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(ARTICLE)

Epidemiological Profile and Seroprevalence of Blood-Borne Pathogens Among 75,910 Donors at the Central Blood Bank of Tobruk, Libya

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الملف الوبائي ومعدل انتشار الأجسام الممرضة المنقولة بالدم بين 75910 متبرع في مصرف الدم المركزي بطبرق، ليبيا ما بين الفترة 2021- 2015

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Abstract:

Background: Ensuring blood transfusion safety requires routine screening for transfusion-transmitted infections (TTIs), including hepatitis B virus (HBV), hepatitis C virus (HCV), human immunodeficiency virus (HIV), and syphilis. This study aimed to determine the seroprevalence of these infections among blood donors at the Central Blood Bank in Tobruk, Libya, over the five years from 2021 to 2025. Methods: A retrospective analysis was conducted on 75,910 blood donors who attended the Central Blood Bank in Tobruk City between 2021 and 2025. All donors were screened for HBV, HCV, HIV, and syphilis using standardized serological assays. Data were extracted from the blood bank information system database. Results: Of 75,910 donors, 74,230 (97.9%) were male, and 1,680 (2.21%) were female. The mean age was 35.02 years with a standard deviation of 10.83 years. The most frequent blood group was O (34.54%), followed by A (32.41%), B (22.51%), and AB (10.55%), with 80.24% Rh-positive. Of 71,175 screened donors, 148 (0.208%) were seropositive for at least one TTI. HBV had the highest prevalence (0.093%; n = 66), followed by HCV (0.076%; n = 54), syphilis (0.031%; n = 22), and HIV (0.008%; n = 6). Yearly HBV rates ranged from 0.061% to 0.171%; HCV from 0.044% to 0.121%; syphilis from 0.008% to 0.082%; and HIV from 0.000% to 0.030%. No co-infections were detected. Conclusion: The seroprevalence of HBV, HCV, HIV, and syphilis among Tobruk blood donors was very low. Nonetheless, rigorous donor selection and screening remain essential to ensure recipient safety and prevent transfusion-transmitted infections.

Keywords: Blood donors, seroprevalence, transfusion-transmitted infections, hepatitis B, syphilis

الملخص

الخلفية: يتطلب ضمان سلامة نقل الدم الفحص الروتيني للعدوى المنقولة بالنقل (TTIs)، بما في ذلك فيروس التهاب الكبد ب (HBV)، وفيروس التهاب الكبد ج (HCV)، وفيروس نقص المناعة البشرية (HIV)، والزهري. هدفت هذه الدراسة إلى تحديد معدل انتشار الأجسام المضادة لهذه العدوى بين المتبرعين بالدم في بنك الدم المركزي بطبرق، ليبيا، خلال الفترة من 2021 إلى 2025.

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المنهجية: أجريت تحليل على 75,910 متبرع بالدم حضروا إلى بنك الدم المركزي بطبرق خلال الفترة من 2021 إلى 2025. تم فحص جميع المتبرعين بحثًا عن HBV وHCV وHIV والزهري باستخدام اختبارات مصلية موحدة. استُخرجت البيانات من قاعدة بيانات نظام معلومات بنك الدم. النتائج: من بين 75,910 متبرع، كان 74,230 (97.9%) من الذكور و1,680 (2.21%) من الإناث. كان متوسط العمر 35.02 سنة بانحراف معياري قدره 10.83 سنة. كانت الفصيلة الأكثر شيوعًا هي O (34.54%)، تليها A (32.41%)، ثم B (22.51%)، وAB (10.55%)، مع كون 80.24% من المتبرعين إيجابيي العامل الريسي. من بين 71,175 متبرع تم فحصهم، كان 148 (0.208%) إيجابيي الأجسام المضادة لواحدة على الأقل من العدوى المنقولة بالنقل. كان التهاب الكبد ب الأعلى انتشارًا (0.093%؛ n = 66)، تلاه التهاب الكبد ج (0.076%؛ n = 54)، ثم الزهري (0.031%؛ n = 22)، وأخيرًا فيروس نقص المناعة البشرية (0.008%؛ n = 6). تراوحت معدلات التهاب الكبد ب السنوية بين 0.061% و0.171%، والتهاب الكبد ج بين 0.044% و0.121%، والزهري بين 0.008% و0.082%، وفيروس نقص المناعة البشرية بين 0.000% و0.030%. لم يُرصد أي حالات للعدوى المشتركة. الاستنتاج: كان معدل انتشار HBV وHCV وHIV والزهري بين متبرعي الدم بطبرق منخفضًا جدًا. ومع ذلك، يظل الاختيار الدقيق للمتبرعين والفحص المنهجي ضروريين لضمان سلامة المستلمين ومنع العدوى المنقولة بالنقل.

الكلمات المفتاحية: متبرعون بالدم، معدل انتشار الأجسام المضادة، العدوى المنقولة بالنقل، التهاب الكبد ب، الزهري.

Introduction

Blood transfusion in the era of modern medicine plays a critical role in saving the lives of patients, especially for those suffering from severe anemia and hemorrhage because of traffic accidents or during major surgeries and in the management of chronic hematological disorders (1). Globally, over 118 million blood donations are collected yearly, saving the lives of millions of patients. Despite its life-saving importance, blood transfusion might expose recipients to a considerable risk of blood-borne pathogens, which can be viruses, bacteria, parasites, and prions (2). The most common transfusion-transmissible infections (TTIs) are hepatitis B virus (HBV), hepatitis C virus (HCV), human immunodeficiency virus (HIV), and syphilis. These infections remain a major public health problem across the world because they can remain asymptomatic in donors or lead to prolonged viraemia and carrier or latent states (3). To minimize this problem, the WHO recommends strict and thorough screening of all blood donations for HIV, HBV, HCV, and syphilis before transfusion to ensure the safety of the blood supply and prevent the transmission of these infectious diseases through transfusion (4). Hepatitis B virus is a highly infectious viral pathogen belonging to DNA viruses, whereas hepatitis C virus is an RNA virus. Both are hepatotropic and blood-borne viruses and can cause acute and chronic liver disease globally, mostly causing cirrhosis and hepatocellular carcinoma (5). Human immunodeficiency virus (HIV) has been a worldwide health problem since its discovery in the 1980s and continues to spread, particularly amongst at-risk groups. HIV has two types: HIV-1 is the most prevalent type throughout the world, while HIV-2 has been found primarily in West Africa (6). This viral agent infects and destroys CD4 T lymphocytes, leading to acquired immunodeficiency syndrome (AIDS). Syphilis is a systemic disease caused by the bacterium Treponema pallidum and can be transmitted through blood transfusion and sexual intercourse (7). This disease can be treated with specific antibiotics, mainly if diagnosed early, but if left untreated, it can lead to many health problems such as cardiovascular disease and brain damage (8). Monitoring seroprevalence, the percentage of blood donors who test positive for specific antibodies or antigens in their blood serum, serves to ensure hemovigilance and acts as an indicator of public health. The epidemiology of these infections differs significantly across geographical locations and societies, determined by various factors such as socioeconomic development, public health infrastructure, and cultural standards (9). Nationality and demographic characteristics, including age, gender, occupation, and high-risk behavior history, substantially influence disease incidence and associated health outcomes (9). While traditional serological assays such as enzyme-linked immunosorbent assay (ELISA) and chemiluminescence immunoassays (CLIA) boast high accuracy, their diagnostic utility is constrained by the window period: the period between initial infection and the appearance or detectability of antigens or antibodies in blood (10). To bridge this gap, many advanced methods can be employed, such as nucleic acid testing (NAT), to detect viral nucleic acid directly and reduce the risk of transfusion-transmitted infections (11). This study aimed to evaluate the seropositivity and co-infection rates of HBV, HCV, HIV, and syphilis among blood donors, utilizing statistical methods and visual analytics to guide evidence-based policy decisions and curtail the transmission of infectious diseases.

Methods

Study Population

A retrospective study was conducted among voluntary and replacement blood donors who attended the central blood bank in Tobruk City, Libya, from January 2021 to December 2025.

Inclusion Criteria of Blood Donors

Blood donors were selected according to WHO guidelines based on predefined inclusion criteria (12). These criteria required an age between 18 and 65 years, body weight ≥ 50 kg, hemoglobin level between 14–18 g/dL for males and 12.5–16 g/dL for females, with an average pulse rate of 60–100 per minute and blood pressure (systolic blood pressure of 100–140 mmHg and diastolic of 60–90 mmHg). Exclusion criteria included a history of blood donation within the preceding 3 months, history of jaundice, cupping, recent surgical operation, hypertension, current fever, recent illness, and failure to give consent.

Laboratory Examination

All blood donor samples were tested for viral markers: hepatitis B surface antigen (HBsAg), anti-HCV, anti-HIV, and syphilis using COBAS E411, Architect I-1000 RS, and GeneXpert Cepheid.

Statistical Analysis

Statistical calculations were performed using SPSS version 27 and Microsoft Excel 365. Descriptive statistics (percentages, frequencies, means, standard deviations, and ranges) were calculated. Confidence intervals (CI) were computed, and a P-value < 0.05 was considered statistically significant.

Results and discussion

Across the whole study period, a total of 75,910 donors were recorded. Of these, 74,230 were male and 1,680 were female. Regarding age, the donor population covered a wide age range, from younger than 18 years to older than 64 years. The mean age was approximately 35.02 years, with a standard deviation of 10.83 years (**Figure 1**).

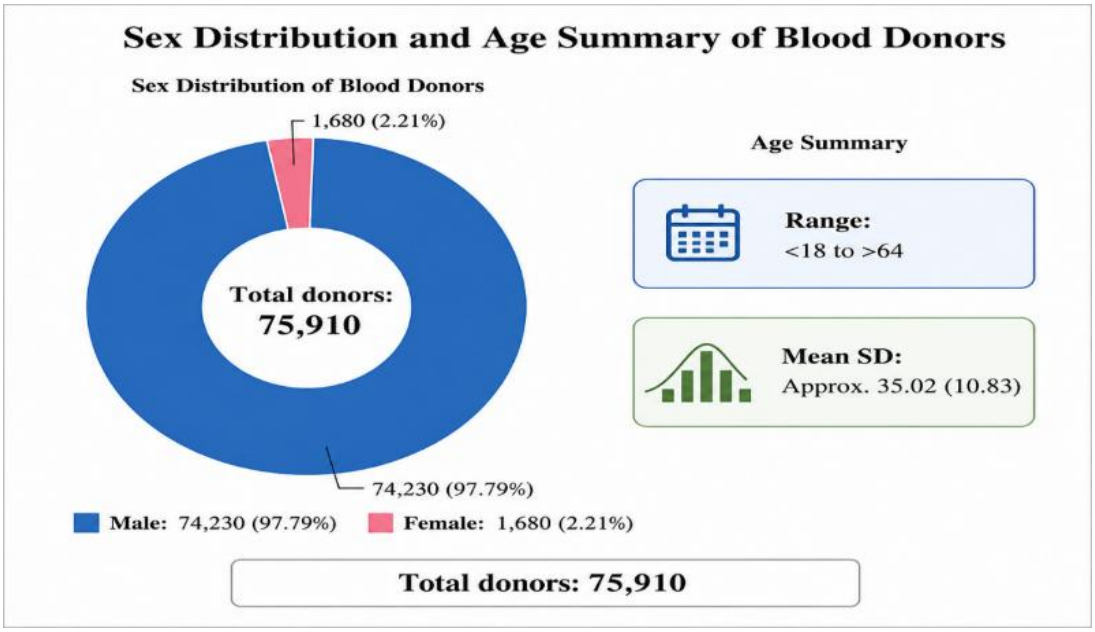

Figure 1: Sex Distribution and Age Summary of Blood Donors

The yearly number of donors varied across the study period. In 2021, 17.61% (n = 13,370); in 2022, 19.87% (n = 15,081); in 2023, 17.72% (n = 13,449); in 2024, 23.79% (n = 18,061); and in 2025, 21.01% (n = 15,949) (Ta**ble 1**).

Table 1. Distribution of Blood Donors by Sex, 2021–2025

Parameter	Female	Male	Number	Percentage
2021	92	13,278	13,370	17.61%
2022	85	14,996	15,081	19.87%
2023	316	13,133	13,449	17.72%
2024	1,091	16,970	18,061	23.79%
2025	96	15,853	15,949	21.01%

Table 2 presents the distribution of blood donors according to the type of donation. The table shows that the largest proportion of donations came from replacement donors (50.43%), while regular donors represented the smallest group (5.27%). The second largest group was volunteer donors (29.77%), and first-time donors represented 14.53% of all donors.

Table 2. Distribution of Blood Donors by Type of Donation

Type of Donation	Frequency	Percentage
Volunteer	22,596	29.77%
Replacement	38,281	50.43%
Regular	4,000	5.27%
First-time	11,031	14.53%

Regarding age distribution, the majority of donors were adults aged 25–44 years (55.82%; n = 42,371). The second most common age group was 18–24 years (23.98%; n = 18,204). The 45–64 years group accounted for 19.94% (n = 15,136), and 0.08% (n = 58) were younger than 18 years. Blood group distribution showed that group O was the most frequent (34.54%), followed by A (32.41%), B (22.51%), and AB (10.55%). Regarding Rhesus (Rh) type, the majority of donors were Rh positive (80.24%), while 19.76% were Rh negative (**Table 3**).

Table 3. Distribution of Blood Donors by Age Group, ABO Blood Group, and Rhesus Type

Parameter	Frequency (%)
Age	
< 18	58 (0.08%)
18–24	18,204 (23.98%)
25–44	42,371 (55.82%)
45–64	15,136 (19.94%)
> 64	141 (0.19%)
ABO blood groups	
O	24,334 (34.54%)
A	22,831 (32.41%)
B	15,856 (22.51%)
AB	7,433 (10.55%)
Rhesus (Rh) type	
Positive	56,533 (80.24%)
Negative	13,921 (19.76%)

Of the 75,910 recorded donors, 71,175 were screened for transfusion-transmissible infections. A total of 71,027 donors were negative, and 148 were positive for at least one transfusion-transmissible infection, giving an overall TTI prevalence of 0.208%. The 95% confidence interval for the overall TTI prevalence was 0.177–0.244%. The most frequently detected infection was HBV, representing 0.093% (66 donors). The second most common infection was HCV, with 54 positive cases, giving a prevalence of 0.076%. For syphilis, there were 22 positive cases, with a prevalence of 0.031%. For HIV, only 6 positive cases were detected, giving the lowest prevalence among the listed infections at 0.008% (**Table 4**).

Table 4. Prevalence of HBV, HCV, HIV, and Syphilis Among Blood Donors at the Central Blood Bank

Variable	Category	Number	Percentage (%)	P-value	95% CI
HBV	Positive	66	0.093%	0.061	0.073–0.118%
	Negative	71,109	99.907%		99.882–99.927%
HCV	Positive	54	0.076%	0.042	0.058–0.099%
	Negative	71,121	99.924%		99.901–99.942%
HIV	Positive	6	0.008%	0.056	0.004–0.018%
	Negative	71,169	99.992%		99.982–99.996%
Syphilis	Positive	22	0.031%	0.001	0.020–0.047%
	Negative	71,153	99.969%		99.953–99.980%
Overall TTIs		148	0.208%	0.004	0.177–0.244%

Table 5 shows the prevalence of TTI among seropositive donors from 2021 to 2025. A total of 148 seropositive cases were recorded during the five years. HBV was the most frequent infection (44.6%), followed by HCV (36.5%), syphilis (14.9%), while HIV was the least frequent infection (4.1%). Yearly proportions of total cases were 18.2% in 2021, 22.3% in 2022, 22.3% in 2023, 14.2% in 2024, and 23.0% in 2025. Viral hepatitis infections constituted the majority of transfusion-transmissible infections detected among donors.

Table 5. Annual Frequency of HBV, HCV, HIV, and Syphilis Cases Among Seropositive Donors

Year	HBV (%)	HCV (%)	HIV (%)	Syphilis (%)	Total (%)
2021	13 (48.1%)	11 (40.7%)	2 (7.4%)	1 (3.7%)	27 (18.2%)
2022	11 (33.3%)	17 (51.5%)	1 (3.0%)	4 (12.1%)	33 (22.3%)
2023	17 (51.5%)	11 (33.3%)	3 (9.1%)	2 (6.1%)	33 (22.3%)
2024	11 (52.4%)	8 (38.1%)	0 (0.0%)	2 (9.5%)	21 (14.2%)
2025	14 (41.2%)	7 (20.6%)	0 (0.0%)	13 (38.2%)	34 (23.0%)
Total	66 (44.6%)	54 (36.5%)	6 (4.1%)	22 (14.9%)	148 (100.0%)
P-value	0.533	0.121	0.254	0.001	0.005

Table 6 demonstrates the prevalence of specific TTIs among 148 seropositive blood donors from 2021 to 2025. HBV was detected in 0.093%, HCV in 0.076%, syphilis in 0.031%, and HIV in 0.008% of donors. Yearly prevalence of TTIs was generally low among all blood donors; HBV and HCV were the most frequently detected infections, while HIV was rare. The increase in syphilis prevalence in 2025 is an important finding.

Table 6. Annual True Prevalence of TTIs Among All Blood Donors

Year	HBV (%)	HCV (%)	HIV (%)	Syphilis (%)	Total (%)
2021	13 (0.099%)	11 (0.084%)	2 (0.015%)	1 (0.008%)	27 (0.206%)
2022	11 (0.078%)	17 (0.121%)	1 (0.007%)	4 (0.028%)	33 (0.234%)
2023	17 (0.171%)	11 (0.111%)	3 (0.030%)	2 (0.020%)	33 (0.332%)
2024	11 (0.061%)	8 (0.044%)	0 (0.000%)	2 (0.011%)	21 (0.116%)
2025	14 (0.088%)	7 (0.044%)	0 (0.000%)	13 (0.082%)	34 (0.213%)
Total	66 (0.093%)	54 (0.076%)	6 (0.008%)	22 (0.031%)	148 (0.208%)
P-value	0.061	0.042	0.056	0.001	0.004

Table 7 shows that most TTI-positive cases occurred among donors aged 25–45 years, especially in the 35–45 years age group. HBV and HCV showed statistically significant differences across age groups, while HIV and syphilis did not.

Table 7. Distribution of TTI-Positive Cases by Age Group

Age Group	HBV N (%)	HCV N (%)	HIV N (%)	Syphilis N (%)
18–25	3 (4.5%)	1 (1.9%)	0 (0.0%)	3 (13.6%)
25–35	24 (36.4%)	16 (29.6%)	1 (16.7%)	6 (27.3%)
35–45	27 (40.9%)	23 (42.6%)	3 (50.0%)	7 (31.8%)
45–55	10 (15.2%)	11 (20.4%)	1 (16.7%)	4 (18.2%)
> 55	2 (3.0%)	3 (5.6%)	1 (16.7%)	2 (9.1%)
Total	66 (100%)	54 (100%)	6 (100%)	22 (100%)
P-value	< 0.001	< 0.001	0.406	0.418

Discussion

Blood donation is a lifesaving treatment that plays a vital role in modern healthcare, particularly during surgical procedures and in the management of severe anemia among children and pregnant women. Nevertheless, the transmission of blood-borne pathogens, especially HBV, HCV, HIV, and syphilis, remains an important public health problem around the world and continues to pose challenges to blood transfusion safety. Moreover, ensuring the safety of blood and blood components is the critical goal of all blood transfusion services. It has been estimated that each unit of transfused blood carries approximately a 1% risk of transfusion-related complications, including TTIs, emphasizing the utmost importance of thorough donor screening to avoid possible health risks (13). The present study investigated the seroprevalence of TTIs among blood donors at the central blood bank in Tobruk City over a five year period from 2021 to 2025. The findings showed that the majority of the donors were male (97.9%), which aligns with previous studies conducted by Ahmed et al. in Sudan, Domínguez et al. in Mexico, and Mohammed et al. in Iraq (13, 14, 15). Globally, studies report that females account for 33% of donated blood. Nevertheless, the contribution remains less than 10% in 14 out of 111 countries (16). This predominance of male donors may be attributed to cultural, social, and medical factors that limit female participation in blood donation, including pregnancy and breastfeeding, menstruation, the higher prevalence of iron-deficiency anemia among female populations, and donor eligibility criteria.

Commonly, blood donors are predominantly young people under 30 years of age, as illustrated in numerous studies (17). In the present study, however, the majority of donors fell within the 25–44 years age group, which represented the most frequent blood donors. Consequently, the rate of TTIs was found to be highest in the age group of 35–44 years. Regarding ABO blood group distribution, the most prevalent blood group was O (34.54%), followed by A (32.41%), B (22.51%), and AB (10.55%). The majority of donors were Rh positive (80.24%).

The present study revealed that the overall prevalence of TTIs among donors was 0.208% among blood donors in Tobruk city. This result places it within the very low prevalence category (< 1%), indicative of effective donor screening protocols. This result aligns with findings from Serbia (0.38%) and Turkey (0.77%), where the overall TTI prevalence among blood donors was low (18, 19), both of which reflect rigorous screening protocols and low infection rates. Conversely, significantly higher findings have been reported in studies from Eritrea (~3.7%), Sudan (8.8%) (20), Saudi Arabia (7.4%) (21), Ethiopia (5.43%) (22), India (1.58%) (23), Kosti (22.52%) (24), Port Sudan (20.1%) (25), White Nile State (15.91%) (26), Ghana (16.1%), and South Sudan (22.1%) (27), highlighting how differences in local infection rates, donor selection criteria, and screening methods affect prevalence. The low overall prevalence of transfusion-transmitted infections among blood donors indicates a safe donor population. This reflects effective blood selection protocols throughout all donation steps: pre-donation screening, health questionnaires, and deferral policies. Moreover, it might indicate good public awareness and a higher reliance on voluntary or repeat donors, who usually carry a lower risk of infection.

Our findings revealed that HBV was the most common TTI, with a prevalence rate of 0.093%, followed by HCV (0.076%), syphilis (0.031%), and HIV (0.008%). No cases of co-infections were detected. Recent evidence demonstrates substantial regional variation in the epidemiology of hepatitis B. In Africa, a large study involving more than 3.5 million blood donors

reported an overall HBsAg seroprevalence of 6.93%, highlighting a significant burden of infection (28). In contrast, a 2022 study conducted in Guinea reported an HBsAg detection rate of 16.4% and an overall hepatitis B marker positivity of 83.2%, highlighting significant intra-regional variability and possible differences in healthcare practices, screening methods, and prevalence of infection (29). On the other hand, data from China in 2017 and 2024 indicated a relatively balanced distribution between first-time (47.78%) and repeat donors (52.22%), revealing a well-established system of blood donations (30). Similarly, the Americas (2015–2023) maintained a relatively stable prevalence, suggesting the efficacy of long-term control measures (31). HBV prevalence rates in other countries include Kosti (6.07%) (24), Port Sudan (11.7%) (25), White Nile State (5.57%) (26), and Saudi Arabia (6.1%) (21). However, these exceed the rates observed in Ghana (3.1%) (27). In this study, the HCV prevalence rate was 0.076%. Global infection rates vary widely; Japan reported an exceptionally low incidence of 0.40 per 100,000 person-years (32), while Georgia saw anti-HCV seroconversion drop from 408 to 218 per 100,000 person-years between 2017 and 2022 (33). Regionally, a study conducted in Qena, Upper Egypt, found a prevalence of 3.18% among blood donors (34). Meanwhile, China recorded a rate of 166.56 per 100,000 first-time donors, with associations found for older age and lower educational level (35).

Additionally, the present study identified a syphilis prevalence rate of 0.031% among blood donors at the Tobruk Blood Bank, a rate significantly lower than those reported regionally and internationally. For instance, prevalence rates reached 5.5% in Saudi Arabia (36) and 3.0% in Gabon (37). South Asian regions recorded lower rates, including Pakistan at 1.2% (38) and India at 0.29% (39). Longitudinal data from Al-Basra, Iraq, showed an overall declining trend with rates ranging from 0.36% to 0.47% (40). The lower prevalence observed in Tobruk likely stems from strict donor selection protocol steps and accurate screening methods. Similarly, the observed HIV prevalence rate in Tobruk was remarkably low at 0.008%. Globally, HIV epidemiology varies substantially: China found a rate of 9.92 per 100,000, predominantly among males and first-time donors (41). While chronic infection predominated at 61.3% in the Brazilian Amazon, among young, single males, Syria reported a low prevalence rate of 0.23% (42). These findings emphasize the necessity of sustained high-sensitivity screening and targeted prevention strategies, particularly in regions with diverse risk profiles.

Conclusion

Our study showed a low seroprevalence of hepatitis B, hepatitis C, human immunodeficiency virus, and syphilis among blood donors, and no cases of co-infections were observed. Even though our observed prevalence rates are low, maintaining blood safety requires strict donor selection and complete screening utilizing standardized and confirmed procedures. The risk of transfusion-transmitted pathogens can be reduced through precise implementation of donor selection criteria, training of blood center personnel, HBV vaccination programs, public awareness campaigns, and avoiding unnecessary blood transfusions. Furthermore, confirmatory tests should be performed for reactive screening results to ensure precise diagnosis. Future research should focus on demographic and cultural factors affecting the prevalence of blood-transmitted diseases amongst blood donors.

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Conflict of Interest
The authors declare no conflicts of interest.

Data Availability
The raw data will remain confidential, and any further inquiries can be directed to the corresponding author, Asmai S.H. Mohammed.

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