major Rhesus antigens revealed that antigen e was the most prevalent (99.2%), followed by D (89.3%), C (69.2%), c (72.7%), and E (22.8%). The Kell antigen (K) was present in 178 donors (18.2%), while it was not present in 81.8% of donors. The DCce was the most common Rh phenotype (24.9%) followed by DCe (22.8%) and Dce (20.2%) at shown in Table 5. Comparison of the Rhesus antigen with other regions in Saudi Arabia shows nearly similar distribution of Rhesus antigens in Saudi Arabia except for limited regions (Table 6).

Table 1. Characteristics of donors age and weight.

	N	Minimum	Maximum	Mean (±SD)
Age (years)	980	18.00	61.00	33.4 (9.3)
Weight (kg)	980	46.00	153.00	86.7(16.1)

Table 2. Distribution of ABO Blood group among donors (N=980).

ABO	Frequency (%)
A	249 (25.4)
B	244 (24.9)
AB	39 (4)
O	448 (45.7)
Total	980

Table 3. ABO blood group and D antigen coexistence among donors.

ABO Blood group	Rhesus D antigen		Total
	Negative	Positive	
A	29	220	249
B	24	220	244
AB	2	37	39
O	50	398	448
Total	105	875	980

Table 4. Expression of e, D, c, E, C, KELL-antigen expression in donors (N=980).

Antigen	Reaction	Frequency	%
e	neg	8	0.80
	pos	972	99.2
D	neg	105	10.7
	pos	875	89.3
c	neg	268	27.3
	pos	712	72.7
E	neg	757	77.2
	pos	223	22.8
C	neg	302	30.8
	pos	678	69.2
K	neg	802	81.8
	pos	178	18.2

Note: neg: abscence of Ag, pos: presence of Ag.

Table 5. The percentage of Rh phenotypes and possible genotypes**.**

Phenotype	Wiener	Fisher-Race	%
DCce	R1r	DCe/ce	24.9
DCe	*R 1R1, R1r-*	*DCe/DCe*	22.8
Dce	R0r	Dce/Dce	20.2
	R0R0	Dce/ce	
DCEce	Rzr	DCE/ce	11.5
ce	rr	ce/ce	4.9
DcEe	R2r	DcE/ce	4.6
Cce	r- r	Ce/ce	2.35
DCE	RzRz	DCE/DCE	2.35
Ce	r-r-	Ce/Ce	2.14
DcE	R2R2	DcE/DcE	1.7
CcEe	r-r--	Ce/cE	1.12

Table 5. The percentage of Rh phenotypes and possible genotypes. (Continued)

Phenotype	Wiener	Fisher-Race	%
DCEe	RzR1	*Rzr-, R1ry*	1.02
cEe	r--r	cE/ce	0.41
CcED	RzR2	*Rzr0, R2ry*	0.2
CE	rYrY	CE/CE	0.1
CEe	ryr-	Ce/CE	0.1

Table 6. The percentage of D, C, E, c, and e antigens in this study compared to other regions of Saudi Arabia and different ethanities.

Region/Area	Antigens (%)				
	C	E	c	e	D
Our study in Jouf	69.2	22.8	72.7	99.2	89.3
Jazan Province[7]	70.97	18.91	75.38	97.95	93.3
Women in Hail Province[36]	76.4	29.4	73.0	97.0	93.4
Eastern Region of Saudi Arabia[17]	59	21	86	97	80
Rhyadh[37]	62.3	23.5	74.3	95	84.8
Taif City[2]	62.3	31.3	81.7	95.8	87.8
In European[15]	68	29	80	98	85
Caucasian[16]	68	29	80	98	85
Blacks[21]	27	22	96	98	92
Asian[20]	93	39	47	96	99

Discussion

In terms of demographics, all members of our study population were men. Due to a number of social and cultural variables, men make up most blood donors. A comparable study conducted in central Saudi Arabia found that 82.98% of donors were men.[28]

According to our findings, the most prevalent blood group is O (45.7%), while the least common is AB (4.0%). This is consistent with a 2011 study conducted in Al-Jouf, which found that O was 39.8%, A was 27.5%, B was 25.5%, and AB was 7.3%.[29]

Additionally, our study concurred with other studies carried out in different Saudi Arabian districts.

O-RhD+ > A-RhD+ > B-RhD+ > O-RhD- > AB-RhD+ > A-RhD- > B-RhD- > AB-RhD- was the blood type frequency order in Asir.[30] The most prevalent blood group in Qassim was O+ (42%), which was followed by A+ (23.4%), B+ (20.9%), O- (5.45%), AB+ (3.4%), A- (2.8%), B- (2.1%), and AB- (0.5%).[7] The outcomes in the province of Jazan were quite similar in which A accounted for 29.44%, B for 10.44%, AB for 1.15 percent, and O for 58.97 percent.[31] Only 7.2% of ABO groups in southwestern Saudi Arabia were Rh-negative, with O accounting for 56.8%, A for 33.4%, B for 6%, and AB for 3.8%.[32] The frequency of the Rh antigens, D, C, E, c, and e is consistent with many studies in Saudi Arabia and contrasted to few ethnics worldwide (Table 6). The Rh haplotype DCe was most prevalent in Caucasians (42%), followed by Asians (70%), and Native Americans (44%). Most Black people (44%) have the Rh haplotype Dce.[33]

According to our research, DCce (24.3%) is the most common Rh phenotype. DCe was represented by about 22.8%, and Dce by 20.8%. CEe and CE phenotypes had the lowest occurrence among donors, with the latter being 0.102%. ce was the most common among Rhesus negative donors, accounting for 4.9% of all cases. Furthermore, these results are consistent with a study done in Hail found that, on average, DCcee was the most prevalent phenotype in the community (32.2%), followed by DCCee (26.6%), while Ccddee (0.8%) and CCDEe (0.2%) were the least prevalent. According to similar screening conducted at King Abdulaziz Medical City in Riyadh, DCcee was the most common Rh phenotype observed (28.7%), DCCee (24.5%), and dccee (13.7%) were the next most common Rh phenotypes, and other phenotypes were DccEe (11.5%), Dccee (8.0%), DCcEe (6.8%), DccEE (4.0%), DCCEE (0.5%) and DEE (0.5%).[35] Also, another study in Taif City found that DCce was the most prevalent phenotype (29.5%).[2] The incidence of Rh phenotypes was in line with a study in Riyadh that indicated the most prevalent phenotypes were R1r (CcDee) (31%) and R1R1 (CCDee) (22%).[35] Accordingly, it seems that the Rhesus phenotypes distribution is approximately similar in different regions of Saudi Arabia. Regarding the Cw phenotype, our study discovered that just 0.3% of donors were Cw positive, whereas 99.7% had a negative Cw phenotype.

In the current study, the frequentcy of KEL1 (K) antigen expression 178 from total donors 980 (18.2%) and this is consistent with other studies in Saudi Arabia as in Riyadh (14%),[36] Taif city (22.1%) [2] and 18.2% among

Saudi Donors at King Abdulaziz Medical City-Riyadh,[37] but this percentage decreased in other regions of the country such as the prevalence of K antigen is found to be (12.3%) among blood donors in Jeddah city[38] and (8%) in the eastern region of Saudi Arabia.[17] This modest variance between regions in Saudi Arabia could be attributed to ethnic diversity, consanguinity, or migratory patterns.

These findings provide prediction of allelic distribution in al-Jouf, Saudi Arabia.

Limitations

The study depends on records of the routine blood group testing so that phenotyping of Kell blood group was restricted to (K) antigen and other antigens not included in the study.

Conclusion

According to our findings, O-RhD+ blood types are the most common among donors in Al-Jouf, Saudi Arabia whereas AB blood types are the least common. The e antigen is the most common Rhesus antigen and the most common phenotype among donors was DCce.

Ethical approval

This study was approved by the Institutional Research Ethics Committee, Qurayyat Health Affairs in Aljouf. (Approval number/protocol number_2023-53.

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Conflicts of interest

The authors declare there are no conflicts of interest.

CRediT authorship contribution statement

Sanaa Hussein: research design and manuscript preparation; **Maram Alruwili, Dina Alruwaili, Layali Alruwaili, Wasan Alblaihed, Joury Alsarrah:** data collection, data analysis; **Motea Eskandar, Kamal Alruwaili, Hamoud Alruwaili, Fadia ALruwaili:** laboratory analysis, analysis coordinating and data reviewing; **Abozer Elderdery:** main role in editing the manuscript; **Fawaz Alenazy, Albadawi Talha:** manuscript writing and layout of results reviewing. Final version of the manuscript was reviewed and approved by All authors.

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