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Prevalence of Infectious Markers among Blood Donors in Sana'a, Yemen: A Cross-Sectional Study

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Abstract

Blood transfusion is a vital therapeutic procedure but carries the risk of transfusion-transmissible infections, particularly in resource-limited settings. This cross-sectional study was conducted to determine the prevalence of infectious markers among voluntary male blood donors in Sana'a, Yemen. A total of 200 donors aged 18–60 years were recruited between June 2024 and May 2025 from three major facilities: Al-Kuwait University Hospital, National Blood Transfusion and Research Center, and National Center for Central Public Health Laboratories in Sana'a City, Yemen. Blood samples were screened for HIV, HBsAg, anti-HBc, HCV, syphilis (*Treponema pallidum*), and malaria using ELISA and microscopy. Overall, 25 donors (12.5%; 95% CI: 8.6–17.8) were positive for at least one infectious marker. Anti-HBc was the most common (7.0%), followed by malaria (5.5%), while HBsAg and HCV were less frequent (1.5% and 0.5%, respectively), and no cases of HIV or syphilis were detected. Statistical analysis showed significant associations between HCV and shamma use ($p = 0.017$) and between anti-HBc and educational level ($p = 0.006$), whereas smoking demonstrated a borderline association with anti-HBc ($p = 0.057$). No significant relationships were found between malaria or HBsAg and sociodemographic or behavioral variables. The results indicate that exposure to hepatitis B virus and malaria remains the predominant transfusion-related risk in this population, whereas exposure to HIV and syphilis appears negligible. These findings underscore the importance of strengthening donor education, sustaining HBV vaccination and screening programs, and improving malaria prevention strategies to enhance the safety of blood transfusion in Yemen

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1. INTRODUCTION

Blood transfusion is an essential component of modern healthcare, providing critical support for patients undergoing surgery, trauma management, and the treatment of chronic illnesses such as anemia and cancer. Ensuring the safety of transfused blood depends on rigorous screening for transfusion-transmissible infections (TTIs) including Human Immunodeficiency Virus (HIV), Hepatitis B Virus (HBV), Hepatitis C Virus (HCV), syphilis, and malaria. However, in low- and middle-income countries (LMICs), limited healthcare infrastructure often constrains the implementation of effective screening programs, thereby increasing the risk of TTIs and contributing to significant morbidity and mortality among transfusion recipients [1, 2].

Yemen, a country experiencing protracted conflict and humanitarian crises, represents a setting in which there is a scarcity of data on infectious diseases, particularly on TTIs among blood donors [3], [4], [5], [6]. Most available studies addressing TTIs have been conducted in other regions, particularly sub-Saharan Africa and Pakistan, where prevalence rates are high and transfusion safety is a major public health concern [2], [7].

In contrast, Yemen lacks updated and localized epidemiological data to inform health policies and strengthen blood safety measures. The absence of systematic studies hampers the development of tailored in-

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terventions and undermines efforts to adapt global transfusion safety guidelines in the Yemeni context [8], [9].

In addition, limited public awareness and insufficient health education regarding infectious diseases contribute to delayed diagnosis, underreporting, and increased transmission risks. Furthermore, many blood banks and healthcare facilities face a shortage of advanced diagnostic technologies and modern laboratory equipment that rely on outdated or basic screening methods. This technological gap limits the capacity to detect and monitor TTIs effectively [10], [11], [12].

Therefore, assessing the prevalence of infectious markers among blood donors in Sana'a, the capital city and primary hub for healthcare services in the country, is critically important. Blood donors represent a diverse demographic group, and evaluating the frequency and distribution of infectious markers within this population is vital for ensuring transfusion safety and protecting vulnerable recipients [13], [14].

The increasing demand for blood transfusions in Yemen combined with the potential risk of undetected infections underscores the need for evidence-based screening strategies. The objective of this cross-sectional study is to determine the prevalence of major infectious markers, specifically HIV, HBV, HCV, syphilis, and malaria, among voluntary blood donors in Sana'a, Yemen. In addition, this study aimed to examine the possible associations between these infections and sociodemographic and behavioral characteristics. These findings are expected to fill a significant knowledge gap and provide evidence to guide effective donor screening protocols and transfusion safety strategies in Yemen.

2. MATERIALS AND METHODS

2.1. Study Design and Duration

This study was conducted as a cross-sectional survey over a 12-month period, from June 2024 to May 2025, in Sana'a, Yemen. The primary aim of this study was to determine the prevalence of major infectious markers among voluntary blood donors at selected health institutions.

2.2. Study Population and Eligibility Criteria

The participants included in the study were male blood donors aged 18–60 years who attended blood donation facilities during the study period. Only healthy individuals who consented to participate were enrolled in this study. Female donors were excluded because of their limited representation in the local donor population, which ensured a more homogeneous study group.

2.3. Study Sites and Sample Size

A total of 200 blood donors were included in this study. Blood samples were collected from three major health facilities in Sana'a. Of these, 50 donors (25%) were recruited from Al-Kuwait University Hospital, 100 donors (50%) from the National Blood Transfusion and Research Center, and 50 donors (25%) from the National Center for Central Public Health Laboratories. This distribution ensured that the study covered a representative range of the major donor facilities in the city.

2.4. Sample Collection and Processing

For each participant, 5 mL venous blood was collected under aseptic conditions. The samples were immediately centrifuged to separate the serum, which was stored at 2–8 ℃ until testing. All the laboratory procedures were performed under standard biosafety conditions.

2.5. Laboratory Investigations

Laboratory analyses focused exclusively on TTIs. Screening for HIV antibodies, hepatitis B surface antigen (HBsAg), hepatitis B core antibody (anti-HBc), and hepatitis C virus antibodies (anti-HCV) was performed using enzyme-linked immunosorbent assay (ELISA). In addition, Treponema pallidum antibodies were tested to detect syphilis, and thick and thin blood smears were prepared and microscopically examined for *Plasmodium* spp. to detect malaria. Positive and negative controls were included in each run according to the manufacturer's protocols to ensure quality assurance.

2.6. Ethical Considerations

Ethical clearance was obtained from the Institutional Review Board of the Department of Biological Sciences, Faculty of Science, Sana'a University, under approval number Bio-Micro-102. Written informed consent was obtained from all participants prior to sample collection, and confidentiality of the donor information was maintained throughout the study.

2.7. Statistical Analysis

Data were entered and analyzed using SPSS software (version 25; IBM Corp., Armonk, NY, USA). Descriptive statistics were applied to summarize the sociodemographic characteristics of the blood donors and the prevalence of infectious markers. Categorical variables are presented as frequencies and percentages, while continuous variables are summarized as means and standard deviations (SD). Chi-square χ^2 tests were performed to assess the association between infection status and selected sociodemographic or behavioral variables. Sta-

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Table 1. Sociodemographic Characteristics of Blood Donors in Sana'a, Yemen (N = 200)

Characteristic	Category	Number of Donors	Percentage (%)
Age (years)	Mean ± SD	32.8 ± 8.5	—
	Range	18–56	—
Sex	Male	200	100.0
Educational Level	Illiterate	9	4.5
	Primary	12	6.0
	Preparatory	21	10.5
	Secondary	62	31.0
	University	96	48.0
Income Level	High	1	0.5
	Medium	137	68.5
	Low	62	31.0
Residence	Urban	178	89.0
	Rural	22	11.0

tistical significance was set at $P < 0.05$. Exact tests were used where appropriate in cases of small cell count.

3. RESULTS

The present study investigated the prevalence of infection markers among 200 voluntary male blood donors in Sana'a, Yemen over a 12-month period. Sociodemographic characteristics were analyzed to provide insights into the donor population, and laboratory screening was conducted for transfusion-transmissible infections. The results are presented in three parts: first, the demographic and socioeconomic profiles of the participants; second, the prevalence of specific infectious markers, including HBV, HCV, HIV, syphilis, and malaria; and third, the associations between donor characteristics and infection status were assessed using chi-square analysis. Table 1 presents the sociodemographic characteristics of the 200 male blood donors included in the study. The mean age of the participants was 32.8 years (SD ± 8.5), with an age range of 18–56 years, indicating that most donors were young to middle-aged adults. In terms of education, nearly half of the donors (48.0%) had attained a university degree, whereas 31.0% had completed secondary education. Smaller proportions reported preparatory (10.5%), primary (6.0%), or no formal education (4.5%). Regarding income, the majority of donors (68.5%) reported a medium-income level, 31.0% had a low income, and only 0.5% reported a high income. Most participants resided in urban areas (89.0%), with only 11.0% living in rural areas.

Figure 1 illustrates the prevalence of major infectious markers screened among blood donors. Malaria was the most common infection, detected in 11 donors

(5.5%). HBsAg was detected in three donors (1.5%), whereas only one donor (0.5%) tested positive for HCV.

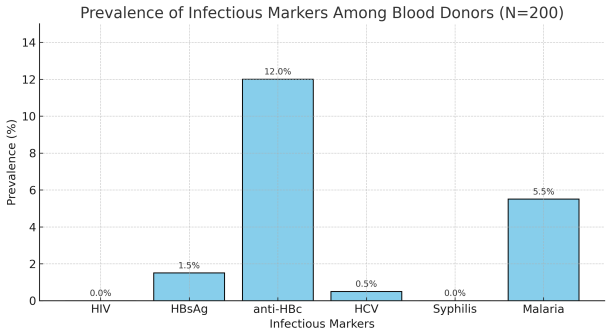


Figure 1. Prevalence of infectious markers among 200 male blood donors in Sana'a, Yemen.

No cases of HIV or syphilis infections were identified. Overall, 14 donors (7.0%) tested positive for at least one infectious marker. These findings highlight malaria as the predominant transfusion-transmissible infection in this donor population, with viral infections such as HBV and HCV being relatively rare, and complete absence of HIV and syphilis. Table 2 shows the prevalence of infectious markers among the 200 male blood donors. Overall, 25 donors (12.5%; 95% CI: 8.6–17.8) tested positive for at least one infection. Anti-HBc was the most frequently detected marker (7.0%) followed by malaria (5.5%). HBsAg was identified in 1.5% of donors, and only one donor tested positive for HCV (0.5%). No cases of HIV or syphilis infection were recorded. These findings indicate that exposure to Hepatitis B, as indicated by anti-HBc, and malaria remain the predominant transfusion-transmissible risk in this donor population. As presented in Table 3, no statistically significant associations were observed between HBsAg levels and any of the sociodemographic or behavioral variables examined. For HCV, a significant association was found with shamma use (χ^2 = 5.70, p = 0.017), whereas other characteristics showed

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Table 2. Prevalence of Infectious Markers Among Blood Donors in Sana'a, Yemen (N = 200)

Marker	Total (N)	Positive (n)	Prevalence (%)	95% CI
HIV	200	0	0.0	0.0–1.9
HBsAg	200	3	1.5	0.5–4.3
anti-HBc	200	14	7.0	4.2–11.4
HCV	200	1	0.5	0.1–2.8
Syphilis	200	0	0.0	0.0–1.9
Malaria	200	11	5.5	3.1–9.6
Any infectious marker	**200**	**25**	**12.5**	**8.6–17.8**

no meaningful relationships. The prevalence of malaria was not significantly associated with any of the factors studied. In contrast, anti-HBc was significantly associated with educational level (χ^2 = 14.39, p = 0.006), with higher positivity rates in certain educational categories. Moreover, smoking showed a borderline association with anti-HBc positivity (p = 0.057).

Table 3. Associations between infectious markers and donor characteristics (Chi-square test, N = 200)

Outcome	Variable	χ^2	df	p-value
HBsAg	Smoking	0.00	1	1.000
HCV	Age group	2.04	3	0.564
	Blood type	12.96	7	0.073
	Educational level	3.84	4	0.428
	Income level	0.35	2	0.841
	Khat chewing	0.00	1	1.000
	Previous donation	0.00	1	1.000
	Residence	0.00	1	1.000
	Shamma use	5.70	1	0.017
	Smoking	0.00	1	1.000
Malaria	Age group	2.95	3	0.400
	Blood type	10.05	7	0.186
	Educational level	6.27	4	0.180
	Income level	0.21	2	0.902
	Khat chewing	0.23	1	0.629
	Previous donation	0.00	1	1.000
	Residence	0.50	1	0.482
	Shamma use	0.02	1	0.896
	Smoking	0.00	1	1.000
anti-HBc	Age group	2.06	3	0.559
	Blood type	2.40	7	0.934
	Educational level	14.39	4	0.006
	Income level	0.22	2	0.895
	Khat chewing	0.47	1	0.493
	Previous donation	0.54	1	0.461
	Residence	0.00	1	1.000
	Shamma use	1.18	1	0.277
	Smoking	3.61	1	0.057

4. DISCUSSION

The analysis of infectious markers among blood donors in Sana'a, Yemen provides important insights into the prevalence and distribution of TTIs in this population. Among the 200 male donors studied, the overall prevalence of the infection markers was 12.5%. Malaria emerged as the most frequent marker detected in 5.5% of the donors, followed by HBsAg (1.5%). Anti-HBc antibodies were observed in 7% of donors, whereas HCV antibodies were identified in only 0.5%. No cases of HIV or syphilis were recorded, indicating a relatively low risk for these infections in the donor pool. The predominance of malaria among infectious markers can be explained by the ecological and socioeconomic conditions in Yemen, where malaria remains endemic. Climatic factors, vegetation, and human exposure to outdoor environments facilitate contact with malaria vectors, particularly Plasmodium falciparum [15], [16].

Male donors, who constitute the entire sample, are likely to have higher levels of outdoor occupational exposure, increasing their vulnerability to malaria transmission [17].

Compared to viral infections, the relatively high burden of malaria suggests that blood transfusion programs in Yemen may face unique risks related to TTM. The prevalence of HBsAg was 1.5%, which is lower than that reported in Ibb city, Yemen, and several neighboring or regional settings, which may reflect the effect of vaccination strategies and stricter donor screening protocols [18], [19], [20], [21].

The near absence of HCV (0.5%) and the complete lack of HIV and syphilis further highlights the relative effectiveness of existing screening practices, in contrast to malaria, for which donor-level preventive measures remain insufficient. Association analysis provides additional context for these findings. No significant relationships were observed between HBsAg and the examined sociodemographic or behavioral factors, suggesting that HBV surface antigen positivity may be relatively evenly distributed across donor subgroups. In contrast, HCV positivity was significantly associated with shamma use (χ^2 = 5.70, p = 0.017). Shamma, a locally prevalent form of oral tobacco, may serve as a behavioral risk factor

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contributing to viral exposure, potentially linked to shared practices in its preparation or use [22].

The prevalence of anti-HBc showed a significant relationship with educational level (χ^2 = 14.39, p = 0.006), indicating differences in health literacy and associated risk behaviors across educational categories [23].

Additionally, smoking exhibited a borderline association with anti-HBc positivity (p = 0.057), warranting further exploration given the established links between smoking, immune function, and infection susceptibility [21].

Malaria did not demonstrate significant associations with any sociodemographic or behavioral factors, consistent with its ecological determinants being more influential than individual-level characteristics. When compared with regional and international literature, the Yemeni data reveal both similarities and distinct differences. Malaria prevalence among blood donors in Sana'a (5.5%) is lower than that reported in West Africa, where studies have documented prevalence rates as high as 13.7% in Ghana and > 50% in Nigeria [17], [24].

Nevertheless, the presence of malaria among donors, even at this lower rate, remains a significant transfusion risk, echoing findings from other malaria-endemic countries [25].

With respect to HBV, the Yemeni donor population appears to show lower prevalence than general population estimates in Ethiopia and elsewhere [19], [26], aligning with the concept that blood donors tend to represent a healthier subgroup of the population due to pre-donation screening and self-selection [27].

The absence of HIV and syphilis cases in this cohort is consistent with trends in several countries, where increased awareness, public health interventions, and strict donor eligibility criteria have contributed to a reduced prevalence in donor populations [28].

These findings should be viewed within the broader epidemiological context of Yemen, where infectious diseases, including those transmitted through blood and food, remain a significant public health concern. Several studies have highlighted the continued circulation of various pathogens in the community and food supply, reflecting gaps in surveillance, limited diagnostic capacity, and challenges in implementing systematic control measures in the country [29], [30].

This situation is further compounded by the lack of effective vaccines or accessible treatments for many infections, along with the emergence of antimicrobial resistance, which threatens the effectiveness of existing therapeutic options [31], [32].

In this context, ensuring the safety of blood transfusion services becomes even more critical as undetected infections in donors can contribute to further transmission. Addressing these challenges requires a multifaceted approach, including strengthening surveillance systems, improving diagnostic technologies, and exploring alternative strategies such as the investigation of natural products for their potential therapeutic and preventive properties [33], [34].

Leveraging Yemen's rich biodiversity to identify bioactive compounds could provide locally adapted solutions to support infection control and enhance transfusion safety, particularly in resource-limited settings where conventional medical interventions are not always available.

5. CONCLUSION

This study highlights the importance of robust surveillance and comprehensive donor screening to ensure the safety of blood transfusions in Yemen, particularly in malaria endemic regions. These findings emphasize the need for targeted public health interventions that address both the ecological determinants of malaria transmission and behavioral practices, such as shamma use. Strengthening awareness and education regarding transfusion risks, along with improved laboratory screening, is crucial for minimizing transfusion-transmitted infections. Overall, these results underscore the complex interplay of biological, social, and environmental factors influencing infection patterns among blood donors and the necessity for context-specific strategies to safeguard transfusion safety.

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Conflict of Interest The authors declare that they have no conflicts of interest regarding the publication of this paper.

Data Availability Statement The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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