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Prevalence and Factors Associated with transfusion-transmissible infections among blood donors in Arua regional blood bank, Uganda

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Abstract

Background Blood transfusion services play a very key role in modern health care service delivery. About 118.5 million blood donations were collected globally in 2022. However, about 1.6 million units of blood are destroyed annually due to transfusion-transmissible infections (TTIs). There is a very high risk of TTIs through donated blood to recipients if safe transfusion practices are not observed. This study determined the prevalence and factors associated with TTIs among blood donors in Arua regional blood bank, Uganda.

Methods This study was a retrospective cross-sectional design that involved a review of a random sample of 1370 blood donors registered between January 1st, 2018 and December 31st, 2019 at Arua regional blood bank, Uganda. Descriptive statistics were used to describe the characteristics of the blood donors. The binary logistic regression was used to determine the factors associated with TTIs.

Results The majority of the blood donors were male (80.1%), and the median donor age was 23 years (IQR=8 years). The overall prevalence of TTIs was found to be 13.8% (95%CI: 12.0-15.6%), with specific prevalences of 1.9% for HIV, 4.1% for HBV, 6.6% for HCV and 2.8% for *treponema pallidum*. Male sex (AOR=2.10, 95%CI: 1.32–3.36, p-value=0.002) and lapsed donor type compared to new donor type (AOR=0.34, 95%CI: 0.13–0.87, p-value=0.025) were found to be associated with TTIs.

Conclusion The prevalence of TTIs among blood donors of West Nile region, Uganda was found to be significantly high, which implies a high burden of TTIs in the general population. Hence, there is need to implement a more stringent donor screening process to ensure selection of risk-free donors, with extra emphasis on male and new blood donors. Additionally, sensitization of blood donors on risky behaviors and self-deferral will reduce the risk of donating infected blood to the recipients.

Keywords Blood donor, Voluntary donor, Transfusion-transmissible infections (TTIs), Seropositive blood donor

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Background

Blood transfusion services play a very key role in the modern health care service delivery [1]. About 118.5 million blood donations were collected globally in 2022, and over a half of these were collected in the low and middle-income countries that host 80% of the world population [2]. In Uganda, there were 300,000 units of blood collected in 2021/2022 financial year [3].

Blood transfusion is indicated among the corrections of severe anaemia due to various aetiologies like; severe malaria, cancers, sickle cell anaemia and other conditions, injuries that are associated with active haemorrhage and surgeries to improve treatment outcome [4]. Nonetheless, one has to weigh the risks and benefits of blood transfusion against those of anaemia [4]. The greatest challenge of blood transfusion is the risk associated with transfusion-transmissible infections (TTIs) that majorly include; Human Immunodeficiency Virus (HIV), Hepatitis C Virus (HCV), Hepatitis B Virus (HBV) and *Treponema pallidum* [2]. In the general population, infections like HIV might not be screened for, and even with massive efforts, only 84% of estimated cases know their status [5]. For this reason, people who are carrying infections in the latent phase may not be motivated to go for blood tests, since they are asymptomatic. As a result, about 1.6 million blood units are destroyed annually due to TTIs [6], which in turn reduces the overall blood supply to the healthcare facilities [2, 7, 8].

Globally, there are approximately 58 million individuals chronically infected with HCV, more than 296 million with HBV, and 39 million with HIV [9]. The prevalence of TTIs among blood donors globally as reported by WHO varies from 0.005 to 6.02% for HBV, 0.002–1.67% for HCV, and 0.001–1.60% for HIV [2]. In Sub-Saharan Africa, the overall prevalence of TTIs was reported in Ethiopia at 4.1% [10], Eritrea at 3.6% [11], Malawi at 10.7% [12], Eastern Democratic Republic of Congo (D.R.C) at 14.7% [13], Western Kenya at 9.4% [14], Northern Tanzania at 10.1% [15], whereas in Southwestern Uganda, the burden of TTIs was estimated at 5.67% [16].

As a reduction and prevention strategy towards TTI transmission, WHO recommends a mandatory screening for at least HIV, HBV, HCV and *Treponema pallidum* by blood banks [2]. In spite of blood banks' testing for common infections, there are still dangers of other untested infections that include yellow fever virus, leishmaniasis, malaria etc. [17]. In the West Nile region of Uganda, the prevalence of TTIs and its associated factors are still unknown. Moreover, the inadequacy of data on TTIs burden has serious implications on efforts toward reduction of new infections by asymptomatic seropositive blood donors in the communities. Therefore, the importance of documenting this problem cannot be overemphasized. Meanwhile, globally, there are several

factors known to be associated with TTIs such as donor age [18–20], sex [19–21], being employed [22], being a commercial donor [21], level of education [23] and donor type (Repeat or new donor) [11, 23]. This study, therefore, aimed to determine the prevalence and factors associated with transfusion-transmissible infections among blood donors in Arua regional blood bank, Uganda.

Methods

Study design and setting

This study was purely quantitative, and employed a retrospective cross-sectional design to review records of blood donors registered between January 1st, 2018 and December 31st, 2019 in Arua regional blood bank. The study inclusion criteria was 'all blood donors registered between the period of January 1st, 2018 and December 31st, 2019 at Arua Regional Blood Bank' whereas the exclusion criteria was 'all blood donors missing information on key variables such as sex, age, rhesus group, blood group and sero results'. The sample size to determine the prevalence of TTIs was calculated using the Kish Leslie formula for a single proportion [24]. Where: $Z_{\alpha/2} = 1.96$ was the standard z normal value corresponding to the default confidence interval of 95%, which was used to derive sufficient statistical power for the study; $P = 3.7\%$ was the prevalence of TTIs among blood donors [11]; $d = 0.01$ was the tolerable sampling error since prevalence is less than 10%. Hence, study sample size of 1,370 blood donors. A total population of 5,343 blood donors were included into sampling frame, and then systematic sampling technique was used to select the blood donors; whereby the initial participant was selected using simple random sampling, and then a constant sampling interval of 4 (i.e. 5,343 blood donor population divided by 1,370 sample size) was employed to reach the study sample size of 1,370 blood donors. The data collection involved the use of a data abstraction form to collect socio-demographic data (such as: donor identification number, age, sex, birth district and availability of telephone contact) and clinical data (such as: donor type, frequency of donation, donation site, blood group, rhesus factor, donor TTIs status and notification status). Research Assistants were recruited and trained prior to the commencement of data collection.

The study was carried out in Arua Regional Blood Bank which is located in Arua Regional Referral Hospital in the North-Western part of Uganda, approximately 480 km North of Kampala Capital City [25]. The Regional Blood Bank serves 12 Districts and 1 City of West Nile, namely: Adjumani, Arua, Koboko, Madi-Okollo, Maracha, Moyo, Nebbi, Obongi, Pakwach, Terego, Yumbe, Zombo and Arua City. The West Nile region shares borders with Democratic Republic of Congo in the West and South Sudan in the North [26]. The population of West-Nile

is estimated at 3.9 million people, with about 500,000 households [27]. Arua Regional Blood Bank collects averagely 80 blood units daily, and approximately 10 units of donations are made at the Bank (static post) and about 70 units collected by two field teams daily [25]. The type of blood donors registered by the blood bank is 100% voluntary non-remunerated blood donors (VNRBD), majority are regular donors and about 80% are students [25]. The collected blood is utilized mainly by Arua Regional Referral Hospital, 9 general Hospitals and a number of Health Centre IVs in the region. At the time of donation, all blood donors go through screening sets of questions about previous illnesses and medical conditions and physical examination for blood donation eligibility according to the blood donation criteria. The inclusion criteria for blood donors are; having body weight >45 kg, no history of high risk sexual behavior and practice, blood transfusion, jaundice, HIV, hepatitis, *Treponema pallidum*, surgery and hypertension, and current fever [25].

Serological analysis

Routine screening by the blood bank includes: anti-HIV, *Treponema pallidum*, hepatitis B surface antigen and anti-hepatitis C using the Abbott ARCHITECT i2000 SR analyzer (manufactured by Flextronics, Singapore) for first line testing. However, for the second line testing, confirmation is done using Enzyme Linked Immunosorbent Assay (ELISA) which uses the semi-automated IRE 96 Reader & IW 96 Washer (manufactured by SFRI Medical Diagnostics, France). Alternatively, the *Treponema Pallidum* Haeagglutination (TPHA) (manufactured by Abbott, USA) test is used for detection of syphilitic infection. The blood unit was considered sero-positive, when both the first and second test results were positive. The Arua regional blood bank subscribed to the European Society for External Quality Assessment (ESFEQA) to ensure compliance with international standards. Additionally, all tests were done according to the manufacturer's guidelines.

Data management and analysis

All collected data were entered into Microsoft excel and exported to STATA version 17.0 for statistical analysis. Participants' characteristics were described using proportions for categorical variables whereas median and interquartile range (IQR) were used to summarize continuous variables (such as age). Proportions were also used to determine the prevalence of the TTIs among the blood donors. A Venn-diagram was used to describe the sero-positivity concordance of the different TTIs.

Binary logistic regression was used to determine the factors (socio-demographic and clinical) associated with TTIs. The outcome variable, Overall TTIs, was defined

as a blood donor having a sero-positive result on any of the four TTIs (HIV, HCV, HBV and *Treponema pallidum*), and hence coded 1 for sero-positive otherwise 0. At bivariate analysis, variables with p-values less than 0.2, and variables cited important in the literature were considered for multivariate analysis. Interaction terms were assessed for statistical significance using the chunk test, and confounding was assessed by comparing adjusted and unadjusted models using a 10% cut-off. The odds ratios were used as the measure of association, and variables with p-values less than 0.05 (in the final model) were considered statistically significant. The final model was also tested using the Pearson chi-square goodness-of-fit test, and we obtained a p-value >0.05 that suggested that the model was adequately fitted.

Results

Description of the blood donors

The study involved 1,370 randomly selected blood donors registered between January 1st, 2018 and December 31st, 2019 at Arua regional blood bank, Uganda. The majority of the donors (80.1%) were male. The minimum and maximum donor age was 16 and 59 years respectively, with a median age of 23 years (interquartile range (IQR)=8 years). Many of the donors (44.2%) hailed from Nebbi district, and more than three quarters (78.8%) did not have telephone contacts. Further, more than a half (57.5%) were repeat donors. All the donors were VNRBD and the majority (97.8%) donated from the out-reach or mobile donation points. Also, the majority of the donors were of blood group O (40.8%), and Rhesus group positive (98.0%) (Table 1).

Prevalence of TTIs

The TTIs considered in this study were: HIV, HBV, HCV and *Treponema pallidum*. The prevalence of HIV was 1.9% (95% confidence interval (CI): 1.3–2.8), HBV was 4.1% (95%CI: 3.1–5.3), HCV was 6.6% (95% CI: 5.4–8.1) and *Treponema pallidum* was 2.8% (95% CI: 2.0–3.8). Consequently, the overall prevalence of the TTIs was 13.8% (95% CI: 12.0–15.6) (Table 2). Meanwhile, there were 21 (11.1%) donors with sero-positive concordance on at least 2 TTIs, and the majority [7] of these had HCV and *Treponema pallidum* sero-positive concordance. Only 1 donor was sero-positive on 3 TTIs i.e. HIV, HCV and *Treponema pallidum*, and none was sero-positive on all the 4 TTIs (Fig. 1).

Factors associated with TTIs

At bivariate analysis, we included social demographic factors (age, sex, birth district and contact available) and clinical factors (donor type, site, blood group and rhesus group). Only being male and having lapsed compared to being a new donor were statistically significant.

Table 1 Socio-demographic and clinical characteristics of 1370 blood donors included in the study, Arua regional blood bank, January 1st, 2018 to December 31st, 2019

Variable	Category	Frequency	%
Sex	Male	1097	80.1
	Female	273	19.9
Age (cont)	(min = 16yrs; max = 59yrs; median = 23yrs; IQR = 8yrs)		
Birth district	Arua	479	34.9
	Nebbi	605	44.2
	Other	286	20.9
Contact available	No	1079	78.8
	Yes	291	21.2
Donor type	New	491	35.9
	Repeat	788	57.5
	Lapsed	91	6.6
Donor category	VNRBD	1370	100.0
Site	Blood bank	30	2.2
	Mobile	1340	97.8
Blood group	A	496	36.2
	AB	74	5.4
	B	241	17.6
	O	559	40.8
Rhesus group	Pos	1342	98.0
	Neg	28	2.0

Cont-continuous variable; IQR- Interquartile range; min- minimum; max- maximum; Pos- Positive; Neg- Negative; other-Adjumani, Koboko, Madi-Okollo, Maracha, Moyo, Obongi, Pakwach, Terego, Yumbe & Zombo); VNRBD- Voluntary Non-Remunerated Blood Donors

Table 2 Prevalence of HIV, HBV, HCV and Treponema pallidum among 1370 blood donors in Arua Regional Blood Bank, January 1st, 2018 to December 31st, 2019

Variable	Category	Number	Prevalence (%)	95% CI
HIV	Pos	26	1.9	1.3–2.8
	Neg	1344		
HBV	Pos	56	4.1	3.1–5.3
	Neg	1314		
HCV	Pos	91	6.6	5.4–8.1
	Neg	1279		
Treponema pallidum	Pos	38	2.8	2.0- 3.8
	Neg	1332		
Overall TTIs	Pos	189	13.8	12.0-15.6
	Neg	1181		

CI=Confidence Interval ; Pos- Positive ; Neg- Negative

At multivariate level, the adjusted regression model also suggested that variables: being male (AOR=2.10, 95%CI: 1.32–3.36, $p=0.002$) and being lapsed compared to new donor (AOR=0.34, 95%CI: 0.13–0.87, $p=0.025$) were significantly associated with TTIs (Table 3).

Discussion

Blood transfusion is one of the integral parts of life-saving procedures of modern medicine despite the very high risk of transmitting infectious diseases such as HIV, HBV, HCV, *treponema pallidum* and malaria. Our study sought to determine the prevalence and factors associated with transfusion-transmissible infections among blood donors in Arua regional blood bank, Uganda. The overall prevalence of TTIs revealed by this study was 13.8%, which is higher than what is reported in several studies in the region [10, 11, 14, 16, 28]. This high prevalence could lead to a reduction in pool of donors, especially for those that shall be permanently referred to chronic care. The high prevalence of TTIs also means an increased burden of destruction of infected blood, and hence increasing the overall operational costs of the blood bank. Studies with similar rates were reported in Kenya (14.1%) [29] and Ethiopia (12.4%) [30]. This could perhaps be due to similarities in the risky sexual behaviors of these populations and the blood donor selection criteria. In contrast, lower overall prevalence has been reported in Southwestern Uganda (5.67%), but also in Western Province of Rwanda (2.1%), Eritrea (3.6%), Ethiopia (4.1%), Western Kenya (9.4%), Northern Tanzania (10.1%) and Malawi (10.7%) [10–12, 14–16, 31]. Meanwhile, a higher prevalence was reported in Eastern D.R.C (14.7%) [13]. These variations in the TTI prevalence could be due to the differences in health care systems in these settings as compared to the West Nile region of Uganda. As such, regions with lower TTI prevalence could be having a healthier donor population, in respect to these TTIs, compared to the West Nile region of Uganda and vice versa.

Specifically, the prevalence of HCV was the highest with 6.6% followed by HBV at 4.1%, *Treponema pallidum* at 2.8% and HIV at 1.9%. Comparatively, a study conducted among a similar donor community in the southwestern part of Uganda got lower prevalence on all the TTIs with HCV at 2.22%, HBV at 1.87%, HIV at 1.03% and *Treponema pallidum* at 0.34% [16]. The discrepancies might be due to the differences in population risks or effectiveness and stringency in procedures of donor screening. However, our findings are similar on the prevalence of HCV being higher than that of HIV and HBV among the Ugandan donor community, although, this is contrary to what is reported in many other studies in Sub-Saharan Africa [10, 11, 13, 14]. This can also be attributed to the fact that, a lot more attention has been given to HIV and HBV, with less being done to treat and prevent HCV transmission in Ugandan communities. Hence, there is need to scale up interventions to prevent HCV transmission. Further, the prevalence of HIV remained comparatively the same but our study showed higher burden of *treponema pallidum* among donors in

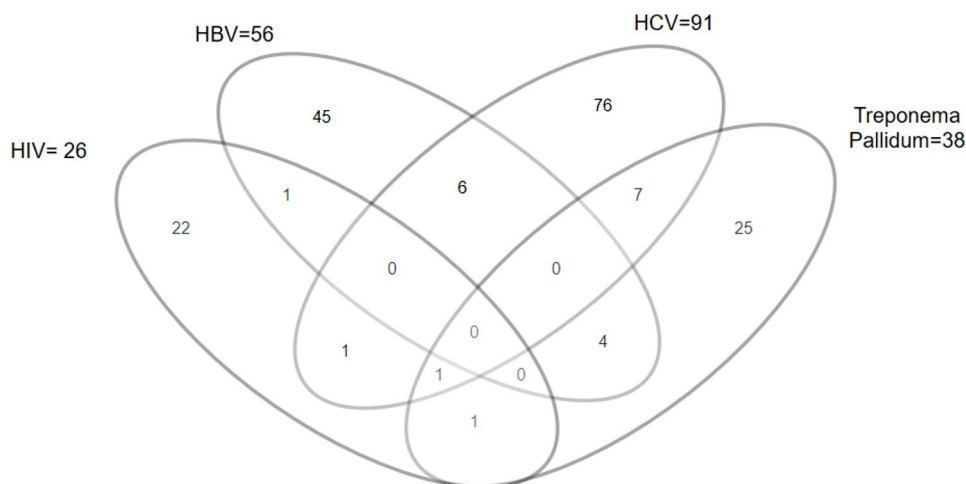


Fig. 1 Venn diagram showing sero-positivity concordance among 1370 blood donors in Arua regional blood bank, between January 1st, 2018 and December 31st, 2019

Table 3 Binary logistic regression model to determine factors associated with transfusion-transmissible infections, Arua Regional Blood Bank, Uganda, January 1st, 2018 to December 31st, 2019

Variable	Category	Bivariate			Multivariate		
		COR	95%CI	P-value	AOR	95%CI	P-value
Sex	Female	1			1		
	Male	2.05	1.28–3.26	0.003	2.10	1.32–3.36	0.002
Age (cont)		1.00	0.98–1.02	0.732			
Birth district	Arua	1					
	Nebbi	0.92	0.65–1.30	0.643			
	Other	1.01	0.66–1.54	0.957			
Contact available	No	1					
	Yes	0.82	0.55–1.21	0.325			
Donor type	New	1			1		
	Repeat	1.04	0.76–1.44	0.789	1.01	0.73–1.40	0.929
	Lapsed	0.35	0.14–0.91	0.031	0.34	0.13–0.87	0.025
Site	Blood bank	1					
	Mobile	2.27	0.54–9.61	0.265			
Blood group	A	1			1		
	AB	1.77	0.96–3.25	0.068	1.81	0.98–3.36	0.059
	B	0.98	0.62–1.54	0.932	1.00	0.64–1.58	0.993
	O	0.98	0.68–1.39	0.898	0.95	0.66–1.35	0.763
Rhesus group	Pos	1			1		
	Neg	1.04	0.36–3.04	0.939	1.10	0.37–3.23	0.862

COR- Crude Odds Ratio; AOR- Adjusted Odds Ratio; 95% CI- 95% Confidence Interval; cont- Continuous variable; Pos- Positive ; Neg- Negative

West Nile region than in the South Western region of Uganda.

Our regression results suggested that factors: male sex and lapsed donor category were significantly associated with TTIs. Male donors were more than twice as likely to have TTIs as the female donors. Perhaps this could be attributed to the risky sexual behaviors among the males compared to the females in the community. This finding was consistent with studies conducted in Honduras [32] and Kenya [29]. However, other studies conducted in Eritrea [11] reported male donors to be less likely to have

TTIs. Meanwhile, the lapsed donors were 66% less likely to have TTIs compared to the new donors. This could be due to the fact that the lapsed donors have been previously screened, counselled and registered into the blood bank database, and hence less likely to have TTIs. On the contrary, other studies have reported the repeat donors to be associated with a higher prevalence of TTIs compared to the new donors [11, 20]. Our study was limited by the fact that it was a retrospective design and hence we were not able to obtain sufficient data to assess for additional potential confounders like occupation, marital

status and educational level, as these were not captured at the time of registration of blood donors. Additionally, this study may also be limited by the blood donor eligibility criteria or/and blood unit screening tests that may not be the same in all blood banks (especially outside Uganda), and hence limiting the applicability of our results. Meanwhile, the major study strength was having sufficient statistical power owing to the large sample size ($n=1,370$ donors).

Conclusion

The overall prevalence of 13.8% is high, which indicates, approximately, 1 in every 7 blood donors have at least one of the TTIs, which implies a high burden of TTIs in the general population and infectivity potential of the viruses and bacteria. Consequently, reviewing the current protocols in order to encourage pre-donation counselling and testing to enable seropositive donors to be deferred and referred for further management promptly. Factors, sex and donor category were significantly associated with TTIs. Hence, there is need to implement a more stringent donor screening process to ensure selection of risk-free donors, with extra emphasis on male and new blood donors. Our findings also justify the use of pathogen reduction technology (PRT) to treat infected blood products with pathogen-inactivating agent in order to ensure safety of blood, and maintain the blood supply that is needed at the health facilities.

Abbreviations

AOR	Adjusted Odds Ratio
CEU	Clinical Epidemiology Unit
CI	Confidence Interval
COR	Crude Odds Ratio
HBV	Hepatitis B Virus
HCV	Hepatitis C Virus
HIV	Human Immunodeficiency Virus
IQR	Interquartile Range
MoH	Ministry of Health
PRT	Pathogen Reduction Technology
RD	Replacement Donors
RPR	Rapid Plasma Reagin
SOMREC	School of Medicine Research and Ethical Committee
TPHA	Test and Treponema Pallidum Hemagglutination
TTIs	Transfusion Transmissible Infections
VNRBD	Voluntary Non-Remunerated Blood Donors
WHO	World Health Organization

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12879-024-09838-4>.

Supplementary Material 1

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Author contributions

NC and HK formulated the research protocol. DO and NC extracted data. DO and NC participated in data cleaning, analysis and interpretation. DO and NC wrote the initial draft of the manuscript. DO, NC, HK, JFZ, RA, TO and FA critically reviewed and revised the manuscript. All authors read and approved the final manuscript.

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Data availability

The data that support the findings of this study are not openly available due to reasons of sensitivity and are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

The ethical approval to conduct this study was obtained from School of Medicine Research and Ethical Committee (SOMREC), College of Health Sciences, Makerere University (#REC REF: 2020-057). Permission to review the blood donor files was sought from the Arua District Local Government and Head of Arua Regional Blood Bank, Uganda. We applied for waiver of consent since this study involved review of data, and there was no chance of interfacing with the study participants. The study protocol and conduct adhered to the principles in the Declaration of Helsinki and good clinical practice (GCP).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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