Original Article

Phenotypic Distribution of ABO and Rh (D) Blood Groups and Their Association with Gender at a Rural-Serving Tertiary Care Hospital in Gazipur, Bangladesh

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Abstract

Background: *The ABO and Rhesus (Rh) blood group systems are the most clinically significant blood group systems in Transfusion Medicine. Knowledge of their distribution is essential for blood bank management, transfusion safety and population genetics.*

Objective: *To determine the distribution pattern of ABO and Rh (D) blood group systems and evaluate gender associations among individuals attending a tertiary healthcare facility in Bangladesh.*

Materials and Methods: *The sample size of this study was 3,561 individuals. ABO and Rh typing were performed using standard agglutination techniques. Data were analyzed using chi-square tests. A p-value <0.05 was considered statistically significant.*

Results: *Blood group B (34.1%) was most prevalent, followed by O (31.7%), A (25.1%) and AB (9.1%). Rh positivity was observed in 96.1%, while 3.9% were Rh negative. No statistically significant association was found between ABO blood group and sex (p=0.691) nor between Rh factor and sex (p=0.198).*

Conclusion: *Blood group B and Rh-positive phenotype predominated in this population. The findings are consistent with previous Bangladeshi studies and provide important implications for transfusion services and blood inventory management.*

Key words: *ABO blood group, Rhesus factor, Phenotypic distribution, Gazipur, Transfusion Practice.*

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Introduction

The ABO blood group system, discovered by Karl Landsteiner in 1901, remains the cornerstone of transfusion medicine.[1] The system is determined by the presence or absence of A and B antigens on erythrocytes. Individuals lacking specific antigens naturally possess corresponding antibodies in plasma, making compatibility essential during transfusion.[2]

The Rhesus (Rh) system, particularly the D antigen, is the second most clinically important blood group system. Rh incompatibility may lead to haemolytic transfusion reactions and haemolytic disease of the newborn.[3]

Blood group distributions vary by ethnicity, geography and migration patterns. Previous Bangladeshi studies have reported varying predominance patterns. A study from Chattogram reported blood group B as most common, while another tertiary hospital study in Dhaka showed B (34.5%) followed by O (33.4%).[4-5]

Regional variations are also observed internationally. A Nepalese study found O as most common and a Sub-Himalayan Indian population also showed similar O predominance.[6-7] Delhi-based data reported B as the leading phenotype.[8]

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Given limited recent data from this specific region of Bangladesh, this study aimed to determine current ABO and Rh distribution patterns and assess gender association in Gazipur, Bangladesh.

Materials and Methods

This retrospective cross-sectional study was conducted at International Medical College Hospital, Gazipur, a tertiary healthcare facility that primarily serves the surrounding rural population. All individuals who underwent ABO and Rh blood grouping in the Department of Transfusion Medicine between January 2020 and June 2021 were included in the analysis. A total of 3,561 records were reviewed and analyzed. Records with incomplete demographic information or blood group data were excluded prior to statistical analysis. Each entry represented a unique individual and duplicate registrations were identified and removed using registration numbers.

ABO and Rh blood grouping were performed using the standard forward agglutination method with commercially available monoclonal antisera (anti-A, anti-B and anti-D) and reverse agglutination method with pooled donor cells (Acell, Bcell and Ocell) along with an autocontrol for each sample.[9-10] Agglutination was observed macroscopically within the recommended reaction time and doubtful reactions were confirmed microscopically. Blood groups were classified into four ABO phenotypes (A, B, AB and O) and two Rh categories (positive and negative) based on agglutination patterns.

Demographic variables collected included sex and age. Data were extracted from laboratory registers and entered into a structured database for analysis. Data cleaning procedures included verification of consistency between ABO and Rh results and screening for missing or implausible values.

Statistical analysis was performed using IBM SPSS Statistics version 25 (IBM Corp., Armonk, N.Y., USA). Categorical variables were summarized using frequencies and percentages. The distribution of ABO and Rh blood groups was presented descriptively. Associations between categorical variables were assessed using the Chi-square (χ^2) test of independence. All statistical tests were two-tailed and a p-value <0.05 was considered statistically significant.

Ethical considerations were maintained throughout the study. As this was a retrospective analysis of existing laboratory records with no direct patient contact, all data were anonymized prior to analysis to ensure confidentiality and privacy of participants. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Results

A total of 3,561 individuals were included in the analysis with a mean age of 30.9 ± 18.5 years. Of these, 1,181 (33.2%) were male and 2,380 (66.8%) were female as shown in Figure 1. This demonstrated a female predominance in the study population with a male-to-female ratio of approximately 1:2.05.

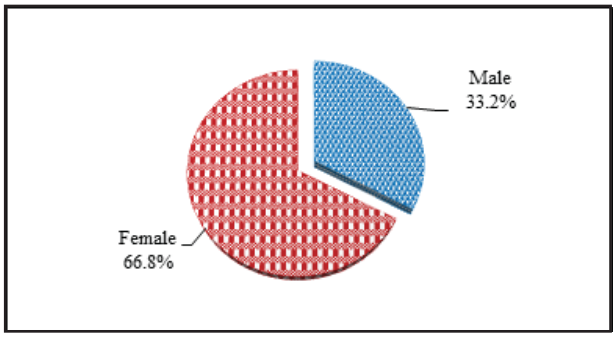

Figure 1: Distribution of the subjects by sex (n=3,561)

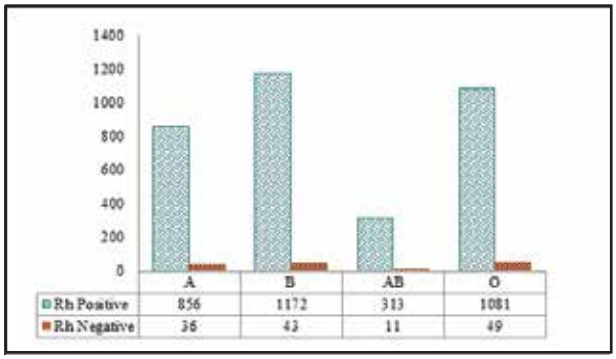

Figure 2: Distribution of ABO and Rh (n=3,561)

Figure 2 illustrates the distribution of ABO blood groups stratified by Rh factor. Rh positivity predominated across all ABO phenotypes. Among individuals with blood group A, 856 (24%) were Rh positive compared to 36 (1%) Rh negative. Similarly, blood group B showed 1,172 (32.9%) Rh-positive and 43 (1.2%) Rh-negative individuals, representing the largest phenotype group in the study population. For blood group AB, 313 (8.8%) individuals were Rh positive and 11 (0.3%) were Rh negative. In blood group O, 1,081 (30.4%) were Rh positive and 49 (1.4%) were Rh negative.

Across all ABO categories, Rh-negative individuals constituted a small proportion relative to Rh-positive individuals. Blood group B positive (B+) was the most frequent combined phenotype, whereas AB negative (AB-) was the least common as shown in Figure 3.

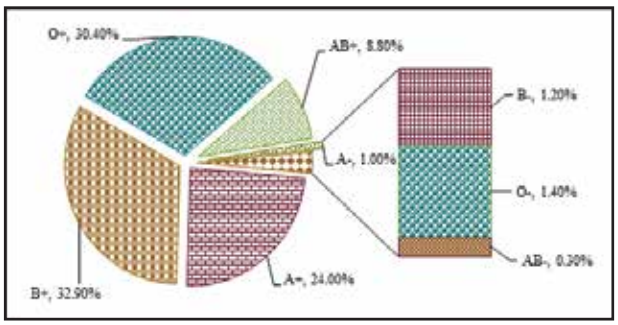

Figure 3: Distribution of combined phenotype (n=3,561)

The association between ABO blood group and sex was examined using the chi-square test. Although minor proportional differences were observed between males and females across ABO categories, statistical analysis demonstrated no significant association between ABO blood group and sex (p=0.691) as shown in Table I. This indicates that the distribution of ABO phenotypes was comparable between male and female participants. Similarly, no significant association was found between Rh factor and sex (p=0.198).

Table I: Gender-wise distribution of ABO and Rh blood groups (n=3,561).

Blood Group	Male (n=1,181) Frequency (%)	Female (n=2,380) Frequency (%)	Total (n=3,561) Frequency (%)	p-value
ABO Blood Group System				
A	308 (26.1)	584 (24.5)	892 (25.1)	0.691*
B	394 (33.3)	821 (34.5)	1215 (34.1)	
AB	107 (9.1)	217 (9.2)	324 (9.1)	
O	372 (31.5)	758 (31.8)	1130 (31.7)	
Rh Blood Group System				
Rh positive	1135 (96.1%)	2302 (96.7%)	3422 (96.1)	0.198*
Rh negative	46 (3.9%)	78 (3.3%)	139 (3.9)	

*χ^2 test showed no statistically significant difference

Overall, the findings demonstrate a predominance of blood group B and a high frequency of Rh positivity in this tertiary care population, with no statistically significant gender-based differences in ABO or Rh distribution.

Discussion

The present study demonstrates that blood group B (34.1%) is the most prevalent phenotype in this tertiary care Bangladeshi population, followed by O (31.7%), A (25.1%), and AB (9.1%). This pattern (B > O > A > AB) is consistent with several contemporary studies conducted within Bangladesh and neighboring South Asian regions, supporting the stability of this distribution trend in this geographic belt.[11-14] The overall distribution pattern of combined ABO-Rh blood group was B+ > O+ > A+ > AB+ > O- > B- > A- > AB-.

Our findings are strongly aligned with data from Chattogram, Bangladesh, where blood group B was reported as the most predominant phenotype (38.07%), followed by O (29.97%), A (23.35%), and AB (8.6%).[4] Similarly, a recent large-scale study conducted at a tertiary care hospital in Dhaka reported blood group B (34.5%) as the most common, followed closely by O (33.4%).[5] The close agreement between our results and these Bangladeshi hospital-based studies suggests a relatively homogeneous ABO distribution pattern in urban and rural Bangladeshi populations.

However, regional variation within South Asia is evident. A Nepalese teaching hospital study reported blood group O (33.9%) as the most prevalent phenotype, followed by A, B and AB.[6] Similarly, a study among the Sub-Himalayan Kami population of West Bengal and Sikkim, India, also found blood group O (31.06%) to be the most frequent.[7] These findings contrast with the B predominance observed in our study and in several Bangladeshi datasets. Such differences likely reflect ethnic composition, founder effects, migration history and genetic drift within distinct communities.

In North India, a large Delhi-based donor study reported blood group B (37.38%) as the dominant phenotype, followed by O (29.27%), A (23.88%) and AB (9.97%).[8] This pattern closely mirrors our findings and reinforces the broader South Asian trend of higher B allele frequency in Indo-Gangetic populations. The predominance of blood group B across Bangladesh and northern India may reflect shared ancestral gene pools and historical migration patterns within the subcontinent.

Globally, ABO distribution varies considerably. While blood group O is predominant in Western populations and group A is common across Central and Eastern Europe, group B frequencies are notably higher in South Asia and group AB is more frequently observed in Japan, China and Korea.[15-17] These patterns support the concept that ABO distribution is strongly influenced by population genetics, selective pressures and historical demographic events.

Regarding Rhesus (D) factor distribution, our study found 96.1% Rh positivity, which is highly consistent with other Bangladeshi data. The Dhaka tertiary hospital study reported 94.3% Rh positivity, while the Evercare Hospital study from Chattogram documented 96.6% Rh positivity.[5,18] These figures demonstrate remarkable consistency across different Bangladeshi healthcare settings.

Internationally, Rh positivity in South Asian populations typically ranges between 94% and 98%.[19] The relatively low

prevalence of Rh-negative individuals (3.9% in our study) aligns with established epidemiological trends in Asia, where Rh negativity is considerably less common compared to Western populations. This has important clinical implications, particularly in Transfusion Medicine and obstetric care, as Rh-negative blood units remain a scarce resource in Bangladesh.

The absence of a statistically significant association between ABO blood group and sex (p=0.691) and between Rh factor and sex (p=0.198) in our study suggests that these blood group systems are inherited independently of gender. This finding is biologically plausible because ABO and Rh genes are located on autosomal chromosomes (chromosome 9 and chromosome 1, respectively) and therefore do not exhibit sex-linked inheritance patterns. Similar observations have been reported in other South Asian studies, reinforcing the concept that ABO and Rh distribution across genders reflects random Mendelian segregation rather than sex-based biological differences.[4,8]

From a transfusion service perspective, the predominance of blood group B and O in this population carries significant operational implications. Since blood group O serves as the universal donor for red cell transfusion (particularly O negative), maintaining adequate stock of O units is essential. However, given that B is the most common phenotype in this population, blood banks in Bangladesh should prioritize inventory management strategies that reflect this distribution pattern. Furthermore, the relatively low Rh-negative frequency underscores the need for targeted donor recruitment programs to ensure availability of Rh-negative units for emergency and obstetric use. Given that haemolytic disease of the newborn remains a clinical concern in Rh-incompatible pregnancies, awareness of Rh distribution at the population level remains crucial.[3]

The observed similarities between our findings and other Bangladeshi and northern Indian studies suggest genetic continuity across this region. In contrast, Himalayan and isolated populations demonstrate variations favoring O predominance, highlighting the role of population structure and historical isolation in shaping allele frequencies.[6-7]

Overall, this study contributes updated epidemiological data on ABO and Rh distribution in Bangladesh and confirms that the B > O > A > AB pattern remains stable in tertiary healthcare settings.[20] The consistency of Rh positivity rates across studies further strengthens the reliability of current transfusion service planning models.

Future research incorporating genotype and allele frequency analysis using Hardy-Weinberg equilibrium would provide deeper insights into population genetics and evolutionary trends in Bangladeshi communities.

Conclusion

This retrospective cross-sectional study demonstrates that blood group B is the predominant ABO phenotype in this tertiary care population of Gazipur, Bangladesh, followed by blood groups O, A and AB. Rhesus (D) positivity was observed in more than 96% of individuals, consistent with regional South Asian trends. No statistically significant association was found between ABO or Rh distribution and sex, confirming autosomal inheritance patterns and absence of gender-related variation.
The findings provide updated epidemiological data that are essential for transfusion service planning, blood inventory management and donor recruitment strategies in Bangladesh. The relatively low prevalence of Rh-negative individuals highlights the need for targeted recruitment to ensure availability of rare blood types. Further multicenter studies incorporating genotype and allele frequency analysis would enhance understanding of population genetics and support evidence-based transfusion practices nationwide.

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