Prevalence and Association of Transfusion-Transmissible Infections with Age of Blood Donors: A Regional Transfusion Centre Study in Northern Pakistan

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ABSTRACT

Objective: To evaluate the prevalence and association of Transfusion-Transmissible Infections (TTIs) with age of blood donors in a regional transfusion centre located in Northern Pakistan.

Study Design: Descriptive study.

Place and Duration of the Study: Armed Forces Institute of Transfusion, Rawalpindi, Pakistan, from January 2017 to December 2021.

Methodology: All blood donors who qualified institutional blood donation criteria were initially screened for HBsAg, Anti-HCV Ab, HIV antigen-antibody combination and syphilis by an automated chemiluminescent microparticle immunoassay analyzer (Architect Plus i 2000 SR, Abbott Diagnostics, Abbott Park, IL). Initially, all seronegative donor blood samples were subjected to nucleic acid amplification test (NAAT). All TTI-positive donors were immediately informed and counselled to consult the medical physicians for further treatment. Descriptive statistics and significance of association were determined.

Results: The prevalence of TTIs among blood donors was calculated to be 3.33% among 308,767 donors. HCV (1.4%) was the most prevalent TTI followed by syphilis (0.9%), HBV (0.68%) and HIV (0.26%), respectively. TTIs were most prevalent in the 26 to 35-year-old group, accounting for 5,143 (50.0%) positive donors ($p<0.05$).

Conclusion: The prevalence of TTIs among blood donors was found to be 3.33%. HCV was the most common TTI, followed by syphilis, HBV, and HIV. The 26 to 35 year-old group had a significantly high prevalence of TTIs.

Key Words: *Transfusion-transmissible infections, Hepatitis B virus, Hepatitis C virus, Human immunodeficiency virus, Treponema pallidum, Syphilis, Automated chemiluminescent microparticle immunoassay analyzer, Nucleic acid amplification test.*

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INTRODUCTION

One of the greatest milestones accomplished in the 20th century is the evolution of modern blood transfusion medicine.[1] Millions of lives are saved each year, all over the globe by therapeutic transfusion of blood. However, it is not free from risk and according to an estimate every donated blood unit has 1% chance of transmitting infections which results in transfusion associated mortality and morbidity.[2] Blood safety is an extremely significant component of transfusion medicine. Transfusion-transmissible infections (TTIs) hampers blood safety and is a serious matter for patients and healthcare authorities.

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Hepatitis B virus (HBV), Hepatitis C virus (HCV), Human immunodeficiency virus (HIV), and *Treponema pallidum* (causative agent of Syphilis) are four main TTIs whose mandatory screening is recommended by the World Health Organization (WHO).[3] About 99.9% donations in the developed countries are screened by mandatory quality standard procedures as compared to 76% in the developing countries.[3] In Pakistan, over 1.5 million units of blood is donated annually.[4] Pakistan has fragmented, demand-driven blood transfusion system. Transfusion practices need to be strengthened according to existing legislation.[5,6] In Pakistan, the overall prevalence of TTIs among blood donors was 5.8% in 2016, 3.72% in 2019, and 4.61% in 2021, according to the published literature.[4,7,8] The most prevalent TTI, in Pakistan was reported to be HCV followed by HBV, syphilis, and HIV, respectively.[7,9]

Currently, there is a limited comprehensive data about prevalence and association of TTIs with blood donors, age in the authors' region. The aim of this study was to determine the prevalence of TTIs in different age groups and to evaluate the association of TTIs with blood donors' age groups in a regional

transfusion centre located in Northern Pakistan. This aspect of demographic data will highlight the donor age groups that is more prone to have TTIs. It will provide a scientific framework to formulate effective screening and control strategies.

METHODOLOGY

The study was carried out from January 2017 to December 2021 after approval of the Institutional Ethical Committee. A descriptive prospective study, using non-probability, consecutive sampling was carried out in a regional blood centre located in Northern Pakistan, Punjab.

All blood donors aged between 18 to 60 years, who fulfilled institutional blood donation criteria as per standard, donor history-based questionnaire, initial general physical examination, and pre-donation blood complete picture were included in the study after taking informed consent. Blood donors who did not meet the standards of blood donation selection criteria outlined by the institute, like age, weight, haemoglobin level, history of Hepatitis B, Hepatitis C or HIV positive, history of fever or dental procedure in the past one week, previous history of malaria in the last 3 years, history of vaccination in the last 1-4 weeks, history of taking any narcotic drugs, and history of extra marital sexual relations were excluded from the study. Demographic details of blood donors like year of donation, age, gender, type of donors, and screening results were entered in computerised Blood Bank Management Information System.

A blood sample of 6ml was collected from all donors. The samples were initially screened for HBsAg, Anti-HCV Ab, HIV antigen-antibody combination assay, and syphilis by an automated chemiluminescent microparticle immunoassay (CMIA) analyzer (Architect Plus i 2000 SR, Abbott Diagnostics, Abbott Park, IL) using (HBsAg qualitative II kit, anti-HCV kit, and HIV Ag/Ab Combo kit, syphilis TP, respectively, Abbott Diagnostics). Initially, positive donor samples were re-checked from donors red cell concentrates on the same day. Internal quality control was ensured by running kit positive and negative controls with each batch as per the instructions of manufacturer. External quality control was ensured by running third party controls (VIROTROL 1 BioRad).

All seronegative donor blood samples were subjected to nucleic acid amplification test (NAAT) by using Grifols Procleix Panther System using Ultra Elite kit to detect early (window period) infections. All NAAT positive samples were re-run by another NAAT analyzer (Roche Cobas 6800 using MPX Cobas Kit). Repeatedly positive donor samples and blood components were traced and sent for incineration. Internal quality control was ensured by running kit positive and negative controls with each batch as per the instructions of manufacturer. The samples and blood components of reactive donors were sorted and sent for incineration. Donors with TTIs positivity were immediately informed and counselled to consult the medical physicians for further work and treatment. The confidentiality of reactive donors was ensured at all steps.

Data were analysed using SPSS version 23 and MS Excel 2016 software. Blood donors were divided into five age groups, <25, 26-35, 36-45, 46-55 and >56-years. The prevalence of TTIs was calculated. Frequency and percentages were calculated for the categorical variables. Fisher's exact test/Chi-square test was used to find the association of age with TTIs. The p-value ≤0.05 was considered significant.

RESULTS

This study included a total of 308,767 donors, comprised of 305,692 (99.0%) males and 3,075 (1.00%) females. Out of 308,767 donors, 280,088 (90.7%) were replacement donors and 28,679 9.3%) were voluntary donors. A majority of the donors (140,357, 45.5%) belonged to 26 to 35-year-old group (45.5%) followed by 118,228 (38.3%) donors who were ≤25 years, 42,821 (13.9%) donors belonged to 36 to 45-year-old group, and 6,565 (2.1%) donors were 46 to 55- year-old. The age group with the least number of donors was found to be >56-years with 796 (0.30%). Characteristics of blood donors according to different age groups during the study period is shown in Table I.

Out of 308,767 blood donations collected during the study period, 10,280 donors were positive for at least one TTI. The prevalence of TTIs among blood donors was calculated to be 3.33% in this study. The overall positivity rate of HCV, syphilis, HBV, and HIV was found to be 1.4%, 0.9%, 0.68%, and 0.26%, respectively.

Of all TTIs, HCV was the most prevalent comprising of 4,457 (43.3%) positive blood donors followed by syphilis with 2,905 (28.3%), HBV with 2,112 (20.5%) and HIV with 806 (7.8%) donor positivity. The trends of TTIs over the study period is demonstrated in Figure 1.

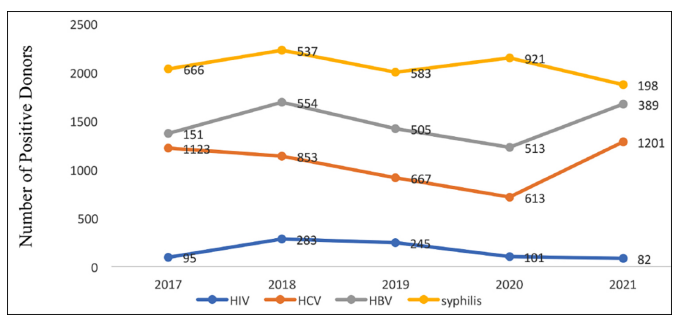

Figure 1: Trends of TTIs over January 2017 to December 2021 (n= 10,280).

TTIs were most prevalent in 26 to 35-year-old donors accounting for 5,143 (50.0%) positive donors followed by 3,214 (31.5%) positive donors in group of <25-year-old, 1,486 (14.4%) donors between 36 to 45 years of age, 357 (2.5%) donors from the group of 46 to 55-year-old, and 80 (0.77%) positive donors were >56 years of age. Regarding individual TTIs, HIV infection was most prevalent in <25-year-old donors (339 donors: 0.29%). HCV, syphilis, and HBV infections were most common in 26 to 35-year old group comprising about 2095 (1.49%), 1722 (1.22%) and 1170 (0.83%) donor positivity, respectively. There was statistically significant association i.e. p-value<0.05 between TTIs prevalence and age groups shown in Table II.

Table I: Characteristics of blood donors according to different age groups (n=308,767).

Variables	Age (<25 years) n=118,228 (38.3%)	Age (26-35 years) n=140,357 (45.5%)	Age (36-45 years) n=42,821 (13.9%)	Age (46-55 years) n=6,565 (2.1%)	Age (>56 years) n=796 (0.30%)
Year of donation					
2017	20,602 (17.4%)	23,130 (16.5%)	7,842 (18.3%)	1,338 (20.4%)	120 (15.1%)
2018	25,275 (21.4%)	31,492 (22.4%)	1,315 (3.1%)	42 (0.6%)	187 (23.5%)
2019	22,810 (19.3%)	25,843 (18.4%)	9,831 (23.0%)	1,651 (25.1%)	170 (21.4%)
2020	20,891 (17.7%)	25,848 (18.4%)	10,909 (25.5%)	1,404 (21.4%)	77 (9.7%)
2021	28,650 (24.2%)	34,044 (24.3%)	12,924 (30.2%)	2,130 (32.4%)	242 (30.4%)
Total	118,228	140,357	42,821	6,565	796
Gender					
Male	116,734 (98.7%)	139,469 (99.4%)	42,366 (98.9%)	6,360 (96.9%)	763 (95.9%)
Female	1,494 (1.3%)	888 (0.6%)	455 (1.1%)	205 (3.1%)	33 (4.1%)
Type of donors					
Replacement	104,140 (88.1%)	130,368 (92.9%)	38,834 (90.7%)	6,092 (92.8%)	654 (82.2%)
Voluntary	14,088 (11.9%)	9,989 (7.1%)	3,987 (9.3%)	473 (7.2%)	142 (17.8%)

Table II: Association between individual TTIs prevalence with different age groups (n=308,767).

TTIs	Age (<25 years) n=118,228 (38.3%)	Age (26-35 years) n=140,357 (45.5%)	Age (36-45 years) n=42,821 (13.9%)	Age (46-55 years) n=6,565 (2.1%)	Age (>56 years) n=796 (0.30%)	p-value
HIV	339 (0.29%)	156 (0.11%)	237 (0.55%)	27 (0.41%)	47 (5.90%)	<0.001
HCV	1527 (1.29%)	2095 (1.49%)	610 (1.42%)	203 (3.09%)	22 (2.76%)	<0.001
HBV	713 (0.60%)	1170 (0.83%)	166 (0.38%)	57 (0.87%)	6 (0.75%)	<0.001
Syphilis	635 (0.53%)	1722 (1.22%)	473 (1.10%)	70 (1.06%)	5 (0.63%)	<0.001
Total	3214	5,143	1,486	357	80	10280

Fisher Exact test was used. The p-value <0.05 was taken as significant.

DISCUSSION

Acquisition of TTIs during transfusion of blood is a global health challenge that threatens blood transfusion safety. It is alarming for the healthcare authorities due to associated mortality and morbidity which overshadows the beneficial effects of transfusion.[10-12] TTIs are silent killers and carry a risk of transmission by each blood transfusion.[13] The knowledge of demographic characteristics of blood donors plays a pivotal role in understanding the donor pool structure and provide framework to formulate and revise donor recruitment and retention policies.[14] Currently, there is an extremely limited literature about association of TTIs and blood donors' age groups in the studied region. This study was conducted to substantiate an association between TTIs prevalence and age of blood donors in a regional transfusion centre in the Northern Pakistan.

A majority of donors in this study (99.0%) were males and only 1% were females. The most common age group in the donor pool was 26 to 35 years of age (45.5%) followed by <25- years of age (38.3%). These findings were consistent with the study of Bukhari *et al.,* conducted at District Head Quarter Hospital Attock, in which 98.2% of donors were males and 1.8% were females. A major contribution to the donor pool belonged to 26 to 34 years of age (46.8%) followed by 18 to 25 years of age group (1.8%).[15] The reason for a predominant male donation is that most males have substantial blood volumes and adequate iron stores enhancing their fitness for blood donations. On the other hand, females are mostly exempted from donating blood due to physiological issues like menstruation, pregnancy and breastfeeding, and pathological issues like anaemia. Moreover, most of the blood donations are from young people as this age group fulfils the selection criteria of donations more frequently as compared to the older age groups.

The prevalence of TTIs in the current study was 3.33%. This was comparable to 3.72% and 3.27% prevalence rates reported in two other studies conducted in Islamabad.[7,16] The prevalence of TTIs in the current study was lower than reported in other national studies conducted in Peshawar (4.0%),[8] Lahore (4.61%),[17] Karachi (5.8%),[4] Rahimyar Khan (6.2%),[18] and Faisalabad (6.55%).[19] When compared to the international literature, the TTI prevalence was high as compared to 0.4% reported in a Chinese study.[20] The reason for varied results in this study might be due to differences in epidemiology and transmission of TTIs in different countries and population differences in terms of lifestyles, religious beliefs, and awareness.

In this study, HCV (1.4%) was the most prevalent TTI followed by syphilis (0.9%), HBV (0.68%), and HIV (0.26%), respectively. These results were similar to the study conducted by Saeed *et al*. which also reported the same order of prevalence of TTIs, leading with HCV (2.62%) followed by syphilis (1.55%), HBV (1.10%), and HIV (0.02%), respectively. However, in comparison to the present study, the higher prevalence rates of HCV, syphilis, HBV, and HIV were reported in the study conducted by Saeed *et al.*[21] Identical results were reported by Memon *et al.* in which the

most common TTI reported among the blood donors was HCV (3.52%) followed by syphilis (3.01%).[22] A systematic analysis of 33 studies showed comparatively high seroprevalence of HCV (2.44 %), syphilis (1.1%), and HBV (2.04%).[5] The donors mostly belonged to a developed urban area with high literacy rate and improved public health knowledge which might have contributed to the low percentage of TTIs observed.

In this study, TTIs were most prevalent in 26 to 35 years of age accounting for 5,143(50%) positive donors. These results were almost consistent with another study conducted by Sundaramurthy *et al.*[23] in which most TTIs were reported among the age group of 20-30 years. High-risk behaviour may be attributing to the higher prevalence of TTIs in this age group. This is alarming because our donor pool is mainly constituted of donors of this age group. There is an urgent need to impart public health awareness about the prevalence and routes of transmission of viral infections to youth. Combined efforts are required at the national and international levels to improve youth knowledge of sexual health and risk behaviour modifications. HCV, syphilis, and HBV infections were most common in the 26 to 35-year-old group comprising about 2095 (1.49%), 1722 (1.22%), and 1170 (0.83%) donor positivity, respectively in this study. Another study conducted by Chang *et al*. showed that in contrast to this study, HCV and syphilis were most common in comparatively older age groups (HCV, age: 46-55 years, 20.4%) and (syphilis, age: 36-45 years, 35.5%), respectively.[20] A study conducted by Mahwish *et al.*[24] in a tertiary care hospital in Islamabad revealed that HCV and syphilis were more prominent in 26 to 35-year-old age group, these results were concordant to this study. There was statistically significant association *i.e*. p-value<0.05 between TTIs prevalence and age groups in the current study. Similar findings were also reported by another study conducted by Nejat *et al*.[25]

To effectively address this issue, it is necessary to emphasise strong advocacy efforts supported by strict monitoring. A continuous improvement and implementation of donor selection criteria and rigorous screening of all blood donors are essential. Additionally, more sensitive testing methods such as NAAT or chemiluminescent assays should be adopted. The public awareness programs, extensive Hepatitis B immunisation campaigns, and educational initiatives on sexual health and risk behaviour modification are urgently required. Adequate public health measures must be instituted to ensure the elimination or at least a significant reduction in the risk of TTIs among recipients.

CONCLUSION

The prevalence of TTIs among blood donors was found to be 3.33%. Among the TTIs, HCV was the most common, followed by syphilis, HBVs, and HIV. The age group with the highest prevalence of TTIs was 26 to 35 years. There was a statistically significant association between TTIs prevalence and all age groups. It is crucial to provide a standard treatment and counseling to all seropositive donors, especially the younger ones, to prevent the transmission of potentially life-threatening infections to their families and society.

ETHICAL APPROVAL:

An approval was taken from Institutional Ethics Review Committee (ERC) prior to the research. The date of approval of the study was 22nd December 2016. A certificate of approval of the study (AFIT-ERC-16-055) was issued. IRB Certificate was also taken from ERC (AFIT-ERC-22-015) prior to the submission of the manuscript for publication.

PATIENTS' CONSENT:

Informed consent was taken from each blood donor before recruiting them in the study ensuring the confidentiality of donors.

COMPETING INTEREST:

The authors declared no competing interest.

AUTHORS' CONTRIBUTION:

NS: Contribution in conception of work, collection of data, analysis, interpretation of data, drafting and editing of the manuscript.
TG, SF, RL, AM: Contribution in conception of work, collection of data, analysis, interpretation of data, and critical revision.
GZ: Contribution in conception of work, interpretation of data, and critical revision.
All authors have approved the final version of the manuscript to be published.

REFERENCES

1. Wondimu H, Addis Z, Moges F, Shiferaw Y. Bacteriological safety of blood collected for transfusion at University of Gondar Hospital blood bank, Northwest Ethiopia. ISRN *Hematol* 2013; **2013**:1-7. doi.org/10.1155%2F2013%2F308204.
2. Negash M, Ayalew M, Geremew D, Workineh M. Seroprevalence and associated risk factors for HIV, Hepatitis B and C among blood donors in South Gondar District blood bank, Northwest Ethiopia. *BMC Infect Dis* 2019; **19**:430. doi.org/10.1186/s12879-019-4051-y.
3. World Health Organization: WHO. Blood safety and availability. WHO; 2022. Available at: http://www.who.int/news-room/fact-sheets/detail/blood-safety-and-availability.
4. Arshad A, Borhany M, Anwar N, Naseer I, Ansari R, Boota S, *et al*. Prevalence of transfusion transmissible infections in blood donors of Pakistan. *BMC Hematol* 2016; **16**:27. doi.org/10.1186/s12878-016-0068-2.
5. Ehsan H, Wahab A, Shafqat MA, Sana MK, Khalid F, *et al*. A systematic review of transfusion transmissible infections among blood donors and associated safety challenges in Pakistan. *J Blood Med* 2020; **136(1):**26-8. doi.10. 2147/JBM.S277541.

6. The Khyber Pakhtunkhwa Government Gazette. The Khyber Pakhtunkhwa blood transfusion safety authority Act, 2016 Act No. XXV of 2016. Provincial assembly of Khyber Pakhtunkhwa. Available from: www.pas.gov.pk/uploads/acts/ Sindh%20Act% 20No.I%20of%202014.pdf. September 27, 2020
7. Siddiqui FM, Ahmed N, Oluwatayo O, Jabeen S, Qadir SM, Khan SA. *et al*. Prevalence of transfusion-transmissible infections among voluntary blood donors in tertiary health-care facility in Islamabad. Pakistan. *J of Clin Trials* 2019; **9(06)**: 383.
8. Saba N, Nasir JA, Waheed U, Aslam S, Muhammad I, Wazeer A. Seroprevalence of transfusion-transmitted infections among voluntary and replacement blood donors at the Peshawar regional blood centre, Khyber Pakhtunkhwa, Pakistan. *J Lab Physicians* 2021; **13(2)**:162-8. doi: 10.1055/s-0041-1729485.
9. Qadir H, Nasir Nadia, Kouser S, Mansoori H, Qadir N, Baig R. *et.al.* Seroprevalence of Hepatitis B, Hepatitis C, human immunodeficiency virus, syphilis, and malaria among blood donors at tertiary care hospital blood bank. *J Pak Med Ass* 2021; **71(3)**:897. doi: 10.47391/JPMA.1344.
10. Abate M, Wolde T. Seroprevalence of human immuno-deficiency virus, Hepatitis B virus, Hepatitis C virus, and syphilis among blood donors at Jigjiga Blood Bank, Eastern Ethiopia. *Ethiop J Health Sci* 2016; **26**:153-60. doi: 10.4314/ejhs.v 26i2.9.
11. Ataro Z, Urgessa F, Wasihun T. Prevalence and trends of major transfusion transmissible infections among blood donors in dire Dawa Blood bank, Eastern Ethiopia: Retro-spective study. *Ethiop J Health Sci* 2018; **28(6)**:701-10. doi: 10.4314/ejhs.v 28i6.4.
12. Al-Hatheq A, Abakar AD, Al-Ofairi B. Seroprevalence of hepatitis C virus infection among blood donors and clinical visitors in Amran Governorate, *Yemen Ejpmr* 2019; **6(9)**: 69-73. ISSN 2394-3211.
13. Bonja F, Hussein M, Alemu J, Gemechu D, Birhaneselassie M. The prevalence of transfusion transmitted infections: A focus on Hepatitis B virus among blood donors at Hawassa Blood Bank Center, Southern Ethiopia. *Int J Blood Transfus Immunohematol* 2017; **7**:7-14. doi:10.5348/ijbti-2017-29-OA-2.
14. Elsafi SH. Demographical pattern of blood donors and pre-donation deferral causes in dhahran, Saudi Arabia. *J Blood Med* 2020; **11**:243-9. doi.org/10.2147%2FJBM.S254168.
15. Bukhari N, Sharif N, Ali A, Majid A, Wali Ur Rehman, Inam-u-llah. Understanding the modern sociology of blood donation, a retrospective study of voluntary blood donors belonging to district Attock Punjab, Pakistan. *J Univ Med Dent Coll* 2022; **13(3)**:417-21. doi.org/10.37723/jumdc.v13i3.584.
16. Awan S A, Junaid A, Sheikh S. Transfusion transmissible infections: maximizing donor surveillance. *Cureus* 2018; **10(12)**: e3787. doi. 10.7759/cureus.3787.
17. Ahmad M, Saeed M, Hanif A. Slump of trends in transfusion-transmissible infectious diseases: Is syphilis alarming in Pakistan? *Glob J Transfus Med* 2019; **4(01)**:45-51. doi.10.4103/GJTM.GJTM_46_18.
18. Ghafoor MB, Mazhar H, Leghari AR, Mehwish A, Zulfiqar S, Mustafa G. Major transfusion-transmissible infections among blood donors in Rahim Yar Khan, a district of Southern Punjab, Pakistan. *ISRA Medical Journal* 2016; 8**(4)**:246-8.
19. Rauf R, Cheema A. Potential risk of transfusion-transmissible infections among blood donors in district Faisalabad of Pakistan. *Clin Med (Lond)* 2019; **19(3)**:27. doi.org/10. 7861%2Fclinmedicine.19-3s-s27.
20. Chang L, Zhao J, Guo F, Ji H, Zhang L, Jiang X. *et al.* Demographic characteristics of transfusion-transmitted infections among blood donors in China. *BMC Infect Dis* 2019; **19**:514. doi.org/10.1186/s12879-019-4044-x.
21. Saeed M, Hussain S, Rasheed F, Ahmad M, Arif M, Hamid Rahmani MT. Silent killers: Transfusion Transmissible Infections-TTI, among asymptomatic population of Pakistan. *J Pak Med Assoc* 2017; **67(3)**:369-74.
22. Memon FA, Ujjan ID, Memon AI, Shaikh AR, Rao AR, Naz A. Seroprevalence of transfusion transmitted infections among different blood group donors at Blood Bank LUMHS, Hyderabad. *Pak J Med Sci* 2017; **33(2)**:443-6. doi: 10.12669/pjms.332.11691.
23. Sundaramurthy R, Arunagiri R, Ganesan V, Perumal S, Tiruvannamalai R, Charles J. Seroprevalence of transfusion transmissible infections among blood donors by chemiluminescent assay in a tertiary care centre. *J Infect Dev Ctries* 2018; **12(1)**:31-6. doi: 10.3855/jidc.9430.
24. Bhatti MM, Junaid A, Sadiq F. The prevalence of transfusion transmitted infections among blood donors in Pakistan: A retrospective study. *Oman Med J* 2022; **37(3)**:e386. doi.10.5001/omj.2022.65.
25. Siraj N, Achila OO, Issac J, Menghisteab E, Hailemariam M, Hagos S, *et al.* Seroprevalence of transfusion-transmissible infections among blood donors at National blood transfusion service, Eritrea: A seven- year retrospective study. *BMC* 2018; **18**:264. doi.org/10.1186/s12879-018-3174-x.