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Seroprevalence of HIV, Hepatitis B, and Hepatitis C among Blood Donors at a Tertiary Care Center

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Abstract: ***Background: Transfusion-transmissible infections (TTIs), particularly Human Immunodeficiency Virus (HIV), Hepatitis B Virus (HBV), and Hepatitis C Virus (HCV), remain major challenges to blood safety worldwide. Regular surveillance of these infections among blood donors is essential to ensure safe transfusion practices and to monitor disease trends in the community. Objectives: 1) To analyze the seroprevalence of transfusion-transmitted infections (TTIs), including HIV, hepatitis B virus (HBV), and hepatitis C virus (HCV), among blood donors. 2) To assess the prevalence of transfusion-transmitted infections (TTIs), namely HIV, HBV, and HCV, among male and female blood donors. 3) To determine the incidence of transfusion-transmitted infections (TTIs), including HIV, HBV, and HCV, among blood donors aged 18–60 years. Materials and Methods: A prospective observational study was conducted in the Department of Pathology, Blood Bank, GMERS Medical College, Gandhinagar, Gujarat, from July 2023 to February 2025. A total of 11,111 eligible blood donors were included after obtaining informed consent. Donor demographic details, blood group, donor type, and relevant clinical information were recorded using a standardized donor registration form. All donated blood units were screened for HIV, Hepatitis B surface antigen (HBsAg), and HCV using standard serological assays as per national blood transfusion guidelines. Data were entered in Microsoft Excel and analyzed using SPSS software. Descriptive statistics were used to summarize the data, and the Chi-square test was applied to determine statistical significance, with a p-value<0.05 considered significant. Results: Among the 11,111 blood donors, G7.5% (n=10,834) were males and 2.5% (n=277) were females. The majority of donors belonged to the 21–30 years age group (55.1%), followed by the 31–40 years age group (35.0%), with a mean age of 30.12±6.G7 years. Voluntary donors constituted 86.6% (n=G,624) of the donor population, while 13.4% (n= 1,487) were replacement donors. O positive was the most common blood group (47.8%), followed by B positive (18.5%) and A positive (16.5%). The overall seroprevalence of transfusion-transmissible infections was 0.4G% (54/11,111). HBV was the most prevalent infection, with 34 (0.31%) seropositive donors, followed by HIV with 18 (0.16%) and HCV with 2 (0.02%) seropositive donors. All seropositive cases were detected among male donors. Most HIV- and HBV-positive donors belonged to the 21–40 years age group. B positive blood group accounted for the highest proportion of HIV- and HBV-seropositive donors; however, there was no statistically significant association between blood group and seropositivity (p = 0.369) or between age group and seropositivity (p = 0.339). Conclusion: The present study demonstrated a low seroprevalence of HIV, HBV, and HCV among blood donors, indicating the effectiveness of current donor selection criteria and mandatory serological screening practices in ensuring blood safety. HBV remained the most prevalent transfusion-transmissible infection among donors. Continued promotion of voluntary blood donation, enhanced female donor participation, strict donor screening, and implementation of more sensitive screening methods such as nucleic acid testing (NAT), wherever feasible, are recommended to further improve transfusion safety.***

Keywords: Blood donors, Transfusion-transmissible infections, HIV, Hepatitis B virus, Hepatitis C virus, Seroprevalence, Blood safety, Voluntary blood donation

1. Introduction

Blood has been regarded as the essence of life since ancient civilization. Early Egyptians believed bloodletting could cure diseases, while the Greeks studied blood flow through human dissections. Modern transfusion medicine began in 1628 when William Harvey described systemic blood circulation [(1)]. In 1665, Richard Lower performed the first successful animal-to-animal blood transfusion, and in 1818, James Blundell successfully transfused human blood to treat postpartum hemorrhage, earning recognition as the father of blood transfusion [(2)]. The discovery of the ABO blood group system by Karl Landsteiner in 1901 revolutionized transfusion medicine, followed by the discovery of the Rh blood group system in 1939–1940[(3)]. Advances in anticoagulants such as citrate phosphate dextrose (CPD) and CPDA-1 significantly extended blood storage life, while the establishment of blood banks during the twentieth century ensured organized collection, storage, and distribution of blood [(4)].

Today, blood transfusion is an essential component of modern healthcare used in trauma care, major surgeries, obstetric emergencies, cancer treatment, hematological disorders, and organ transplantation[(5)]. Despite remarkable technological advances, ensuring blood safety remains a major challenge due to the risk of transfusion-transmitted infections (TTIs) [(6)].

Blood Donation Process

Blood donation follows standardized procedures to ensure donor and recipient safety. The process begins with donor registration, during which demographic details, informed consent, and medical history are documented. A pre-donation questionnaire identifies high-risk behaviors associated with transfusion-transmitted infections (TTIs), while physical examination evaluates hemoglobin concentration, blood pressure, pulse rate, body weight, and overall fitness[(7)]. Eligible donors undergo blood collection through sterile venepuncture, typically donating 350–450 mL of whole blood into anticoagulant-containing collection bags. After donation, donors remain under observation for 10–15 minutes to monitor immediate adverse reactions and receive post-donation advice regarding hydration, nutrition, and avoidance of strenuous activities [(8)].

1.1 Types of Blood Donors[9,10]

Blood donors are classified into three categories. Voluntary non-remunerated donors donate blood without financial incentives and represent the safest donor population because of their lower prevalence of transfusion-transmitted infections. The World Health Organization recommends achieving 100% voluntary non-remunerated blood donation. Replacement donors are relatives or friends who donate blood to replace blood used by a patient. Although useful during shortages, replacement donations carry relatively higher risks due to social pressure and incomplete disclosure of high-risk behaviors.

Paid or professional donors receive monetary compensation for blood donation. Because they frequently conceal high-risk behaviors, this practice significantly increases the risk of transfusion-transmitted infections and has been prohibited in India under the National Blood Policy.

1.2 Pre-Transfusion Testing[11]

Pre-transfusion compatibility testing is a critical component of safe blood transfusion practice, aimed at preventing hemolytic transfusion reactions and ensuring compatibility between donor and recipient blood. Before any blood component is issued, routine immunohematological investigations are performed, including ABO blood grouping, Rh(D) typing, antibody screening, and cross-matching between donor and recipient samples. In selected patients requiring chronic transfusion support, extended red cell phenotyping or genotyping may also be performed to reduce alloimmunization and delayed hemolytic transfusion reactions. These investigations significantly improve transfusion safety and clinical outcomes.

1.3 Screening of Transfusion-Transmissible Infections (TTIs)[12]

Transfusion-transmissible infections (TTIs) are infections transmitted through transfusion of contaminated blood or blood components. Mandatory screening of donated blood includes Human Immunodeficiency Virus (HIV), Hepatitis B Virus (HBV), Hepatitis C Virus (HCV), syphilis, and malaria, as recommended by national and international guidelines. Laboratory methods used for screening include Enzyme-Linked Immunosorbent Assay (ELISA), Chemiluminescence Immunoassay (CLIA), Rapid Diagnostic Tests (RDTs), and Nucleic Acid Testing (NAT). Among these, NAT has substantially reduced the residual risk of transfusion-transmitted viral infections by shortening the diagnostic window period

1.4 Global and Indian Burden of TTIs

Transfusion-transmissible infections remain an important public health challenge, particularly in low- and middle-income countries where access to advanced screening technologies is limited. Developed countries have achieved very low residual risks through universal voluntary blood donation, stringent donor selection, and implementation of NAT. In India, reported seroprevalence among blood donors generally ranges from 0.14–0.30% for HIV, 1.0–2.5% for HBV, and 0.4–1.0% for HCV, with regional variations across different states[13]. Continuous surveillance of donor seroprevalence assists in strengthening blood safety policies, improving donor selection, and monitoring trends in transfusion-transmissible infections.

2. Major Transfusion-Transmissible Viral Infections [14,15,16]

2.1 Hepatitis B Virus (HBV)

Hepatitis B virus (HBV) is a partially double-stranded DNA virus belonging to the *Hepadnaviridae* family and remains one of the most significant transfusion-transmissible viral infections worldwide. Chronic HBV infection may progress to chronic hepatitis, liver cirrhosis, and hepatocellular carcinoma. The virus is transmitted through transfusion of infected blood or blood products, perinatal (vertical) transmission, sexual contact, and exposure to contaminated needles or unsafe injections. Routine blood donor screening includes detection of hepatitis B surface antigen (HBsAg), while some centers also perform anti-hepatitis B core antibody (anti-HBc) testing and HBV DNA detection by nucleic acid testing (NAT) to identify occult HBV infection and reduce the residual risk of transfusion-transmitted HBV. Although universal hepatitis B vaccination has significantly reduced disease prevalence globally, chronic carriers continue to represent a potential source of transfusion-transmitted infection.

2.2 Hepatitis C Virus (HCV)

Hepatitis C virus (HCV) is an enveloped, single-stranded RNA virus belonging to the Flaviviridae family and is a major cause of chronic hepatitis, liver cirrhosis, and hepatocellular carcinoma. Transmission primarily occurs through transfusion of infected blood, injection drug use, unsafe healthcare practices, and less commonly through vertical transmission. Blood donor screening is based on anti-HCV antibody detection, with HCV RNA NAT providing early identification of infection during the serological window period. Unlike HBV, there is currently no licensed vaccine against HCV, making stringent donor selection and laboratory screening essential for preventing transfusion-transmitted infection.

2.3 Human Immunodeficiency Virus (HIV)

Human Immunodeficiency Virus (HIV) is an enveloped RNA retrovirus of the family Retroviridae that causes Acquired Immunodeficiency Syndrome (AIDS) by progressively destroying CD4-positive T lymphocytes. HIV is transmitted through transfusion of infected blood or blood components, sexual exposure, mother-to-child transmission, and sharing of contaminated needles. Blood donor screening routinely employs fourth-generation enzyme-linked immunosorbent assay (ELISA) or chemiluminescence immunoassay (CLIA) for simultaneous detection of HIV antigen and antibodies, while NAT enables detection of viral RNA during the early window period, thereby significantly reducing the risk of transfusion-transmitted HIV infection.

3. Screening Technologies

3.1 Enzyme-Linked Immunosorbent Assay (ELISA)

Enzyme-linked immunosorbent assay (ELISA) remains one of the most widely used serological methods for screening blood donors. The assay is based on antigen-antibody interactions and has evolved through successive generations, with fourth-generation assays capable of simultaneously detecting HIV-1/2 antibodies and p24 antigen, thereby shortening the diagnostic window period and improving sensitivity.

3.2 Chemiluminescence Immunoassay (CLIA)

Chemiluminescence immunoassay (CLIA) is an automated immunoassay that utilizes chemiluminescent reactions for antigen or antibody detection. Owing to its excellent analytical sensitivity, specificity, rapid turnaround time, and high throughput, CLIA has become the preferred screening platform in many modern blood centers.

3.3 Nucleic Acid Testing (NAT)

Nucleic acid testing (NAT) directly detects viral DNA or RNA before the development of detectable antibodies or antigens, thereby substantially reducing the diagnostic window period for HIV, HBV, and HCV. NAT is considered the most sensitive screening method currently available for blood donor testing and has markedly reduced the residual risk of transfusion-transmitted viral infections. However, its implementation remains limited in many low- and middle-income countries because of high infrastructure and operational costs.

3.4 Rapid Diagnostic Tests (RDTs)

Rapid diagnostic tests (RDTs) provide qualitative results within minutes and are particularly useful in emergency situations and resource-limited healthcare settings. Although less sensitive than ELISA, CLIA, and NAT, they remain valuable where laboratory infrastructure or automation is unavailable.

4. Challenges and Future Perspectives

Despite major advances in blood safety, several challenges continue to affect transfusion services, particularly in developing countries. Limited implementation of NAT because of financial constraints, regional disparities in laboratory infrastructure, continued dependence on replacement blood donors, and inadequate public awareness regarding voluntary blood donation remain important concerns. Furthermore, the emergence of new transfusion-transmissible pathogens- including Zika virus, Dengue virus, and Chikungunya virus- poses additional challenges to blood safety and necessitates continuous surveillance and adaptation of screening strategies. Future efforts should focus on expanding voluntary non-remunerated blood donation, strengthening donor education, improving laboratory infrastructure, increasing access to molecular screening technologies, and implementing continuous epidemiological surveillance to ensure a safe and sustainable blood supply.

5. Aims and Objectives

5.1 Aim

The aim of the study is to detect the seroprevalence of HIV, HBV, and HCV among healthy blood donors at a tertiary care center.

5.2 Objectives

- To analysis the seroprevalence of transfusion-transmitted infections (TTIs) HIV, HBV, HCV) among blood donors.
- To assess the transfusion-transmitted infections (TTIs) of HIV, HBV, and HCV in male and female donors.
- To incidence of the transfusion-transmitted infections (TTIs) HIV, HBV, HCV in donors aged 18-60 years.

6. Methodology

6.1 Study Design

This study was designed as a prospective observational study to evaluate the seroprevalence of Human Immunodeficiency Virus (HIV), Hepatitis B Virus (HBV), and Hepatitis C Virus (HCV) among blood donors.

6.2 Study Site

The study was conducted in the Department of Pathology, Blood Bank, GMERS Medical College, Gandhinagar, Gujarat, India. Data were collected using the standardized Donor Registration and Consent Form maintained in the blood bank.

6.3 Study Duration

The study included donor records collected from July 2023 to February 2025.

6.4 Sample Size

All eligible blood donors who fulfilled the inclusion criteria and provided informed consent during the study period were included in the study.

6.5 Study Procedure

Data were collected from the Donor Registration and Consent Form, which records demographic details, medical history, risk factors, physical examination findings, and laboratory screening results.

Donor Demographic Details The following information was recorded: • Name • Age • Sex/Gender • Occupation • Contact details • Type of donor (Voluntary/Replacement)

Medical History and Risk Assessment Donors were assessed for: • Past or present medical illnesses • History of jaundice or liver disease • Recent surgery • History of tattooing or ear piercing • Smoking and alcohol consumption • High-risk behaviors such as multiple sexual partners or intravenous drug use

Female Donor Assessment Female donors were evaluated

for: • Menstruation • Pregnancy • Lactation

Physical Examination Blood bank staff recorded the following parameters: • Weight • Pulse rate • Blood pressure • Body temperature • Hemoglobin level • Blood group

Serological Testing Laboratory records were reviewed for serological screening results of: • HIV • HBV (HBsAg) • HCV These results were used to determine the seroprevalence of HIV, HBV, and HCV among blood donors.

Inclusion Criteria

- Blood donors aged 18–65 years.
- Hemoglobin ≥ 12.5 g/dL for both male and female donors.
- Body weight ≥ 45 kg.
- Donors who provided informed consent.

Exclusion Criteria

- Donors aged 65 years.
- Donors who had donated blood within the previous 3 months.
- Donors with recent use of medications such as antibiotics, steroids, or aspirin within the past 72 hours.
- History of jaundice or liver disease. • Major or minor surgery within the previous 6 months.
- Females who were menstruating, pregnant, or lactating.
- Donors reporting high-risk behaviors (multiple sexual partners, intravenous drug use, etc.).
- Donors with tattooing, ear piercing, or dental extraction within the previous 6 months.

Outcome Measures

The primary outcome measure was the seroprevalence of HIV, HBV, and HCV among blood donors.

Secondary analyses included distribution of seropositive cases according to:

- Age group
- Sex
- Type of donor (Voluntary/Replacement)

Data Management and Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS (Statistical Package for the Social Sciences) version XX or equivalent statistical software. Descriptive statistics were used to calculate frequencies and percentages. Seroprevalence rates of HIV, HBV, and HCV were expressed as proportions. Associations between seropositivity and demographic variables were assessed using appropriate statistical tests such as the Chi-square test, with a p-value < 0.05 considered statistically significant.

7. Result

Table 1: Age Distribution of Donors

The age distribution of the 11,111 blood donors is presented in Table 1. The majority of donors belonged to the 21–30 years age group (55.1%, *n* = 6,124), followed by the 31–40 years age group (35.0%, *n* = 3,885). Donors aged 41–50 years and 51–60 years constituted 5.8% (*n* = 646) and 1.4% (*n* = 160), respectively, while the 18–20 years age group accounted for only 2.7% (n = 296). The mean age of the study population was 30.12 ± 6.67 years.

Table 1: Age Distribution of Donors

Age	No.	Percentage
18 - 20	296	2.7%
21 - 30	6124	55.1%
31 - 40	3885	35.0%
41 - 50	646	5.8%
51 - 60	160	1.4%
Total	11111	100.0%
Mean	30.12	
SD	6.97	

Table 2: Gender Distribution of Donors

Among the 11,111 blood donors, males constituted 97.5% (*n* = 10,834) of the study population, whereas females accounted for only 2.5% (*n* = 277), indicating a marked predominance of male donors.

Table 2: Gender Distribution of Donors

Gender	No.	Percentage
Male	10834	97.5%
Female	277	2.5%
Total	11111	100.0%

Table 3: Distribution by Type of Donors

The majority of blood donors were voluntary donors, accounting for 86.6% (*n* = 9,624), whereas replacement donors constituted 13.4% (*n* = 1,487) of the study population.

Table 3: Distribution by Type of Donors

Type of Donor	No.	Percentage
Replacement	1487	13.4%
Voluntary	9624	86.6%
Total	11111	100.0%

Table 4: Blood Group wise Distribution of Donors

The distribution of blood groups among the 11,111 blood donors is shown in Table 4. The most common blood group was O positive (47.8%, *n* = 5,306), followed by B positive (18.5%, *n* = 2,057), A positive (16.5%, *n* = 1,830), and AB positive (10.7%, *n* = 1,191). Among the Rh-negative blood groups, O negative accounted for 2.2% (*n* = 248), B negative for 2.1% (*n* = 228), A negative for 1.3% (*n* = 143), and AB negative for 1.0% (*n* = 108).

Table 4: Blood Group wise Distribution of Donors

Blood Groups	No.	Percentage
A Positive	1830	16.5%
A Negative	143	1.3%
B Positive	2057	18.5%
B Negative	228	2.1%
AB Positive	1191	10.7%
AB Negative	108	1.0%
O Positive	5306	47.8%
O Negative	248	2.2%
Total	11111	100.0%

Table 5: Blood Group & Type of Donors wise Distribution

The distribution of blood groups in voluntary donors (n = 9,624), O positive was the most common blood group (49.7%, n = 4,783), followed by B positive (17.1%, n = 1,643), A positive (16.2%, n = 1,558), and AB positive (10.7%, n = 1,031). Among replacement donors (n = 1,487), O positive was also the predominant blood group (35.2%, n = 523), followed by B positive (27.8%, n = 414), A positive (18.3%, n = 272), and AB positive (10.8%, n = 160). Rh-negative blood groups were comparatively less frequent in both voluntary and replacement donors.

Table 5: Blood Group & Type of Donors wise Distribution

Blood Groups	Replacement		Voluntary	
	No.	Percentage	No.	Percentage
A Positive	272	18.3%	1558	16.2%
A Negative	4	0.3%	139	1.4%
B Positive	414	27.8%	1643	17.1%
B Negative	22	1.5%	206	2.1%
AB Positive	160	10.8%	1031	10.7%
AB Negative	17	1.1%	91	0.9%
O Positive	523	35.2%	4783	49.7%
O Negative	75	5.0%	173	1.8%
Total	1487	100.0%	9624	100.0%

Table 6: Seropositivity

Among the 11,111 blood donors screened, 54 (0.49%) were seropositive for transfusion-transmissible infections (TTIs). The overall seroprevalence of HBsAg was the highest at 0.31% (n = 34), followed by HIV at 0.16% (n = 18) and HCV at 0.02% (n = 2)

Table 6: Seropositivity

Seropositivity	No.	Percentage
HIV	18	0.2%
HBsAg	34	0.3%
HCV	2	0.0%
Total	54	0.5%

Table 7: Blood Group & Seropositivity wise Distribution

The distribution of seropositive donors according to blood group is shown in Table 7. Among HIV-seropositive donors (n = 18), the highest proportion was observed in the B positive blood group (66.7%, n = 12), followed by O positive (27.8%, n = 5) and AB positive (5.6%, n = 1). Among HBsAg-positive donors (n = 34), B positive accounted for 32.4% (n = 11), followed by O positive (29.4%, n = 10), A positive (17.6%, n = 6), AB positive (11.8%, n = 4), A negative (5.9%, n = 2), and B negative (2.9%, n = 1). Both HCV-seropositive donors belonged to the B positive blood group. No statistically significant association was observed between blood group and seropositivity (p = 0.369)

Table 7: Blood Group & Seropositivity wise Distribution

Blood Groups	HIV		HBsAg		HCV		p Value
	No.	Percentage	No.	Percentage	No.	Percentage	
A Positive	0	0.0%	6	17.6%	0	0.0%	0.369
A Negative	0	0.0%	2	5.9%	0	0.0%	
B Positive	12	66.7%	11	32.4%	2	100.0%	
B Negative	0	0.0%	1	2.9%	0	0.0%	
AB Positive	1	5.6%	4	11.8%	0	0.0%	
AB Negative	0	0.0%	0	0.0%	0	0.0%	
O Positive	5	27.8%	10	29.4%	0	0.0%	
O Negative	0	0.0%	0	0.0%	0	0.0%	
Total	18	100.0%	34	100.0%	2	100.0%	

Table 8: Gender & HIV Seropositivity wise Distribution

The distribution of HIV seropositivity according to gender is presented in Table 8. All 18 (100%) HIV-seropositive blood donors were male, while no HIV-seropositive cases were detected among female donors (0%).

Table 8: Gender & HIV Seropositivity wise Distribution

Gender	HIV	
	No.	Percentage
Male	18	100.0%
Female	0	0.0%

Table 9: Gender & HBsAg Seropositivity wise Distribution

The distribution of HBsAg seropositivity according to gender is presented in Table 9. All HBsAg-seropositive donors were male (100.0%, n = 34), while no female donor tested positive for HBsAg.

Table 9: Gender & HBsAg Seropositivity wise Distribution

Gender	HBsAg	
	No.	Percentage
Male	34	100.0%
Female	0	0.0%

Table 10: Gender & HCV Seropositivity wise Distribution

The distribution of HCV seropositivity according to gender is presented in Table 10. Both HCV-seropositive donors were male (100.0%, n = 2), while no female donor tested positive for HCV.

Table 10: Gender & HCV Seropositivity wise Distribution

Gender	HCV	
	No.	Percentage
Male	2	100.0%
Female	0	0.0%

Table 11: Age & Seropositivity wise Distribution

The age-wise distribution of seropositive donors is presented in Table 11. Among HIV-seropositive donors (n = 18), the majority belonged to the 21–40 years age group (66.7%, n = 12), followed by the 41–60 years age group (33.3%, n = 6). No HIV-seropositive donor was observed in the 18–20 years age group. Among HBsAg-seropositive donors (n = 34), 76.5% (n = 26) were aged 21–40 years, 14.7% (n = 5) were aged 41–60 years, and 8.8% (n = 3) were aged 18–20 years. Both HCV-seropositive donors (100.0%, n = 2) belonged to the 21–40

years age group. There was no statistically significant association between age group and seropositivity ($p = 0.339$).

Table 11: Age & Seropositivity wise Distribution

Age	HIV		HBsAg		HCV		p Value
	No	%	No	%	No	%	
18 - 20	0	0.0%	3	8.8%	0	0.0%	0.339
21 - 40	12	66.7%	26	76.5%	2	100.0%	
41 - 60	6	33.3%	5	14.7%	0	0.0%	

Table 12: Type of Donor & HIV Seropositivity wise Distribution

The distribution of HIV-seropositive donors according to donor type is presented in Table 12. All the 18 HIV-seropositive donors, 14 (77.8%) were voluntary donors, whereas 4 (22.2%) were replacement donor.

Table 12: Type of Donor & HIV Seropositivity wise Distribution

Type of Donor	HIV	
	No.	Percentage
Replacement	4	22.2%
Voluntary	14	77.8%

8. Discussion [17-26]

Blood transfusion is an essential component of modern healthcare; however, it carries the potential risk of transmitting infectious agents such as Human Immunodeficiency Virus (HIV), Hepatitis B Virus (HBV), and Hepatitis C Virus (HCV). Continuous surveillance of transfusion-transmissible infections (TTIs) among blood donors is therefore crucial for ensuring blood safety and monitoring disease trends in the community. The present study evaluated the seroprevalence of HIV, HBV, and HCV among 11,111 blood donors and compared the findings with those reported in previous national and international studies.
The majority of blood donors in the present study belonged to the 21–30 years age group (55.1%), followed by the 31–40 years age group (35.0%), with a mean age of 30.12 ± 6.67 years. These findings are comparable with those reported by Guerrero-García et al. and Nagalo et al., who also observed that young adults constituted the largest proportion of blood donors. The predominance of younger donors may be attributed to better health status, greater awareness regarding blood donation, and higher eligibility for blood donation than older individuals.

A marked male predominance was observed in the present study, with 97.5% of donors being male and only 2.5% female. Similar observations have been reported by Assefa et al. in Ethiopia and Belkacemi et al. in Algeria, where male donors also constituted the majority of the donor population. The low participation of female donors may be explained by physiological factors such as anemia, menstruation, pregnancy, lactation, and lower body weight, as well as social and cultural barriers. Increasing awareness and implementing targeted recruitment strategies may improve female participation in voluntary blood donation programs.
Voluntary blood donors constituted 86.6% of the study population, whereas 13.4% were replacement donors. This high proportion of voluntary donors reflects successful implementation of voluntary blood donation programs and is consistent with the recommendations of the World Health Organization, which advocates voluntary non-remunerated blood donation as the safest source of blood. Similar findings have been reported by Negash et al. and Mobarki et al., whereas Fouelifack Ymele et al. reported greater dependence on replacement donors in Cameroon. The increasing proportion of voluntary donors is encouraging because they are generally considered a safer donor population.

The distribution of ABO and Rh blood groups showed that O positive (47.8%) was the most common blood group, followed by B positive (18.5%), A positive (16.5%), and AB positive (10.7%). Similar blood group distributions have been reported by Guerrero-García et al. and several Indian studies. Knowledge of blood group distribution is important for effective blood inventory management and ensuring adequate availability of commonly required blood components.

The overall seroprevalence of TTIs in the present study was 0.49%, with HBV (0.31%) being the most prevalent infection, followed by HIV (0.16%) and HCV (0.02%). The HBV prevalence observed in this study was lower than that reported by Assefa et al. (4.07%) and Nagalo et al. (14.96%), but comparable to findings reported by Belkacemi et al. and Saini et al**.** Similarly, the prevalence of HIV and HCV in the present study was considerably lower than that reported from several African countries but was comparable with studies from India, Mexico, and Saudi Arabia. These differences may reflect variations in disease epidemiology, donor selection criteria, vaccination coverage, public health awareness, and the effectiveness of donor screening protocols across different regions.

Analysis of blood group and seropositivity demonstrated that HIV and HBV positivity were more frequently observed among B positive donors, while both HCV-positive cases also belonged to the B positive blood group. However, no statistically significant association was found between ABO blood group and seropositivity ($p = 0.369$). The higher proportion of seropositive cases among B positive donors is likely attributable to the distribution of blood groups within the donor population rather than to any biological association. Similar observations have been reported in previous studies, suggesting that ABO blood groups are not independent predictors of transfusion-transmissible infections.

All HIV-, HBV-, and HCV-seropositive donors in the present study were male. However, this finding should be interpreted cautiously because males represented almost the entire donor population. Likewise, the majority of seropositive donors belonged to the 21–40 years age group, although the association between age and seropositivity was not statistically significant ($p = 0.339$). This distribution most likely reflects the predominance of donors within this age group rather than age being an independent risk factor. Similar age-related trends have been reported by Fouelifack Ymele et al. and Nagalo et al.

Among HIV-seropositive donors, 77.8% were voluntary donors and 22.2% were replacement donors. Since voluntary

donors constituted the majority of the donor population, this finding should not be interpreted as indicating a higher risk among voluntary donors. Rather, it reflects the greater representation of voluntary donors in the study. Comparison of infection rates rather than absolute numbers would provide a more meaningful assessment of risk between donor groups.

Overall, the findings of the present study indicate a low prevalence of transfusion-transmissible infections among blood donors, suggesting that current donor selection criteria, pre-donation counselling, and mandatory serological screening are effective in maintaining blood safety. Nevertheless, HBV remains the most common transfusion-transmissible infection detected among donors, emphasizing the need for continued surveillance, promotion of HBV vaccination, strengthening of voluntary blood donation programs, and adoption of more sensitive screening methods such as nucleic acid testing (NAT). These measures will further reduce the residual risk of transfusion-transmitted infections and improve the safety of the blood supply.

Study & Year	Total Donors	HIV Prevalence (%)	HBV Prevalence (%)	HCV Prevalence (%)	Dominant Donor Type	Dominant Age Group
Current Study	11111	0.2	0.3	0.02	Voluntary (86.6%)	21-30 years
Quintas et al. (2023) [Angola]	2734	7	50.2	5.1	Voluntary	18-64 years
Assefa et al. (2022) [Ethiopia]	426	-	4.07	0.48	Voluntary	Varied
Nagalo et al. (2011) [Burkina Faso]	4520	2.21	14.96	8.69	Mixed	20-29 years
Belkacemi et al. (2023) [Algeria]	10386	0.1	0.4	0.4	Voluntary	Varied
Saini et al. (2017) [India]	58998	0.09	0.98	0.07	Voluntary	Varied
Fouelifack Ymele et al. (2012) [Cameroon]	4650	4.44	12.14	1.44	Replacement	28 years(median)
Guerrero-GarcÃa et a (2021) [Mexico]	80391	0.17	0.22	0.48	Voluntary	Younger donors
Negash et al. (2019) [Ethiopia]	310	2.6	5.8	4.2	Voluntary	Varied
DoÄŸan et al. (2024) [Somalia]	109385	0.03	0.6	0.01	Voluntary	Varied
Mobarki et al. (2022) [Saudi Arabia]	4977	0.16	0.6	1.09	Voluntary	Varied

9. Conclusion

The present prospective observational study evaluated the seroprevalence of Human Immunodeficiency Virus (HIV), Hepatitis B Virus (HBV), and Hepatitis C Virus (HCV) among 11,111 blood donors attending the Blood Bank, Department of Pathology, GMERS Medical College, Gandhinagar, during the study period from July 2023 to February 2025. The findings provide valuable information regarding donor demographics, blood group distribution, and the burden of transfusion-transmissible infections (TTIs) in the study population.

The donor population was predominantly composed of young adults aged 21–30 years, with a marked predominance of male donors and voluntary blood donors. These findings indicate that young, healthy individuals continue to constitute the major source of blood donation and highlight the success of voluntary blood donation programs in reducing dependence on replacement donors. However, the very low participation of female donors emphasizes the need for targeted awareness programs, correction of nutritional deficiencies such as anemia, and strategies to encourage greater female participation in voluntary blood donation.

The study demonstrated that O positive was the most common blood group among donors, followed by B positive, A positive, and AB positive, while Rh-negative blood groups were relatively uncommon. This information is valuable for blood bank inventory management and planning to ensure adequate availability of blood and blood components.

The overall seroprevalence of transfusion-transmissible infections was 0.4G%, with HBV (0.31%) being the most prevalent infection, followed by HIV (0.16%) and HCV (0.02%). The relatively low prevalence of these infections reflects the effectiveness of stringent donor selection criteria, comprehensive pre-donation counselling, mandatory serological screening, and adherence to national blood safety guidelines. Nevertheless, HBV remains the leading transfusion-transmissible infection among blood donors, indicating the continuing need for enhanced preventive strategies, including universal hepatitis B vaccination, health education, and regular surveillance.

Although seropositive cases were more frequently observed among B positive blood group donors, male donors, and individuals aged 21–40 years, no statistically significant association was found between blood group or age and seropositivity. These findings suggest that the observed distribution is more likely related to the demographic characteristics of the donor population rather than these variables acting as independent risk factors for infection.

Overall, the findings of this study confirm that the prevalence of HIV, HBV, and HCV among blood donors at this tertiary care centre is low and comparable to that reported in other Indian studies, indicating a high standard of blood safety. Continuous monitoring of transfusion-transmissible infections remains essential to identify changing epidemiological trends and to maintain a safe and reliable blood supply.

Strengthening voluntary blood donation programs, increasing participation of female donors, promoting hepatitis B vaccination, maintaining strict donor selection protocols, and implementing highly sensitive screening techniques such as Nucleic Acid Testing (NAT), wherever feasible, will further reduce the residual risk of transfusion-transmitted infections. Sustained public health initiatives, periodic surveillance, and continuous quality improvement in blood bank services are essential to ensure the availability of safe blood and to protect both donors and recipients.

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