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Association of ABO and Rh Blood Groups with Transfusion-Transmitted Infections among Blood Donors in Lahore

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ABSTRACT

BACKGROUND AND OBJECTIVES: Blood transfusion carries the risk of transmitting infections collectively known as transfusion-transmitted infections (TTIs) or transfusion-transmitted pathogens. Major TTIs include the Hepatitis C virus, Hepatitis B virus, HIV, syphilis, and malaria. Different factors can expose individuals to these TTIs, but the effect of blood groups on susceptibility is not well understood. This study aimed to find any association of these TTIs with specific blood groups in the donor population.

METHODOLOGY: We conducted a prospective cross-sectional study among eligible donors who attended the Punjab Institute of Cardiology, Lahore, from October 1, 2023, to September 30, 2024. Donor data, including screening results and blood groups, were recorded and analysed using SPSS. Chi-square was used to assess the association between TTIs and blood groups.

RESULTS: Out of 17,770 donors, 92.77% were Rh-positive and 7.23% were Rh-negative. Blood group B was identified as the most frequent blood group (36.1%). The remaining donors had blood group O (29.2%), blood group A (24.7%), and blood group AB (10.1%). 3.5% of the total donors tested positive for different TTIs. HCV was the most prevalent TTI (1.40%), followed by syphilis (1.09%), HBV (0.87%), HIV (0.10%), and malaria (0.04%). On statistical analysis, no significant associations were observed between ABO/Rh blood groups and TTIs ($p > 0.05$).

CONCLUSION: Blood groups influence susceptibility to certain infections and diseases. Although TTIs are highly prevalent in the donor population, they are not associated with ABO/Rh blood groups. Further large-scale studies are needed to confirm whether TTIs are associated with blood groups.

KEYWORDS: Blood-Borne Infections, ABO Blood Group System, Hepatitis C, Blood Donors.

INTRODUCTION

Blood transfusion is a critical life-saving therapeutic procedure. It is irreplaceable in the treatment and management of medical emergencies such as surgeries, traumas, and different hematological disorders, including thalassemia, leukemias, and anemias. Pakistan, with the world's fifth-largest population, has a substantial requirement for whole blood and blood components, with an estimated 3.5 million donations collected annually^[1].

Despite the well-established role of blood transfusion in medicine, it remains a risky procedure because of the potential transmission of blood-borne pathogens. These include the hepatitis C virus, hepatitis B virus, human immunodeficiency virus (HIV), syphilis, and malaria, which are some of the major TTIs that can be transmitted via transfusion of infected blood and blood products^[2]. Pakistan is already grappling with one of the highest burdens of HCV

infection, largely driven by unsafe healthcare practices, including inadequately screened blood transfusions, unsafe therapeutic injections, and poor infection control^[3].

Multiple risk factors influence an individual's probability of acquiring TTIs. These include the donor's medical history, unsafe transfusion practices, poor screening methods, and socioeconomic factors^[2]. While much attention has focused on these traditional risk factors, one relatively underexplored aspect is the potential influence of an individual's blood group on susceptibility to TTIs.

Blood-group antigens, particularly those of the ABO and Rh systems, may represent an additional biological factor modulating susceptibility to infection. Among 43 recognised blood group systems, the ABO system is most important because of its central role in transfusion medicine^[4]. The expression of specific ABO antigens can influence an individual's susceptibility to various infections

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and illnesses [5]. Some blood group antigens function as receptors or ligands, aiding pathogen attachment, cellular signalling, and infection processes [6]. One example of this antigen-pathogen association is the increased susceptibility of individuals who express the Duffy antigen (Fya/Fyb) to Plasmodium vivax infection (the antigen acts as a receptor for the parasite) [7]. ABO blood-group antigens have also been associated with susceptibility to Helicobacter pylori, SARS-CoV-2 and hepatitis B virus, suggesting that specific antigens may enhance or reduce vulnerability to these pathogens [8-10].

Blood group antigens are expressed not only on red blood cells but also on platelets, leukocytes, epithelial cells of the gastrointestinal tract, and various other cell-surface molecules [11]. In secretors, water-soluble ABO antigens are present in bodily fluids including saliva, breast milk, seminal fluid and gastric mucosa [12]. The widespread distribution of these antigens in the body further emphasizes their role in modulating disease susceptibility.

Although the role of different blood groups in determining susceptibility to various pathogens and infections has been extensively documented, the subject of the potential association between common TTIs (HBV, HCV, HIV, syphilis, and malaria) and ABO/Rh blood groups remains underexplored, particularly among blood donors in Lahore. This study aims to fill this gap by investigating the possible association of TTIs with ABO and Rh blood group systems.

METHODOLOGY

This prospective observational cross-sectional study was conducted at the blood bank of Punjab Institute of Cardiology (PIC), Lahore, Pakistan, from October 1, 2023, to September 30, 2024. Ethical approval was sought from the institute's ethical committee, which gave approval for the research (Ref. No.: RTPGME-Research-339).

Donors who were deemed eligible for the study had haemoglobin levels >13.5 g/dl for males and > 11.5 g/dl for females, age between 18 and 60 years, body weight greater than 50 kg, absence of any chronic illness, no history of drug use, and a 4-month gap from their previous blood donation. On the contrary, donors who were underweight, anemic, suffering from chronic disease and those who had made a blood donation within the past 4 months were excluded. Each study participant signed written consent before inclusion in the study.

The minimum sample size was calculated using the single population proportion formula, with a 95% confidence level ($Z = 1.96$), an anticipated TTI prevalence of 4.61% ($p = 0.0461$) taken from a previous Pakistani study of 41,817 blood donors, and an absolute precision of 5% ($d = 0.05$). This calculation gave a minimum required sample size of 68 donors [13]. A total of 17,770 eligible donors were included in the present study.

Table-II: Prevalence of common TTIs among Rh-positive and Rh-negative blood groups.

Blood Group	HBsAg (%)	HCV (%)	HIV (%)	Syphilis (%)	Malaria (%)	Total (%)
Rh +ve	144 (0.81)	224 (1.26)	16 (0.09)	180 (1.01)	7 (0.04)	571 (3.21)
Rh -ve	11 (0.06)	26 (0.15)	1 (0.01)	13 (0.07)	0 (0.00)	51 (0.29)
Total	155 (0.87)	250 (1.40)	17(0.10)	193 (1.09)	7 (0.04)	622 (3.50)

Medical history and demographics of each eligible donor were recorded on a donor form. Blood grouping was performed using A, B and Rh antisera, utilizing the tile method. Donor blood was later screened for TTIs, including anti-HCV, HIV1/2 Ag/Ab, HBsAg, and syphilis antibodies (SYPH), using the ARCHITECT i1000SR immunoassay analyser (Abbott Laboratories, Chicago, IL, USA). For the detection of the malarial parasite, rapid test kits (Abbott Malaria Ag P.f/Pan rapid antigen strips, Abbott Laboratories, Chicago, IL, USA) were used.

The data were analyzed using SPSS Statistics (version 27). Chi-square was employed to ascertain any association between TTIs and blood groups, with statistical significance set at $p < 0.05$. For TTIs with low expected counts, we applied the Fisher-Freeman-Halton exact test.

RESULTS

Out of the 17,842 blood donors who visited the hospital's blood bank during the study period, 72 donors failed to fulfil the inclusion criteria and were excluded. Of the remaining 17,770 eligible donors, 99.28% were male ($n = 17641$), while 0.72% were female ($n = 129$). Over one-third of the donors had blood group B (36.10%), which was the most prevalent blood group, followed by O (29.02%), A (24.71%), and AB (10.17%). Out of the 17770 donors, 16486 (92.77%) were found to be Rh-positive, while the remaining 1284 (7.23%) donors were Rh-negative (Table- I).

Table-I: Frequency distribution of different blood groups.

Blood Group	Rh +ve (%)	Rh -ve (%)	Total (%)
A	4104 (23.10)	287 (1.62)	4391 (24.71)
B	5938 (33.42)	477 (2.68)	6415 (36.10)
AB	1703 (9.58)	105 (0.59)	1808 (10.17)
O	4741 (26.68)	415 (2.34)	5156 (29.02)
Total	16486 (92.77)	1284 (7.23)	17770 (100)

The cumulative seroreactivity of TTIs was 3.5% ($n = 622$). The most prevalent TTI was HCV (1.40%, $n = 250$), followed by syphilis (1.09%, $n = 193$), HBV (0.87%, $n = 155$), HIV (0.10%, $n = 17$), and malaria (0.04%, $n = 7$). Among the seroreactive cases, 91.8% ($n = 571$) of individuals were Rh-positive, while the remaining 8.2% ($n = 51$) were Rh-negative (Table- III). Overall, the highest seroprevalence of TTIs was in blood group B positive (1.02%; $n=181$), followed by blood group O positive (0.96%; $n=171$) and then blood group A positive (0.88%; $n=157$).

The results of the chi-square analysis for ABO blood groups are summarized in Table-III. No statistically significant association was found between TTIs and ABO blood groups ($p > 0.05$). Likewise, no association was observed between different TTI markers and Rh blood groups ($p > 0.05$).

Table- III: Association of transfusion-transmitted infections with ABO blood groups.

TTI	Results	A	B	AB	O	χ^2	P-value
HBV	Positive	40 (0.9)	50 (0.8)	18 (1.0)	47 (0.9)	1.13	0.771
	Negative	4351 (99.1)	6365 (99.2)	1790 (99.0)	5109 (99.1)		
HCV	Positive	67 (1.5)	74 (1.2)	30 (1.7)	79 (1.5)	4.83	0.185
	Negative	4324 (98.5)	6341 (98.8)	1778 (98.3)	5077 (98.5)		
Syphilis	Positive	54 (1.2)	66 (1.0)	16 (0.9)	57 (1.1)	1.74	0.628
	Negative	4337 (98.8)	6349 (99.0)	1792 (99.1)	5099 (98.9)		
Malaria	Positive	2 (0.05)	3 (0.05)	0 (0)	2 (0.05)	—	1.000
	Negative	4389 (99.95)	6412 (99.95)	1808 (100)	5154 (99.95)		
HIV	Positive	2 (0.05)	5 (0.1)	0 (0)	5 (0.1)	—	0.334
	Negative	4389 (99.95)	6410 (99.9)	1808 (100)	5151 (99.9)		

Values are presented as n (%), with percentages calculated within each blood group. Pearson's chi-square test was used to assess associations between ABO blood groups and HBV, HCV, and Syphilis. For Malaria and HIV, the Fisher Freeman Halton exact test was applied due to low expected cell counts; therefore, χ^2 values are not reported (—).

DISCUSSION

This study assessed the potential association between ABO and Rh blood group systems and common transfusion-transmitted pathogens. The research took place at the blood bank of Punjab Institute of Cardiology, Lahore, Pakistan. Replacement donors comprised the bulk of blood donations, while a minute percentage of donations were from voluntary donors.

Majority of participants were males (99.27%), compared to females, who formed the minority of the study cohort (0.72%). Other blood banks of the country also report similar gender distribution patterns, where males typically form the bulk of the donor population^[14,15]. This gender-based difference can be due to multiple reasons including high prevalence of anemia among the young female population, high physiologic demands during pregnancy and menstruation and due to other socioeconomic factors.

Blood group B was the most common phenotype in our donor population, followed by O, A, and AB. Studies conducted in other parts of Pakistan and neighbouring India also exhibit similar stratification patterns of different ABO blood groups (B>O>A>AB)^[14,16]. Pertaining to the Rh status, majority of donors comprised of Rh +ve blood group (92.77%) compared to Rh -ve (7.23%). Quite similar patterns have been documented in a study conducted in India with a predominance of Rh +ve blood group phenotype (94%)^[17]. Such similar patterns in blood group distribution could be either due to shared genetic factors or certain evolutionary benefits that these phenotypes may provide in the local environment.

3.5% (n = 622) of the total donors in our study tested positive for TTIs. A study from Rawalpindi found almost identical infection rate (3.537%) in their local donor population^[18]. While a large-scale study conducted in Sindh from 2018 to 2022 also reported a steady rate of TTIs among the donor population (2.78%, 3.82%, 3.65%, 4.15%, and 4.04%, respectively)^[19]. The observed homogeneity in

TTI prevalence across different regions may suggest that the infection rate is relatively stable across the country.

The most prevalent TTI was HCV 1.40% (n = 250), followed by syphilis 1.086% (n = 193), HBV 0.872% (n = 155), HIV 0.095% (n = 17), and malaria 0.039% (n = 7). This is an alarming situation, considering that many of these individuals are active donors who have either donated blood previously and have unintentionally contracted or transmitted these infections. Other studies conducted in the Punjab province have also reported similar infection rates and TTI distribution patterns with HCV as the dominant TTI affecting donors^[20]. A meta-analysis including data from 88 million donations made in different regions of the country discovered an even higher overall load of HCV (2.71%) infection, with Punjab bearing the greatest burden of HCV among the donor cohort (3.94%)^[21]. Such high seroreactivity rates of HCV infection, particularly in the Punjab, demand for active measures to limit the exposure and spread of the pathogen.

On statistical analysis, no association was found among different TTIs and ABO/Rh blood groups. A retrospective study conducted in India identified significant association between ABO groups and different TTIs^[22]. Subsequently, a study that assessed the association between ABO, Rh, and Kell blood groups and TTIs found several associations of ABO and Kell blood groups with different TTIs^[23]. However, in our study, no significant link was established between other ABO/Rh blood groups and TTI susceptibility. Similar research conducted at a blood bank in North West Ethiopia also found no significant association between ABO-blood groups and TTI markers^[24]. The lack of association between these infections and blood groups could be due to reasons such as regional differences in ABO-blood group distribution, geographic and environmental factors, and random variations. The fact that different populations exhibit potential links with specific TTIs might be due to factors beyond blood groups (genetic or environmental) that can also assert their influence on the likelihood of contracting these infections.

Our study highlighted major TTIs infecting the donor population of Lahore along with their probable links to specific blood groups. While the overall infection rate was lower compared to the general population, these infected

individuals pose a considerable risk to public health, as many of them are routine blood donors who frequently make blood donations, unknowingly spreading the pathogens. Findings from such studies can help to classify donors into risk groups for a particular TTI, based on their blood group antigens, so that valuable screening resources could be directed more effectively, targeting those who present the greatest risk.

LIMITATIONS:

The male cohort formed the majority of study sample which limits the generalizability of its findings to female donors. The predominance of Rh-positive donors, with a relatively small Rh-negative group, may have limited the statistical power for comparisons based on Rh status. Additionally, replacement donors constituted the majority of the study population, limiting the applicability of the findings to voluntary donor populations. Socioeconomic factors such as donor lifestyle and demographics can also influence the susceptibility to TTIs.

CONCLUSION

TTIs are a huge threat to safe transfusion. Our study found a high frequency of common TTIs in the donor population of Lahore, with HCV topping the list as the most prevalent TTI. The lack of any association between these common TTIs and blood groups in our study does not exclude the possibility of potential link of blood groups with these infections. Future large-scale studies should be conducted to confirm if any association exists, and to identify other potential links between TTIs and blood groups.

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Author Contributions:

Hafiz Osama Amjad Iqbal: Substantial contributions to the conception and design of the work.

Kainaath Mahzaib John: Drafting the work and reviewing it critically for important intellectual content.

Sadaf Farzand: Analysis and interpretation of data for the work.

Ambereen Anwar: Final approval of the version to be published.

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