Clin. Lab. 2026;72:XXX-XXX

ORIGINAL ARTICLE

ABO and Rhesus (D, C, c, E, and e) Antigen Frequencies Among Blood Donors in Saudi Arabia

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ABSTRACT

Background: **Knowledge of blood group antigen frequencies in a population is essential for the efficient working of transfusion services. This study aimed to report the frequencies of ABO antigens and the 5 main Rhesus (Rh) antigens (D, C, c, E, and e) in Saudi Arabian blood donors.**
Methods: **Blood samples were collected in EDTA tubes from 6,188 blood donors for determination of ABO and Rh blood group antigens and Rh phenotypes over a 6-month period. The testing was done using the TANGO Optimo automated blood bank analyzer system. The criteria for selection of blood donors were according to the recommendations of the Saudi Central Board for Accreditation of Healthcare Institutions (CBAHI).**
Results: **Blood donors aged 17 - 60 years with a mean age of 30 ± 6 years were included in this study. The ABO frequencies observed in this study were as follows: A, 26.5%; B, 19.2%; O, 48.2%, and AB, 6.1%. In the Rh system, the e antigen (97.2%) was the most frequent antigen, followed by D (91.3%), c (77.7%), C (69.2%), and E (29.1%). The most common phenotype found was R_1r (32.7%), followed by R_1R_1 (22%). Presence of C antigen was more common in D-positive donors (75.8%) compared to D-negative donors (8%), while 99.4% of the D-negative donors were c-positive.**
Conclusions: **The observed frequencies and distribution of ABO and Rh antigens in Saudi Arabs are different from the reported results for white people, Asians, and black people. Knowledge about the frequency and phenotype distribution of red cell antigens would help in providing antigen-negative compatible blood for patients with multiple alloantibodies and will also help the blood banks in improving their inventory management.**
(Clin. Lab. 2026;72:xx-xx. DOI: 10.7754/Clin.Lab.2025.251009)

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Manuscript accepted October 15, 2025

KEYWORDS

blood group antigens, ABO system, Rh system, frequency, phenotype

INTRODUCTION

Knowledge of various blood group antigen frequencies in a population is important for providing compatible and matched blood to the patients. Matching for ABO and Rhesus (Rh) blood groups is one of the primary and

essential steps for providing safe blood transfusion and avoiding transfusion reactions in blood recipients.

After the ABO blood group system, the complex and polymorphic Rh system is the next clinically significant blood group system [1,2]. Rh system antigens have commonly been implicated in causing hemolytic disease of the newborn (HDN), delayed transfusion reactions, and alloimmunization [2,3]. Alloimmunization to antigens of the Rh system is a serious consequence of blood transfusion and is commonly seen in multi-transfused patients with sickle cell anemia (SCA), thalassemia, patients on renal dialysis, and oncology patients [4-6]. This leads to subsequent complications and difficulties in the provision of compatible blood. The five principal antigens (D, C, E, c, and e) are responsible for the majority of Rh incompatibilities; however, the system is more complex, and antigen numbers through Rh58 have been assigned [7]. Antigens of the Rh system are highly immunogenic, with D antigen inducing an immune response in around 80% of the D-negative subjects when transfused with 200 ml of D-positive blood [3].

Establishing the frequencies of blood group antigens is important as it would help to determine the distribution of these antigens in this population and help the blood banks in the region to provide antigen-negative compatible blood to the patients quickly and efficiently. The ABO and Rh D frequencies from this region have been reported in a few smaller studies; however, data on the main antigens of the Rh system are scanty. This study aimed to report the frequencies of ABO and Rh antigens and Rh phenotypes in blood donors from the Central region of the Kingdom of Saudi Arabia (KSA).

MATERIALS AND METHODS

Study participants

This study was conducted on blood samples from donors attending the blood donation center at King Khaled University Hospital, a tertiary care hospital in Riyadh, over a 6-month period. The blood samples from 6,188 voluntary and replacement blood donors were collected in EDTA tubes for determination of the ABO and Rh blood groups and Rh phenotypes. The criteria for selection of blood donors were according to the recommendations of the Saudi Central Board for Accreditation of Healthcare Institutions (CBAHI) [8].

The study was approved by the institutional review board, and all participants provided informed consent.

Antigen testing

The ABO and the five Rh antigens were determined using the TANGO Optimo automated blood bank analyzer system (Bio-Rad Laboratories, Hercles, CA, USA), which uses the principle of solid plate technology. The phenotypes for Rh system are presumed phenotypes, as the genotyping for these antigens was not done.

Statistical analysis

The data were analyzed by the statistical package SPSS, version 18. Simple statistics were used in the form of percentages and frequencies.

RESULTS

Six thousand one hundred and eighty-eight blood donor samples were typed for ABO and five main Rh antigens. The donors were in the age range of 17 - 60 years, with a mean age of 30 ± 6 years. The O antigen was most common in the ABO group, followed by A, B and AB antigen. Among the Rh antigens, e antigen (97.2%) was the most common, followed by D (91.3%) and c (77.7%) antigen. The frequencies of the ABO antigens, along with the frequencies of the five main Rh antigens, are summarized in Table 1. The frequencies of the antigens were also compared with the data from Caucasian, Black, and Asian populations, as shown in Table 1.

The frequency of the Rh antigens was also determined separately for D-positive and D-negative donors. Among the D-positive donors, 75.8% also expressed the C antigen, while 99.4% of the D-negative donors were c-positive. In the D-negative group, the expression of C was seen only in 8% of the donors. The frequencies of different Rh antigens in the D+ and D- donors are shown in Table 2.

Twelve probable Rh phenotypes were found to be present in our population; however, no cases of R_zR_z were found. The most common phenotype seen was R_1r (32.7%), followed by R_1R_1 (22%). Frequencies of the Rh phenotypes are given in Table 3.

DISCUSSION

The blood group antigens and phenotype frequencies show a wide variation depending on the population being studied [9-11]. The ABO and Rh antigens are the most important antigen systems in transfusion medicine [12-14]. Knowledge of the ABO frequencies in the population is important as the antibodies against these antigens are naturally occurring and lead to serious hemolytic reactions, which can be fatal. In addition, the Rh system antigens have been commonly implicated in causing delayed transfusion reactions and alloimmunization [2,3]. Alloimmunization to Rh system antigens is a serious consequence of blood transfusion and more commonly seen in multi-transfused patients.

To our knowledge, this is the largest study reporting the frequency of ABO and Rh antigens and Rh phenotypes from the Central region of the Kingdom of Saudi Arabia (KSA). The ABO frequencies observed in our study were found to be: A, 26.5%; B, 19.2%; O, 48.2%; and AB, 6.1%. These frequencies are similar to those reported by earlier studies from Saudi Arabia [15-18]. The A antigen showed a decreased expression as compared to that in the Caucasian population and is rather

Table 1. Frequencies (%) of ABO and Rh blood group antigens in the present study (donors) compared with the published data from other populations.

Antigen	Saudi donors	Caucasians [7]	Blacks [10]	Asians [9]
O	48.2	44	49	43
A	26.5	43	27	27
B	19.2	9	20	25
AB	6.1	4	4	5
D	91.3	85	92	99
C	69.2	68	27	93
E	29.1	29	22	39
c	77.7	80	96	47
e	97.2	98	98	96

Table 2. Frequency of Rh antigens in D+ and D- Saudi Arabian blood donors.

Gene	Antigen	Antigen frequency in D+ donors (%) n = 5,651 (91.3%)	Antigen frequency in D- donors (%) n = 537 (8.7%)
C	C+	75.8	8
E	E+	31.7	2
c	c+	75.7	99.4
e	e+	97.0	99.6

Table 3. Comparison of Rh phenotype frequencies (%) in this study compared with the published results from other populations [7].

Antigen	Phenotype	Saudi donors	Caucasians	Asians	Blacks
CcDe	R1r	32.7	34.9	8.5	21
CDe	R1R1	22	18.5	51.8	2
CcDEe	R1R2	14.3	13.3	30	4
cDEe	R2r	11.8	11.8	2.5	18.6
cDE	R2R2	2.6	2.3	4.4	0.2
CcDE	R2Rz	0.1	0.1	0.4	rare
cDe	R0r	7.6	2.1	0.3	45.8
CDEe	R1Rz	0.2	0.2	1.4	rare
CDE	RzRz	0	0.01	rare	rare
cde	rr	7.9	15.1	0.1	6.8
Ccde	r'r	0.6	0.8	0.1	rare
cdEe	r"r	0.1	0.9	rare	rare
CcdEe	r'r"	<0.01	0.05	rare	rare

similar to that reported for Blacks [1,7,11]. The B blood group expression in Saudi donors is similar to that reported for other countries in the Arabian Gulf region [19-22]. The frequency of blood group B is higher in Africa as well as in the Indian subcontinent [1,10,11]. The AB blood group was present in 6% of our donors, which is more common than seen in the Caucasian population [7] (Table 1).

ABO blood groups are also important as they have been associated with some diseases, although no diseases have been conclusively linked to a patient's ABO blood group. Nevertheless, some controversial associations, like gastric cancer being more common in group A and peptic ulcer being more common in group O individuals, have been described [23-25]. One of the most significant disease associations with non-group O subjects is susceptibility to arterial and venous thromboembolism [25,26]. This could be related to the fact that the levels of factor VIII and von Willebrand factor are ~ 25% less in group O individuals when compared to non-group O subjects [26,27].

The incidence of D antigen in the present study was found to be 91.3%, which is similar to other studies from the same region [15-18,23]. Table 1 shows the frequencies of the antigens of the Rh system in our population compared with the published results from other populations. The e antigen (97.2%) showed the highest frequency, followed closely by the D antigen (91.3%) and c antigen (77.7%) [23]. These frequencies bear similarity to the Caucasian population, and there are significant differences in the C and c allele expression when compared with some of the Asian populations [1,7].

There were 12 presumable Rh phenotypes reported among our donors (Table 3). The R_1r phenotype was found to be the most common, followed by R_1R_1 and R_1R_2, and this is similar to what has been reported for the Caucasian population [1,7]. No cases of R_zR_z phenotype were detected. The R_0r phenotype is the most common phenotype in Black people, but in our donor population only 7.6% had this phenotype. In a study by Thakral et al, R_1R_1 was the most common phenotype found among North Indian donors [9].

Antigen expression of C and E showed a marked difference in D-negative and D-positive donors. It was observed that 75.8% of D-positive donors are also C-positive, while 99.4% of the D-negative donors were c-positive. Information regarding the phenotype frequencies is very helpful in locating antigen-negative units quickly and efficiently; for example, the chances of finding a C-negative and E-negative unit are better when screening the D-negative units, while the chances of finding a c-negative unit are more likely in D-positive units.

Autosomal recessive diseases are relatively common in this part of the world as consanguineous marriage rates exceed 50% [24,25]. As a result of which thalassemia and sickle cell disease (SCD) have a high prevalence in KSA. The carrier state for SCD ranged from 2% to 27% in studies from different regions, and in some areas, up to 1.4% of individuals had SCD [26-31]. A study by Castro et al., looking at the rates of alloimmunization among SCD patients while following various phenotype matching protocols, showed that the provision of blood matched only for ABO and Rh antigens decreased the incidence of developing antibodies by 37.2%. With the addition of matching for Kell antigen, development of antibodies was further reduced by 52.9% [32].

Differences in the RBC antigen profile of the donor and the recipient have been postulated to be the most important reason for allosensitization [33-36]. Transfusion therapy for patients with alloantibodies is complicated by various issues such as the need to identify the antibodies and providing antigen-negative compatible blood to avoid immediate and delayed transfusion reactions [37-39]. Having an idea about the phenotypic frequencies in the population would help in predicting the chances of locating a compatible unit without delay and help the blood banks across the region to manage their inventories more efficiently.

Limitations

Although this study is one of the largest studies on ABO and Rh antigen frequencies in KSA, it has certain limitations, which include data being collected retrospectively from a single center in the Riyadh area, which means it may not represent blood group antigen frequencies in other regions of the country.

CONCLUSION

To our knowledge, this is the largest study of ABO and Rh antigen frequencies in the Central region of KSA. Significant differences in the pattern of ABO and Rh antigen frequencies were found in our study as compared with other populations. This information would help avoid delays in arranging specific antigen-negative blood, especially for multi-transfused alloimmunized patients, and help the blood banks maintain efficient inventories.

Source of Funds:

This research was funded by the ongoing research funding program (ORF-2026-2181) of King Saud University, Riyadh, Saudi Arabia.

Ethical Approval Statement:

The study was approved by the Institutional Review Board of King Saud University, Riyadh, Saudi Arabia. All donors gave informed consent. The study adhered to the principles of the Declaration of Helsinki, 2013.

Data Availability Statement:

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declaration of Generative AI in Scientific Writing:
The authors declare that no AI was used in the preparation of this manuscript.

Declaration of Interest:
The authors have no conflict of interest to declare.

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