

Profiling the ABO and Rh (D) Antigen Frequencies among Blood Donors in Nangarhar

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ABSTRACT

Knowledge of ABO and Rh (D) blood-group distribution is essential for effective blood-bank management, transfusion planning, and emergency preparedness. Regional variation in blood-group frequencies necessitates population-specific data. This study aimed to determine the frequency of ABO and Rh (D) blood groups and describe the sociodemographic characteristics of blood donors in three major public hospitals in Jalalabad city, Nangarhar Province, Afghanistan. This retrospective descriptive cross-sectional study included 70,890 eligible blood donors based on complete records extracted from blood-donor registers of Nangarhar Regional Hospital, Nangarhar University Teaching Hospital, and Fatima Zahra Provincial Hospital from 01/01/1401 to 30/12/1403. Data on age, sex, marital status, residence, employment status, type of donation, ABO blood group, and Rh (D) status were analyzed using the Statistical Package for the Social Sciences (SPSS), version 27.0. The mean age of donors was 32.02 ± 5.86 years. Males constituted 96.1% (68,128) and females 3.9% (2,762). Most donors were single (68.9%), urban residents (84.2%), and voluntary donors (91.1%). Blood group B was the most prevalent ABO blood group at 32.2% (22,828), followed by O at 29.1% (20,616), A at 26.7% (18,965), and AB at 12.0% (8,481). Rh(D) positivity was observed in 90.31% (64,023) of donors, while 9.69% (6,867) were Rh(D)-negative. The most common ABO/Rh(D) blood-group combination was B-positive at 28.8% (20,410), followed by O-positive at 26.9% (19,046) and A-positive at 24.1% (17,077). Blood group B and Rh(D)-positive status predominated among the blood donors included in this study. These findings provide important baseline data for transfusion services and may support region-specific blood-inventory planning and donor-recruitment strategies.

Keywords: ABO, Antigens, Blood, Groups, Nangarhar, Rh antigen.

INTRODUCTION

Blood group types are genetically inherited and are defined by specific surface antigens present on red blood cells (RBCs), which are crucial in ensuring compatibility during blood transfusions (Dharshan et al., 2025). Currently, the International Society of Blood Transfusion (ISBT) recognizes 33 distinct blood group systems comprising more than 300 identified antigens. The ABO blood group system holds the utmost significance in transfusion medicine and was the first to be identified. This pivotal medical discovery was made by Karl Landsteiner in 1900, when he noted that “the serum of healthy individuals not only agglutinates animal red blood cells but also induces agglutination in human red blood cells from other individuals (Khade et al., 2025). In 1902, Alfred von

Decastello and Adriano Sturli identified and named the AB blood group. Later, in 1940, Karl Landsteiner and A.S. Weiner introduced the Rhesus (Rh) blood group system. Based on the existence or absence of the Rh antigen on the surface of red blood cells, individuals are categorized as either Rh-positive or Rh-negative (Woldu et al., 2022).

Large-scale blood donor studies reveal patterns in the distribution of ABO and Rh(D) blood groups across diverse regions. In Addis Ababa, Ethiopia among 1,700 volunteer donors, group O was most prevalent at approximately 44.7%, followed by group A at 28.4%, B at 21.2%, and AB at 5.7%. Rh(D)-positive donors accounted for 94.8%, with 5.2% Rh-negative (Debele et al., 2023). In the Kilimanjaro region of Tanzania (2017–2019), among 65,535 first-time donors, O was again

dominant (~52 %), followed by A (~24 %), B (~19–20 %), and AB (~3–5 %) in different sub-studies; Rh-negative frequency hovered around 2 % in similar East African contexts (Vuhahula et al., 2023). In the Hail region of Saudi Arabia, O comprised 44.5 %, followed by B at 26.4 %, A at 23.4 %, and AB at 5.7 %; Rh(D)-positive donors were 88.2 %, with only 11.8 % Rh-negative overall (Eltayeb, 2024). These findings show remarkable consistency: group O systematically predominates (40–52 %), AB is the rarest (3–6 %), and Rh-positive donors typically exceed 88 %, with Rh-negative percentages ranging from about 2 % to 12 % depending on region. But some studies conducted in various regions of the world reveal significant variations in the distribution of ABO and Rh blood group antigens among blood donors, influenced by ethnic and geographical factors; In Pakistan, a study conducted in District Peshawar among female donors indicated that blood group B was most prevalent (31.7%), closely followed by A (31.2%), O (27.0%), and AB (10.1%). The Rh-positive frequency was reported at 92.5%, while Rh-negative constituted 7.5% of the donors (Nazli et al., 2015). Additionally, blood donor data from Rawalpindi and Islamabad showed comparable distributions, with blood group B (32.9%) and O (31.9%) being the most common, A comprising 24.0%, and AB accounting for 11.2%, with Rh-positive donors making up 92.45%

Assessing the prevalence of ABO and Rh blood groups is essential for ensuring both the safety and effectiveness of blood transfusion practices and for preventing erythroblastosis fetalis in cases where Rh-negative mother carries Rh-positive fetus. Furthermore, research has demonstrated correlations between specific blood groups and various medical conditions, including duodenal ulcers, diabetes mellitus, Rh incompatibility, and ABO incompatibility in newborns (Kumar et al., 2018; Wolde et al., 2022). The Rhesus (Rh) blood group system is among the most intricate and highly polymorphic of all blood group classifications. The occurrence of hemolytic disease of the newborn (HDN), often resulting in stillbirth due to maternal immune responses against paternal Rh antigens, has significantly deepened our understanding of the Rh system's complexity (Pahuja et al., 2020). The primary goal of transfusion services is to guarantee a sufficient and safe supply of blood products, focusing on minimizing transfusion-transmitted infections and ensuring compatibility with recipients to avoid

alloantibody formation and adverse transfusion reactions (Nguyen et al., 2025).

Although all human populations share the same fundamental blood group systems, the distribution of specific blood group types varies considerably among different races, ethnicities, and socio-economic groups worldwide (Parvin et al., 2025). The prevalence of ABO and Rh blood groups shows marked diversity across various regions and populations. In contemporary medicine, investigating blood group frequencies serves numerous important functions. Such research, especially among blood donors, is vital for managing blood bank inventories efficiently. Additionally, beyond their role in transfusion compatibility and organ transplantation, blood group antigens are valuable in fields like genetic studies, forensic science, anthropology, and the investigation of human ancestral lineages. To avoid transfusion mismatches, it is imperative to determine an individual's blood group prior to any transfusion procedure. Understanding the distribution and availability of blood groups across different settings is critical for the proper management of blood recipients. Therefore, this study aimed to determine the frequency of ABO and Rh (D) blood groups among blood donors in three public hospitals in Jalalabad City, Nangarhar Province.

MATERIALS AND METHODS

Study design and setting

This study employed a retrospective descriptive cross-sectional design based on a review of blood donor records covering a three-year period from 01/01/1401 to 30/12/1403. The study was conducted in three public hospitals, including Nangarhar Regional Specialization Hospital, Fatima Zahra Provincial Hospital, and Nangarhar University Teaching Hospital.

Study population and sampling

The study population comprised all individuals who donated blood at the three participating hospitals during the study period and whose donor records met the eligibility criteria applied by the respective blood banks. The study used total enumeration of eligible donor records rather than a formal sampling procedure. All eligible and complete donor records available for the specified study period were included, resulting in a total of 70,890 donors. Therefore, a formal sample size calculation was not required.

Donor eligibility was determined at the time of donation according to the routine blood-donation

criteria applied at the participating hospitals, based on applicable Ministry of Public Health of Afghanistan and World Health Organization recommendations. Information regarding conditions that would preclude blood donation, including anemia, chronic illness, or transfusion-transmissible infections, was considered only when documented in the donor records. The same general donor eligibility criteria were applied routinely across the three participating hospitals. Because the study was based on existing donor registers, the investigators did not independently reassess donor eligibility or clinical status.

Inclusion criteria:

Donor records were included if the donor was aged 18–60 years, had donated blood at one of the three selected hospitals during the study period, and had complete and valid information on the required demographic and blood-group variables, including ABO and Rh (D) status.

Exclusion criteria

Records were excluded if they had missing or incomplete information on ABO or Rh (D) blood-group status or other essential study variables, or if the donor had been documented as having anemia, a chronic medical condition, or a transfusion-transmissible infection that resulted in ineligibility for blood donation.

Data collection and blood-group testing

Data were extracted from the official donor registers using a structured data-extraction form. The variables included age, sex, marital status (single or married), type of donation (voluntary or replacement), residence (urban or rural), occupation (employed or unemployed), ABO blood group, and Rh (D) antigen status.

ABO blood grouping and Rh (D) typing at the participating hospitals were routinely performed at the time of blood donation by trained laboratory technologists using the standard slide agglutination method with commercially prepared anti-A, anti-B, and anti-D reagents. For ABO typing, separate drops of anti-A and anti-B reagents were placed on a clean glass slide, and a drop of the donor's blood sample was added to each reagent and gently mixed. For Rh (D) typing, the same procedure was performed using anti-D reagent. The reactions were observed for visible agglutination within two minutes and interpreted according to standard

laboratory procedures. Visible agglutination was considered a positive reaction, whereas the absence of agglutination was considered a negative reaction.

The reagents were used according to the manufacturers' instructions and were subject to routine quality-control procedures at the participating laboratories. Appropriate positive and negative controls were used to verify reagent and test performance. Any discrepant, doubtful, or technically questionable result was repeated before the final result was entered into the donor register. The study used the blood-group results recorded in the official donor registers for subsequent data analysis.

Ethical considerations

Ethical approval for the study was obtained from the Research Committee of the Faculty of Medicine, Nangarhar University (Approval No. 11, dated 21/11/1404). Because the study involved retrospective review of existing hospital records and did not involve direct contact with donors, individual participant interaction was not required. Donor confidentiality was strictly maintained throughout data extraction, entry, analysis, and reporting. No personally identifying information was included in the analytical dataset or reported in the manuscript, and the extracted data were used solely for academic and research purposes.

Statistical analysis

The extracted data were reviewed for completeness and consistency and entered into the Statistical Package for the Social Sciences (SPSS), version 27.0, for statistical analysis. Descriptive statistics were used to summarize the characteristics of the donor population. Categorical variables, including ABO blood group and Rh (D) status, were summarized using frequencies and percentages, while continuous variables such as age were summarized using the mean and standard deviation.

RESULTS

A total of 70,890 eligible blood-donor records were included in the study based on complete records extracted from the blood-donor registers of three major public hospitals in Jalalabad city, Nangarhar Province, Afghanistan, covering the period from 01/01/1401 to 30/12/1403. Of these, 33,432 (47.2%) donors were from Nangarhar

Regional Hospital (NRH), 21,010 (29.6%) from Nangarhar University Teaching Hospital (NUTH), and 16,448 (23.2%) from Fatima Zahra Provincial Hospital (FZPH). The ABO and Rh (D) blood-group distributions were analyzed among the included donors (Figure 1).

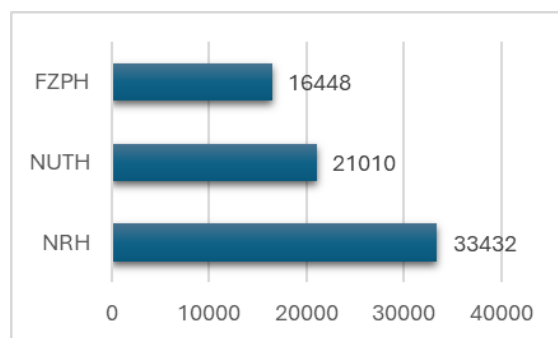


Figure 1. Number of blood donors.

NRH, Nangarhar Regional Hospital; NUTH, Nangarhar University Teaching hospital; FZPH, Fatima Zahra Provincial Hospital.

Sociodemographic features of blood donors

A total of 70,890 blood donors were included in the study. The mean age of the blood donors was 32.02 ± 5.86 years. The vast majority of donors were male, comprising 68,128 individuals (96.1%), while females accounted for only 2,762 donors (3.9%). With regard to marital status, most participants were single, with 48,790 donors (68.9%), whereas 22,100 donors (31.1%) were married. In terms of place of residence, 59,695 donors (84.2%) were from urban areas, while 11,195 donors (15.8%) resided in rural settings. Concerning employment status, 23,895 donors (33.7%) were employed, whereas a larger proportion, 46,995 donors (66.3%), were unemployed. Regarding the type of donation, voluntary donors constituted the majority, with 64,589 individuals (91.1%), while 6,301 donors (8.9%) were replacement donors (table 1).

Table 1. Sociodemographic features of blood donors.

Sociodemographic features	n (%)
Age, years ($\pm$ SD)	32.02 $\pm$ 5.86
Gender	
Male	68128 (96.1%)
Female	2762 (3.9%)
Marital status	
Single	48790 (68.9%)
Married	22100 (31.1%)
Residence	
Urban	59695 (84.2%)
Rural	11195 (15.8%)

Job status	
Employed	23895 (33.7 %)
Jobless	46995 (66.3%)
Type of donation	
Voluntary	64589 (91.1%)
Replacement	6301 (8.9%)

Distribution of ABO blood Groups

Among the 70,890 donors, blood group B was the most prevalent ABO blood group, accounting for 22,828 (32.2%) donors, followed by blood group O with 20,616 (29.1%), blood group A with 18,965 (26.7%), and blood group AB with 8,481 (12.0%) (Figure 2).

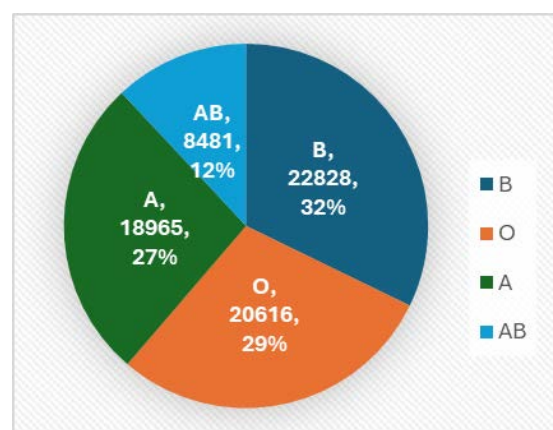


Figure 2. distribution of ABO Groups

Hospital-wise Distribution of ABO Blood Groups

The distribution of ABO blood groups varied across the three hospitals. At Nangarhar Regional Hospital (NRH), blood group B was the most prevalent, accounting for 10,658 (31.88%) donors, followed by A with 9,634 (28.82%) and O with 9,247 (27.66%); AB was the least prevalent, with 3,893 (11.64%) donors. At Nangarhar University Teaching Hospital (NUTH), blood group B was also the most prevalent, with 6,765 (32.20%) donors, followed by O with 5,895 (28.06%) and A with 5,809 (27.65%); AB was the least prevalent, with 2,541 (12.09%) donors. At Fatima Zahra Provincial Hospital (FZPH), blood group O was the most prevalent, with 5,474 (33.28%) donors, followed by B with 5,405 (32.86%) and A with 3,522 (21.41%); AB was the least prevalent, with 2,047 (12.45%) donors (Table 2).

Table 2. Hospital-wise distribution of ABO blood groups

Hospital	Blood Group	Frequency (n)	Percentage (%)
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NRH	A	9634	28.82
	B	10658	31.88
	O	9247	27.66
	AB	3893	11.64
NUTH	A	5809	27.65
	B	6765	32.20
	O	5895	28.06
	AB	2541	12.09
FZPH	A	3522	21.41
	B	5405	32.86
	O	5474	33.28
	AB	2047	12.45

NRH, Nangarhar Regional Hospital; NUTH, Nangarhar University Teaching hospital; FZPH, Fatima Zahra Provincial Hospital.

Distribution of Rh (D) antigen

Among the 70,890 donors, 64,023 (90.31%) were Rh (D)-positive and 6,867 (9.69%) were Rh (D)-negative, demonstrating a marked predominance of Rh (D)-positive donors (Figure 3).

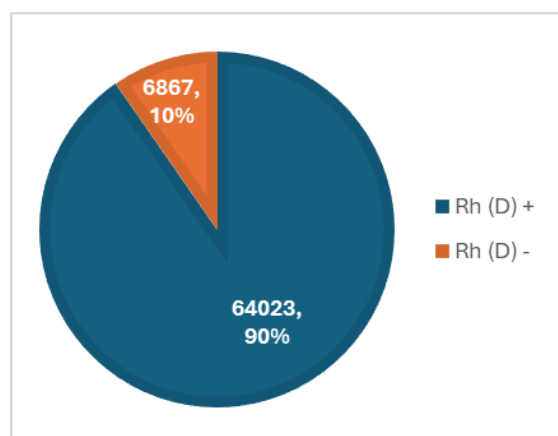


Figure 3. Distribution of Rh (D) antigen

Hospital-wise Distribution of Rh (D) antigen

Rh (D)-positive donors predominated across all three hospitals. At Nangarhar Regional Hospital (NRH), 30,005 (89.75%) donors were Rh (D)-positive and 3,427 (10.25%) were Rh (D)-negative. At Nangarhar University Teaching Hospital (NUTH), 18,971 (90.30%) donors were Rh (D)-positive and 2,039 (9.70%) were Rh (D)-negative. At Fatima Zahra Provincial Hospital (FZPH), 15,047 (91.48%) donors were Rh (D)-positive and 1,401 (8.52%) were Rh (D)-negative (Table 3).

Table 3. Hospital-wise distribution of Rh (D) antigen

Hospital	Rh (D)	Frequency (n)	Percentage (%)
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NRH	Rh (D) +	30005	89.75
	Rh (D) -	3427	10.25
NUTH	Rh (D) +	18971	90.30
	Rh (D) -	2039	9.70
FZPH	Rh (D) +	15047	91.48
	Rh (D) -	1401	8.52

NRH, Nangarhar Regional Hospital; NUTH, Nangarhar University Teaching hospital; FZPH, Fatima Zahra Provincial Hospital.

Distribution of ABO and Rh (D) Blood groups.

Among the 70,890 donors, B-positive was the most prevalent combined ABO/Rh (D) blood group, accounting for 20,410 (28.8%) donors, followed by O-positive with 19,046 (26.9%) and A-positive with 17,077 (24.1%). AB-positive accounted for 7,490 (10.6%) donors. Among Rh (D)-negative groups, B-negative was the most frequent, with 2,418 (3.4%) donors, followed by A-negative with 1,888 (2.7%), O-negative with 1,570 (2.2%), and AB-negative with 991 (1.4%) (Table 4).

Table 4. Distribution of ABO and Rh (D) Blood groups

Blood Group	Frequency (n)	Percentage (%)
A+	17077	24.1
A-	1888	2.7
B+	20410	28.8
B-	2418	3.4
AB+	7490	10.6
AB-	991	1.4
O+	19046	26.9
O-	1570	2.2
Total	70890	100%

DISCUSSION

This study aimed to evaluate the frequency and distribution of the ABO and Rh (D) blood groups among 70,890 blood donors from three public hospitals in Jalalabad city, Nangarhar Province, Afghanistan. The findings describe the blood-group distribution within this donor population and provide locally relevant information that may support blood-bank inventory management, transfusion planning, and emergency preparedness. Because the study population consisted exclusively of eligible blood donors, the observed frequencies should not be interpreted as estimates of ABO or Rh (D) distribution in the general population of Nangarhar.

In this study, blood group B was the most prevalent ABO phenotype among the donors, accounting for 32.2%, followed by groups O, A, and AB. This finding differs from the predominance of group O

reported in several populations but is consistent with some studies from neighboring South Asian populations. A systematic review of ABO and Rh (D) blood-group distributions in Pakistan reported group B as the most frequent ABO phenotype overall, with a frequency of approximately 33.4% (Rehman & Shi, 2020). Similarly, a study of 5,342 individuals in Peshawar reported group B as the most common ABO group (37.0%), followed by O, A, and AB (Riaz & Arif, 2024). This confirms a high relative B prevalence similar to the present Afghan donor group. A large donor study from Delhi, India, also reported group B as the predominant ABO phenotype (37.68%), followed by O, A, and AB (Thakur et al., 2023). These findings indicate that the predominance of group B observed among donors in the present study is comparable with patterns reported in some neighboring populations. However, differences between populations may reflect a combination of demographic, geographic, and population-specific factors, and the present study did not investigate genetic ancestry or other genetic determinants of ABO distribution. Similarly, studies from Bangladesh have similarly revealed a predominance of blood group B, with one large dataset showing B as the most frequent ABO type (around 37.8%), followed by O and A. This pattern of elevated B frequency in Bangladesh supports our findings in eastern Afghanistan and reflects a broader South Asian trend, particularly in populations that share similar ancestry and historical population migrations (Parvin et al., 2025).

In contrast to the this study, where blood group B was the most prevalent phenotype (32.2%), several recent studies from different regions have reported other ABO groups as predominant, particularly blood group O. A study from Lahore, Pakistan found blood group O (49.3%) to be the most common among donors, followed by A, B, and AB (Ghafoor et al., 2024). Similarly, a study from Bahir Dar Blood Bank in northwest Ethiopia reported O (41.5%) as the dominant blood group (Legese et al., 2021). A cross-sectional study from the Hail region of Saudi Arabia showed O (44.5%) to be the most prevalent blood group, and a large Tanzanian donor study reported an even higher predominance of O (52.4%) (Eltayeb, 2024; Vuhahula et al., 2023). These findings collectively indicate that although blood group B predominates

in the current Afghan donor population, blood group O is more commonly reported as the leading ABO phenotype in many African, Middle Eastern, and South Asian populations, underscoring marked regional and ethnic variability in blood group distribution.

In the present donor population, Rh (D) positivity was high (90.31%), while Rh (D) negativity accounted for 9.69% of donors. This predominance of Rh (D)-positive donors is consistent with findings from other donor populations. For example, a study among 1,700 volunteer blood donors in Addis Ababa reported 94.82% Rh (D)-positive and 5.18% Rh (D)-negative donors (Debele et al., 2023). Similarly, a large donor study from Delhi, India, reported 94.99% Rh (D)-positive and 5.01% Rh (D)-negative donors (Thakur et al., 2023). In contrast, other studies have reported variable Rh (D) prevalence, highlighting regional differences. A study from the Hail region of Saudi Arabia reported 88.2% Rh (D) positive donors, somewhat lower than our observed rate, suggesting slight geographic variation in Rh distribution within neighboring Middle Eastern populations (Eltayeb, 2024). Although the proportion of Rh (D)-positive donors in the present study was somewhat lower than that reported in these populations, the overall predominance of Rh (D) positivity was similar. These findings are relevant to blood-bank inventory planning within the study setting, while they should not be interpreted as representing Rh (D) frequencies in the general population of Nangarhar. Regarding residence, 84.2% of the donors in the present study were urban residents, while 15.8% were rural residents. This distribution indicates that the study donor pool was predominantly urban. A donor study from Ghaziabad, India, similarly reported a predominance of urban donors, although the magnitude differed from that observed in the present study (Kumar et al., 2024). Such differences may be related to the location of blood-collection facilities, accessibility, recruitment practices, or differences in the composition of the donor population. However, because the present study did not assess these factors directly, the high proportion of urban donors should not be interpreted as evidence that urban residents have higher blood-donation rates than rural residents in Nangarhar. In terms of age, the mean age of donors in the present study was 32.02 ± 5.86 years. This

finding is broadly comparable with donor populations reported from neighboring settings. For example, a study from the Peshawar Regional Blood Center reported that 45.6% of donors were aged 18–29 years, indicating a substantial representation of young adults among donors (Saba et al., 2021). The age distribution observed in the present study should therefore be interpreted as describing the characteristics of the participating donor population rather than the age structure of the general population of Nangarhar. Regarding donor type, voluntary donors constituted 91.1% of the donor pool, while replacement donors accounted for 8.9%. This indicates a predominantly voluntary donor model within the participating hospitals. A large study of 101,616 blood donors in northern Tanzania reported a lower proportion of voluntary donors (78.3%) and a higher proportion of replacement donors (21.7%) (Vuhahula et al., 2023). The higher proportion of voluntary donors observed in the present study may be favorable for maintaining a more stable donor base; however, differences in donor recruitment practices and health-service organization between settings should be considered when comparing these proportions. In contrast, recent data from Assam, India demonstrated that 98.14% of donors were replacement donors and only 1.86% were voluntary, representing a very different pattern from our findings and highlighting significant regional variability in donor recruitment models where family replacement remains the dominant source of blood supply (Das et al., 2025). Despite its strengths, including the large sample size and multicenter design, this study has several limitations. First, the analysis was based on retrospective blood-donor register data, which limited the availability of detailed clinical, ethnic, and genetic information that might help explain variation in ABO and Rh (D) frequencies. Second, the study population consisted exclusively of eligible blood donors attending three public hospitals in Jalalabad and was therefore subject to donor-selection and eligibility effects. In particular, the predominance of male donors (96.1%) and urban residents (84.2%) may limit the representativeness of the findings for women, rural residents, and the general population of Nangarhar. Accordingly, the observed ABO and Rh (D) frequencies should be interpreted as estimates for the study donor population and should not be generalized directly to the broader population.

Future studies using community-based sampling and, where appropriate, prospective designs could provide a more representative assessment of ABO and Rh (D) distribution in the general population and could investigate demographic, ethnic, and genetic factors underlying observed regional variation.

CONCLUSION

This study provides essential baseline data on ABO and Rh (D) blood group distribution among blood donors in three major public hospitals of Jalalabad, with blood group B as the most prevalent phenotype and a marked predominance of Rh (D) positivity. The donor pool was largely male, urban, and voluntary, reflecting encouraging public engagement but also highlighting significant gaps in female participation and rural access. These findings emphasize the importance of region-specific blood group epidemiology for effective blood inventory management, transfusion planning, and emergency preparedness in Nangarhar Province. Targeted donor recruitment strategies, particularly to increase female involvement and expand outreach to rural communities, are recommended to strengthen the regional blood transfusion system and ensure equitable and reliable access to safe blood.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest related to the study and report no financial or personal influences.

FUNDING

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AUTHORS CONTRIBUTION

Sayed Zekria Hashimi conceptualized the study, performed data analysis, and drafted the manuscript. Muhammad Baz Afridi reviewed and revised the draft. Qareebullah Ameer supervised and guided the research process. Muhammad Ishaq Shinwary, Lemar Rodwal and Fawad Zakhil contributed in data collection.

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