International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Available online on: https://ijmpr.in/

Original Article

Association of ABO and Rhesus Blood Types with Transfusion-Transmitted Infections among Blood Donors at a Tertiary Care Centre in Northern India: A Retrospective Cross-Sectional Study

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Received: 21-06-2026
Accepted: 15-07-2026
Available online: 27-07-2026

ABSTRACT

Introduction: The association of blood groups and transfusion transmitted infections has been evaluated in several studies, however, the results remain inconclusive. This study was conducted to evaluate the association between ABO, Rh blood groups and transfusion transmitted infections (TTIs) as well as to calculate the prevalence of TTIs among blood donors at a tertiary health centre in Northern India.

Methods: All the eligible blood donors who donated blood at a tertiary health care centre in Northern India over a period from April 2024 to March 2025 were included. The information regarding donor's age, sex, blood groups and the screening results for TTIs (HIV, HCV, HBV, syphilis and malaria) was collected from donor register. Associations between TTIs and categorical variables were assessed using Chi-square or Fisher's exact test, and odds ratio were calculated. A *p* value of <0.05 was considered statistically significant.

Results: A total of 5974 blood donors were included**.** The overall prevalence of TTI noted in this study was 3.63%, HCV being the most prevalent TTI among donors. We observed a borderline significant association between HCV seroreactivity and blood group O. However no significant association was obtained between HBV, HIV, syphilis positivity and ABO/Rh blood groups.

Conclusion: A significant TTI positivity among donors advocates implementation of stringent blood screening policy. Also, more elaborative studies are recommended to validate the results of present study.

Keywords*: blood donors, blood bank, transfusion transmitted infections.*

INTRODUCTION

Blood transfusion is a cornerstone of therapeutic interventions, saving millions of lives each year by supporting medical procedures, trauma care, major surgeries and management of hematological disorders. Despite the fact that blood transfusion plays a pivotal role in saving lives, there is always an inherent risk of transmission of infectious diseases through donated blood. There is a 1% chance of transfusion associated issues including transfusion transmitted infections (TTIs), with every unit of blood transfused.[1] The World Health Organization (WHO) has recommended proper screening of blood and blood products for at least HIV, HBV, HCV and syphilis prior to transfusion.[2] This becomes more important for developing countries like India where the prevalence of TTIs remains higher. According to available statistics, the prevalence of HIV, HBV, HCV and Syphilis among blood donations in high income countries is 0.002%, 0.02%, .007% and 0.02% respectively, compared to 0.19%, 1.70%, 0.38% and 0.69%, respectively, in lower middle income countries.[2] Blood group determination forms an essential part of safe blood transfusion practices. There are more than 40 blood groups systems as described by International Society of Blood Transfusion. ABO and Rh blood groups systems are the most clinically significant. Beyond their role in immune-hematological compatibility, blood groups have also been linked to various cardiovascular diseases and malignancies. [3,4] Simultaneously, studies suggest that blood groups antigens may influence an individual's susceptibility to certain infections including tuberculosis, small pox and COVID -19.[5]

Several studies in the past reported conflicting results of association between blood groups and TTIs. This study was conducted to evaluate the association between ABO, Rh blood groups and TTIs as well as to calculate the prevalence of TTIs among blood donors at a tertiary health centre in Northern India.

MATERIAL AND METHODS

Study design and setting:

This retrospective cross-sectional study was conducted at Blood Centre in Pandit Deendayal Upadhyay District Combined Hospital attached to Mahatma Vidur Autonomous State Medical College, Bijnor which is a tertiary care centre in North India, from April 2024 to March 2025.

Study population and Data Collection: All blood donors who attended the blood centre and blood camps organized by blood centre for voluntary blood donation from April 2024 to March 2025, fulfilling the national blood donor selection criteria: (1) age between 18 to 65 years old, (2) weight >45 kg, (3) no significant medical history, (4) Hb > 12.5 gm/dl (5) blood donation interval of more than three months (6) blood pressure systolic 100-160 mmHg and diastolic 60-100 mmHg (7) pulse rate 50-100 beats per minute without pathological irregularities (8) oral temperature <37.5 °C, were included as study participants. All blood donor information was obtained from the blood donor register. The information like age, sex, blood groups and status of TTIs such as HIV, HBV, HCV, Syphilis and Malaria were collected from database in donor register.

ABO blood grouping and Rhesus (RH) typing:

ABO and Rh blood groups determination was carried out by forward and reverse blood grouping method using monoclonal blood grouping antisera; anti-A, anti-B, and anti-D (Spanclone Anti-A, B and D (Rh0) Monoclonal, ARKRAY Healthcare Pvt. Ltd) and corresponding red cell antigens prepared in house.

Serological Investigations for HIV, HBV, HCV, Syphilis and Malaria

All donated blood units were screened for transfusion transmitted infections. HBsAg surface antigen and HCV antigen were tested using Enzyme Linked Immunosorbent Assay (ELISA) [Merilisa HbsAg ELISA, Meril Diagnostics Pvt. Ltd.; HCV: Merilisa HCV Ag ELISA, Meril Diagnostics Pvt. Ltd.];HIV by using ELISA [HIV1/2: Merilisa HIV Ag/Ab fourth generation ELISA, Meril Diagnostics Pvt. Ltd]. Syphilis screening was done using the Rapid Plasma Reagin (RPR) test kit [Rapid test device for qualitative detection of plasmodium antigen (pLDH &HRP-II) in human whole blood, SUNWEST BIOMEDIAL Pvt. Ltd.]. Malaria was tested by using rapid test kits [Malaria: Sunsure One Step Rapid Test Malaria Pf/Pv Antigen]. All tests were performed according to the manufacturer's instructions.

Statistical Analysis

The collected data were compiled, coded, tabulated, and subjected to statistical analysis using an appropriate statistical software package. Data cleaning and validation were performed before analysis to identify inconsistencies, missing values, and data-entry errors. The prevalence of individual transfusion-transmitted infections was determined using frequency and percentage distributions.

Associations between categorical variables and TTI status were evaluated using the Chi-square test of independence. When the assumptions of the Chi-square test were not satisfied because of small expected cell frequencies or zero observations, particularly for rare infections such as HIV and Syphilis, Fisher's exact test was applied. The association of gender, ABO blood group, and Rh factor with individual transfusion-transmitted infections, including HIV, HCV, HBsAg, and syphilis positivity, was further assessed by calculating odds ratios (ORs) with corresponding 95% confidence intervals (95% CIs). For the analysis of ABO blood groups, blood group A was considered the reference category, and the odds of infection among donors with blood groups B, AB, and O were compared against it. Similarly, an appropriate reference category was used for gender and Rh factor comparisons. For contingency tables containing zero cells, direct calculation of an odds ratio could result in an undefined or unstable estimate. In such situations, Fisher's exact test was preferred for hypothesis testing, and where an odds ratio was required, an appropriate continuity correction could be considered. Results based on very small numbers of positive cases were interpreted cautiously because of wide confidence intervals and limited statistical precision. All statistical tests were two-tailed, and a p-value < 0.05 was considered statistically significant. A p-value ≥ 0.05 was considered statistically non-significant.

RESULTS

In this study, a total of 5974 blood donors were included, majority of them were males 5,581 (93.42%) and females accounted for only 393 (6.58%). Among the total 5,974 blood donors, 1918 (32.11%) donors belonged to blood group B, followed closely by blood group O with 1786 (29.90%) donors. A total of 1509 (25.25%) donors belonged to blood group A, while blood group AB was the least common, comprising 761 (12.74%) donors. Furthermore, 5,547 (92.85%) blood donors were Rh-positive (Rh+), whereas 427 (7.15%) were Rh-negative (Rh-).

Out of 5974 blood donors, 217 blood donors (3.63%) were found reactive for transfusion-transmitted infection (TTI). The most prevalent infection was HCV (169; 2.82%) followed by HBV (32; 0.53%), syphilis (12; 0.20%) and HIV (4; 0.06%). No donor was tested positive for malaria. [Table-1]

The prevalence of transfusion-transmitted infections (TTIs) was slightly higher among male donors (3.65%) compared to female donors (3.27%). [Table-2]

[Table-1]-TTI Distribution among Blood Donors

Sr. No.	Variables (TTI)	Frequency (N=5974)	
		Number (n)	Percentage (%)
1.	HIV	04	0.06%
2.	HCV	169	2.82%
3.	HbsAg	32	0.53%
4.	Syphilis	12	0.20%
Overall		217	3.63%

[Table-2]: Prevalence of TTI among Males and Females

	Frequency	Percentage (%)
Male (5547)	203	3.65%
Female (427)	14	3.27%

Of the 217 TTI-positive donors, the O blood group showed the highest positivity rate (81; 37.32%), followed by blood group B (65; 29.95%), blood group A (48; 22.11%), and blood group AB (23; 10.59%). When positivity was assessed within individual blood groups, blood group O continued to demonstrate the highest positivity rate (4.53%), followed by blood groups B (3.39%), A (3.18%) and AB (3.02%).[Table-3]

[Table-3]: Distribution of blood groups in TTI Positive Blood Donors

	TTI Positive Donors	Percentage (%)
A (1509)	48 (22.11%)	3.18%
B (1918)	65 (29.95%)	3.39%
AB (761)	23 (10.59%)	3.02%
O (1786)	81 (37.32%)	4.53%
Total	217	3.63%

Among the total transfusion-transmitted infection (TTI) positive donors (217 individuals), the majority of TTI positive blood donors were young adults aged 18 to 30 years consisting 123 (56.22%) individuals followed by blood donors aged 31 to 40 years accounting for 67 (30.87%) individuals of TTI-positive cases. [Table-4]

[Table-4]: Age Distribution of TTI Positive Blood Donors

Age Group (in years)	TTI Positive Donors	Percentage (%)
18-30 yrs	123	56.22
31-40 yrs	67	30.87
41-50 yrs	18	8.29
More than 50 years	9	4.15

The analysis of HIV status, among 5,974 blood donors revealed an extremely low prevalence, with only four HIV positive blood donors. HIV positive donors belonged to blood groups A and B, with 2 positive cases of each and all four were Rh positive. Data indicates no statistically significant association between HIV status and ABO blood groups (p-value 0.657) as well as Rh status (p=1.000). Also HIV seropositivity did not show a statistically significant association with gender distribution. [Table-5]

[Table-5]: Influence of Gender, ABO blood group and Rh Typing on HIV status in Blood Donors

		Total Blood Donors	HIV Positive	HIV Negative	OR	IC	P-value
Gender	i) Male	5581	4	5577	-	-	1.000{Non-Sig}
	ii) Female*	393	0	393			
Blood Groups	i) A*	1509	2	1,507	-	0.11 to 5.55	0.657 {Non-Sig}
	ii) B	1918	2	1,916	0.78		
	iii) AB	761	0	761	-	-	-
	iv) O	1786	0	1,786	-	-	-
Rh Factor	i) Rh+	5547	4	5,543	-	-	1.000 {Non-Sig}
	ii) Rh+*	427	0	427			

Among a total of 5,974 (5581 male and 393 female) blood donors, HCV positivity was noted in 160 males (2.87%) and 9 females (2.29%). However, the distribution of HCV infection did not differ significantly between genders. HCV positivity was found in 34, 52, 22 and 61 donors of blood groups A, B, AB and O respectively. The odds ratios were calculated relative to blood group A as reference. Blood group O showed a borderline significant result, {OR=1.53(95% CI: 1.00-2.34)}. No statistically significant difference was observed in HCV risk based on Rh status. [Table-6]

[Table-6]: Influence of Gender, ABO blood group and Rh Typing on HCV status in Blood Donors

	Total Blood Donors	HCV Positive	HCV Negative	OR	CI	P-value
iii) Male	5581	160	5421	1.26	0.64 - 2.48	0.50
iv) Female*	393	9	384			
B-ABO Blood Group						
v) A*	1509	34	1475			
vi) B	1918	52	1866	1.21	0.78 -1.88	0.39
vii) AB	761	22	739	1.29	0.75 -2.22	0.36
viii) O	1786	61	1725	1.53	1.00 - 2.34	0.05
C-Rh Blood group						
iii) Rh+	5547	160	5,387	1.38	0.70-2.72	0.36
iv) Rh-*	427	9	418	-		

In this study 34 male and four female donors were found positive for HBsAg. Gender wise distribution of HBsAg was not statistically significant. HbsAg positivity was found in 11, 8, 3, 16 donors of blood groups A, B, AB and O respectively and 35 and 3 donors with Rh positive and Rh negative respectively. The data suggests no statistically significant association of HBsAg positivity with ABO blood group or Rh factor. [Table-7]

[Table-7]: Influence of Gender, ABO blood group and Rh Typing on HBsAg status in Blood Donors

Characteristics	Total Blood Donors	HbsAg Positive	HbsAg Negative	Prevalence	OR	IC	P-value
A-Gender							
v) Male	5581	34	5,547		0.595	0.21 to 1.69	0.32
vi) Female*	393	4	389		-		
B-ABO Blood Group							
ix) A*	1509	11	1498	0.72			
x) B	1918	8	1910	0.41	0.57	0.23–1.42	0.23
xi) AB	761	3	758		0.54	0.15–1.94	0.34
xii) O	1786	16	1770		1.23	0.57–2.66	0.60
C-Rh Blood group							
v) Rh+	5547	35	5,512		**0.90**	0.28-2.92	0.86
vi) Rh-*	427	3	424				

Amid all donors, 11 (0.20%) males and only one (0.25%) female were found syphilis positive. Syphilis positive donors were distributed among blood groups A(4 donors), B (3 donors) and O(5 donors). All donors tested positive for syphilis were Rh positive. Overall, the data demonstrates a very low prevalence of syphilis among blood donors with no significant differences detected across gender, ABO blood groups, or Rh factor. [Table-8]

[Table-8]: Influence of Gender, ABO blood group and Rh Typing on syphilis status in Blood Donors

Characteristics	Total Blood Donors	Syphilis Positive	Syphilis Negative	OR	IC	P-value
A-Gender						
vii) Male	5581	11	5,570	0.77	0.10 to 6.01	0.56
viii) Female*	393	1	392			
B-ABO Blood Group						
xiii) A*	1509	4	1505			
xiv) B	1918	3	1915	0.59	0.13-2.64	>0.05
xv) AB	761	0	761	0.25	0.013-4.72	>0.05
xvi) O	1786	5	1781	1.06	0.28-3.96	>0.05

C-Rh Blood group						
vii) Rh+	5547	12	5535	-	-	1.000 {Non-Sig}
viii) Rh-*	427	0	427			

DISCUSSION:

Transfusion transmissible infections (TTIs) include a range of illnesses that can be transmitted through the use of contaminated blood or blood products. Key TTIs include hepatitis C virus (HCV), hepatitis B virus (HBV), human immunodeficiency virus (HIV)-I/II, syphilis and malaria parasite (MP). In India, screening for TTIs is mandatory before any blood transfusion. [6]

The WHO Global Database on Blood Safety (GDBS) periodically publishes statistics on blood donations and acquired blood-borne infections worldwide.[7] The prevalence of TTIs varies significantly across different regions within India and in other countries worldwide.[6] In low-income countries, the prevalence of TTIs is relatively high and quite far from achieving a zero-risk level.[8] Transfusion-transmissible infections are well-known global health challenges. Blood screening ensures the safety of transfusion and declines the risk of TTIs.[9] The identification of TTI antigen/antibodies in donor blood is crucial for ensuring the integrity and safety of the blood supply. It protects both donors and recipients by preventing the transmission of infectious agents during blood transfusions and other medical procedures. These have made rigorous screening protocols and compliance with regulatory standards essential components of blood safety programs worldwide. [10] Despite the fact that blood and blood components can save patient lives, contaminated blood still poses a threat in regard to spreading infection. Extensive research has been carried out on the relationship between blood groups and numerous diseases, including TTIs.[11] Blood banks are valuable sources of epidemiological data, especially in developing countries and during humanitarian crises. The current study focused on the prevalence of TTIs among blood donors and association of TTIs with blood groups in a cohort of 5974 blood donors.

In this study majority of blood donors were males (93.42%), which was concordant with numerous studies conducted worldwide.[6-20] The reasons for lesser number of female contributing towards voluntary blood donation are higher deferral rate especially due to low hemoglobin levels, lack of awareness and household responsibilities.

The maximum number of donors in this study belonged to blood group B (32.11%) closely followed by O blood group (29.90%), which was found concordant with the study by Tyagi S. et al[21]. However, Almugadam BS et al[9], Shaikh AA et al [11], Halawani AJ et al[12], Hroob AMA et al[17], Belkacemi M et al [22], Legese B et al[23] found Blood Group O as the most frequent among blood donors while Saba N et al [8] documented maximum donors with blood group A.
In this study Rh-positive (Rh+) blood donors accounted for 92.85% of total donors which was found concordant with the study by Thakur SK et al[6], Saba N et al[8], Almugadam BS, Halawani AJ et al[12], Altayar MA et al[16], Hroob AMA et al[17], Kengne M et al[19], Tyagi S. et al[21], Belkacemi M et al[22], Legese B et al[23].

The overall prevalence of TTI revealed by this study was 3.63%. The prevalence rate of TTIs reported in previous studies has shown considerable variation. Studies conducted by Thakur SK et al[6], Alshehri AA et al[10], Shaikh AA et al [11], Ntawuyamara E et al[14], Belkacemi M et al [22], Legese B et al [23], Saba N et al [8] reported prevalence rate of 2.07%, 10.9%, 6.35%, 6.06%, 0.8%, 5.43% and 4.61% respectively. These variations may be attributed to differences in geographical location, socioeconomic conditions, prevalence of infections in e general population and difference in screening methodologies applied.

In this study, the most prevalent TTI was HCV with prevalence rate of 2.82%. This is in line with various studies by Saba N et al [8], Ntawuyamara E et al[14], Aabdien M et al[18] which documented a prevalence of 1.38%, 2.90% and 0.60% respectively. However, Thakur et al [6], Alassad A et al [7], Saba N et al [8], Almugadam BS et al[9], Alshehri AA et al[10], Halawani AJ et al [12], Mangala C et al [13], Altayar MA et al[16], Haroob AMA et al [17], Kengne M et al [19], Abate M et al [20], Belkacemi M et al [22] and Legese B et al [23] found HBV as most prevalent TTI and prevalence varied from 0.38% to 11.7%. The prevalence of HCV by different studies varied from 0.0425% to 6.8% [6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 19, 20, 22, 23].

The prevalence of HBV in the present study was observed as 0.53%, however the prevalence of HBV by different studies varied from 0.30% to 11.7% [6, 7, 8, 9, 10, 12, 13, 14, 16, 17, 18, 20, 22, 23].

In this study, the prevalence of syphilis was found as 0.20% which was comparable to findings reported by Thakur SK et al [6], Alshehri AA et al [10] and Ntawuyamara E et al [14]. In contrast, studies conducted by Mangala C et al [13], Alharazi T et al [15], Kengne M et al [19], Legese B et al [23] observed higher prevalence rates, whereas Almugadam BS et al [9] documented a prevalence of 11.8%. A lower prevalence of 0.025 was observed by Hroob AMA et al [17].

The prevalence of HIV in present study was 0.06% which was comparable to the studies conducted by Halawani AJ et al [12], Aabdien M et al [18] and Belkacemi M et al [22]. However, Mangala C et al [13], Kengne M et al [19] and Abate M

et al [20] found higher prevalence as 3.0%, 5.3% and 3.16% respectively. While Hroob AMA et al [17] observed lower prevalence as 0.006%.

In the current study the highest TTI sero-reactivity was observed among blood group O positive donors (4.53%), which was in agreement to findings of Shaikh AA et al [11], Altayar MA et al [16], Abate M et al [20] Belkacemi M et al [22] and Legese B et al [23]. However, Alshebri AA et al [10] reported the highest sero-reactivity in blood group AB donors.
In the present study, only four donors, were found to be seropositive for HIV, including two donors each from blood groups A and B. Similar studies by Almugadam B S et al [9], Abate M et al [20], Belkacemi M et al [22] and Legese B et al [23] identified blood group O as the most commonly affected whereas Hroob AMA et al [17] reported blood group AB as most commonly affected.

Among the 169 sero-reactive HCV donors in the present study, the majority belonged to blood group O. Similar observations were reported by Abate M et al [20] and Legese B et al [23]. However, Hroob AMA et al [17] documented a higher frequency of HCV positivity among donors with blood group B.

In this study HBsAg sero-reactivity with highest frequency was noted in blood group O. Comparable findings were reported by Hroob AMA et al [17], Abate M et al [20], Belkacemi M et al [22] and Legese B et al [23]. In contrast Almugadam BS et al [9] documented highest HbsAg sero-reactivity among blood groups B and A.
In this study syphilis sero-reactivity was found across all blood groups, almost comparable numbers fall under blood groups A, B and O.

Further the association between blood groups A, B, O and AB with TTIs among blood donors was evaluated in the current study. No significant link was observed between blood groups and HBV, HIV and Syphilis. However, blood group O showed a borderline significant association with HCV status suggesting a possible trend towards higher HCV prevalence among blood group O donors. The results of distribution of ABO blood groups and TTIs differ among various studies. Shaikh AA et al [11] documented significant link of HIV with blood group A and HBs Ag with blood group AB. In the present study low number of HIV-seropositive donors limited the ability to assess any significant association with blood groups. Santos SL et al [5] documented significant association of HBV with B blood group. While Legese B et al [23] found no association between TTI and ABO/RH blood groups. The reasons for such varied findings may be due to ethnic variation of cohorts and difference in frequency distribution of blood groups in different regions.

In the study, no any significant link was found between Rh status and TTI among donor cohort. A similar result is documented by Hroob AMA et al [17] and Legese B et al [23] in their study.

The present study has certain limitations because of its retrospective design. The study included donor cohort from single centre so its results lack generalizability. Also the numbers of female donors included in the study are far less than male donors, so further studies are needed to evaluate the trends of TTI among female donors.

CONCLUSION

The current study was conducted at a single centre focused to analyze the link between ABO and Rh blood groups with TTI among blood donors. The overall prevalence of TTI noted in this study was 3.63%. We found HCV as the most prevalent TTI among blood donors followed by HBV. It was also observed that highest TTI positive donors belonged to blood group O. We documented a borderline significant association between HCV positivity and blood group O. However no significant association was obtained between HBV, HIV, syphilis positivity and ABO/Rh blood groups. These findings may aid in improving donor screening strategies. However, further more elaborative studies are required to validate the observed results.

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