

Prevalence and Associated Factors with Transfusion-Transmitted Infections among Blood Donors at the National Blood Transfusion and Research Center, Sana'a, Yemen

Yasser Ahmed Ghaleb (✉ ysrghaleb@gmail.com)

Yemen Ministry of Public Health and Population <https://orcid.org/0000-0001-6697-0753>

Aymn Zaid Alshahari

National Blood Transfusion and Research Center

Majdi Abdulhabeeb Ali

National Blood Center

Mohammed Abdullah Al Amad

Y-FETP

Abdulwahed Abduljabbar Al Serouri

Y-FETP

Research article

Keywords: Transfusion transmitted infections, Blood donors, HIV, Syphilis, Malaria, Conflict

Posted Date: December 2nd, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-116777/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Background: Yemen is facing major challenges in ensuring the safety and availability of blood transfusion to meet the increased demand for blood transfusion due to the protracted conflict. However, Transfusion-transmissible infectious (TTIs) agents such as hepatitis B virus (HBV), hepatitis C virus (HCV), human immunodeficiency virus (HIV), syphilis and malaria remain the greatest threats for blood transfusion safety in such fragile, conflict-affected and vulnerable settings. This study aimed to determine the magnitude of TTIs among blood donors attending National Blood Transfusion and Research Center (NBTRC) and its associated factors.

Methods: Cross-sectional study was conducted on 340 blood donors at the NBTRC during November and December 2017. Data was collected through face-to-face interview using a predesigned questionnaire that covered socio-demographic characteristics and possible TTIs associated factors. Blood samples were drawn and tested for HBV surface antigen (HBsAg), HCV antibodies, HIV1, 2 by using electrochemiluminescence immunoassay technique and rapid immunochromatographic for screened syphilis and malaria antibodies.

Result: The overall prevalence of TTIs was 8.8% where 2.5 %, 1.2%, 0.3%, 1.2%, 3.2% have HBV, HCV, HIV, syphilis and malaria respectively. HBV was significantly associated with history of jaundice and cupping. Furthermore, urethra-vaginal excretion was significantly associated with syphilis while malaria was significantly higher among donors from malaria endemic areas. Nearly three-fourth of donations were from replacement donors who had significantly higher TTIs prevalence than the voluntary donors: 10.4% vs. 3.3%, OR 3.4 (CI: 1.1-11.6).

Conclusions: Although the prevalence of TTIs is low, it poses a serious risk for blood recipients especially in fragile, conflict-affected and vulnerable settings where needs for blood transfusion are increasing and resources are limited. Therefore, using more sensitive screening methods and establishment of TTIs surveillance system should be considered. Efforts should be made to improve donor recruitment procedures and increase the proportion of regular and voluntary donation.

Background

Blood transfusion (BT) is a life-saving intervention where it saves millions of lives each year globally, however it's associated with risks that could lead to adverse consequences. Besides BT acute and delayed complications, there is a risk of 1 to 2 per 1000 recipients, to receive contaminated blood with viral, bacterial or parasitic Transfusion Transmitted Infections (TTIs) [1, 2].

The strategic framework for blood safety and availability 2016–2025 of WHO recommends an integrated strategy including availability of a well-organized and adequately funded nationally coordinated BTS, with an effective blood component programme under well-defined regulatory oversight. In addition, prioritization of blood donation from voluntary non-remunerated donors (VNRD), quality-assured testing of all donated blood, including screening for TTIs, reduction in unnecessary transfusions through

appropriate clinical use and safe administration of blood and blood products; and implementation of effective quality systems in all areas of BTS were recommended [3].

TTIs is defined as any infection that is transmissible from person to person through blood transfusion of blood or blood products [4]. Among them, are hepatitis B virus (HBV), hepatitis C virus (HCV), human immunodeficiency virus (HIV 1,2), syphilis and transfusion associated malaria infection [5]. According to WHO reports, the prevalence of HBV, HCV, HIV and syphilis infections among blood donors in different parts of the world varies from 0.03% – 8.47%, 0.02% – 1.80%, 0.003% – 2.69%, and 0.05% – 1.88%, respectively [6]. However, in low-income countries, such prevalence rates increase to 3.34% – 8.47%, 0.67% – 1.80%, 0.56% – 2.69% and 0.31% – 1.88% respectively [6]. Furthermore, malaria constitutes a big health problem in general population where in 2016; there were an estimated 216 million cases in 91 countries [7]. Transfusion-transmitted malaria occurs at an estimated rate of 0.25 cases per 1 million blood units collected [8].

In Yemen, TTIs found to be an important health problem due to war consequences and conflict, as well as upsurge of casualties and injuries that may increase the possibility of TTIs among recipients through using rapid blood screening methods that have low sensitivity and specificity. Studies that were conducted in Sana'a City, Aden and Hodeidah revealed that hepatitis B and C viruses and HIV are a major issue among blood donors. The prevalence of HBV, HCV, HIV and syphilis according those studies varies from 2.1%- 5.1%, 0.79%- 3%, 0.34%- 0.39% and 0.34%- 0.75%, respectively [9–12]. Furthermore, previous study found that 8.33% of blood donors were positive for malaria [13].

The National Blood Transfusion and Research Center (NBTRC) is the main blood transfusion center in Sana'a City, which launched in 2006 to ensure safe blood and blood products for all patients' needs and regulate the BTS in whole country. During 2006 to 2017, the center collected 144,458 blood units from VNRD and family replacement donors (FRD).

Since its establishment, the NBTRC is focusing on blood transfusion services provision with little emphasis on research component due to limited capacities, lack of earmarked research budget and poor documentation caused by absence of computerized registration system. Therefore, there is few studies that were conducted at the NBTRC and none of them was on TTIs.

This study aims to determine the prevalence of TTIs among blood donors and its associated factors. It will help to understand the magnitude of the problem and to guide evidence-based decision making to ensure the safety of blood transfusion through better donor selection, motivation, retention and care as well as improving screening practices against TTIs.

Methods

Study population and setting

The study was conducted on blood donors at the NBTRC during November to December 2017. It is the main center for blood transfusion services in Sana'a, which provides blood transfusion services to the local, as well as for population coming from different governorates. All healthy donors from different localities (rural and suburban population) come to donate as VNRD or for their relatives. The standard criteria for selection of blood donors was used based on NBTRC and WHO guidelines [14]. These criteria include: age of donor arranged between 18 to 55 years, body weight greater than 50 kg, hemoglobin level between 14–18 g/dl for male and 12.5–16 g/dl for female with normal pulse rate of 60–100 per minute and blood pressure (systolic of 100–140 mmHg and diastolic of 60–90 mmHg). In addition to, the exclusion criteria were age less than 18 years or more than 55 years, body weight less than 50 kg. Hemoglobin values less than 12.5 g/dl for female and 14 g/dl for male, history of jaundice, cupping, surgical operation, hypertension or current fever, recent illness or transfusion, and not giving a consent.

Sampling method

The sample size calculated using Epi- info with an acceptable error fixed at three, confidence levels 99% and the prevalence of HBV was 5.1% [11]. The sample size comes to be 311. We increased the sample by 10% to be 340 in order to overcome refusal of some of blood donors in the sample to participate due to their own reasons. A sampling frame was created using the blood donor register. The number of blood donations at NBTRC was an average of 1,300 per month. The sample was selected by using simple random sampling method.

Data collection

Data were collected through face-to-face interview with blood donors by trained staff from NBTRC using a predesigned questionnaire that covers socio-demographic characteristics (e.g. age, sex, marital status), special habits (e.g. cigarette smoking, khat chewing), and past history (e.g. of jaundice, surgical operation, dental clinic visiting, cupping, hepatitis B vaccination).

Laboratory test

Three to five ml whole blood sample was collected from each donor in a labeled plain and EDTA tubes with the unique identifier number. The serum was separated and screened for HBV, HCV, HIV by using a commercially available electro-chemi-luminescence immunoassay (ECLIA) - Roche technique [15]. Any sample found reactive was retested for confirmation by using BioRad Kits ELISA. In addition, the samples were screened for syphilis and malaria antibodies by rapid immune-chromatographic assay method. Any unit found to be reactive was discarded.

Blood donors grouping and Rh factor were tested by used monoclonal antisera (serological method).

Data management and analysis

Data was entered and analyzed using Epi info 7.2 version where it was presented as frequencies and percentage. Cross-tabulation was used to identify associated factors with TTIs using the Chi-squared test (χ^2) and odd ratio (OR). *P-Value* ≤ 0.05 is considered statistically significant.

Results

Three hundred-forty out of **2566** total blood donors received by NBTRC during November and December 2017 were interviewed. Table (1) shows the blood donors according to socio-demographic information. Literate, male, and married formed the majority: 97%, 95%, and 77% respectively. Only 27% of the donors was VRCD. The most common age group was 26–35 years (43%) and blood donors mostly came from Sana'a City (42%). Regarding special habits, 89% was Qat chewers and 53% was current smokers. There were no association between TTIs and gender, age groups, donation type, marital status, residence place, smoking or Khat chewing.

Table 1

Distribution of the blood donors by socio-demographic information and transfusion transmitted infections markers reactivity, National Blood Transfusion and Research Center, Sana'a City, 2017

Category	No. (%)	TTIs -Reactive No. (%)	Odd Ratio (Confidence interval)	P- Value
Gender				
Male	323 (95)	28 (8.7)	0.65 (0.05-5.15)	>0.05
Female	17 (5)	1 (5.9)		
Age group				
18 – 25	72 (21)	9 (9.8)	1.24 (0.54- 2.82)	>0.05
26 – 35	146 (43)	7 (4.8)		
36 – 45	89 (26)	10 (12.5)		
>45	33 (10)	3 (13)		
Donation type				
VNRD*	91 (27)	3 (3.3)	0.29 (0.08- 0.99)	>0.05
FRD*	249 (73)	26 (10.4)		
Marital Status				
Married	263 (77)	24 (9)	1.44 (0.53 -3.9 2)	>0.05
Single	77 (23)	5 (6.5)		
Education				
Literate	329 (97)	28 (8.5)	1.08 (0.13-8.71)	>0.05
Illiterate	11 (3)	1 (9)		
Occupation				
Not employed	169 (50)	14 (8.3)	0.93 (0.43-2.01)	>0.05
Employed	171 (50)	15 (8.8)		
Residence				
Sana'a City	143 (42)	11 (7.7)	0.82 (0.38 – 1.81)	>0.05
Other	197 (58)	18 (9.1)		
Cigarette Smoking				
Smoker	182 (53)	17 (9.3)	1.3 (0.58 -2.71)	>0.05

Non-smoker	158 (47)	12 (7.6)		
Khat chewing**				
Khat Chewer	302 (89)	26 (8.6)	1.1 (0.32-3.82)	>0.05
Non-Khat chewing	38 (11)	3 (7.9)		
*VNRD: Voluntary Non-Remunerated Donors *FRD: Family Replacement Donors				
** Khat is a plant, cultivated in Yemen, the young leaves and stems of khat are chewed for several hours for their stimulant action				

Table (2) O Positive (53.8%) and A Positive (29.7%) are the most encountered groups while the AB positive (0.6) is the least and there is no significant association between TTIs and blood grouping.

Table 2
Distribution of TTIs by of blood group types and Rh factors
among blood donors at NBTRC , Sana'a city,2017

Blood group	No. (%)	TTIs -Reactive No. (%)	P- Value
A RhD Negative	183 (53.8)	19 (10.4)	>0.05
A RhD Positive	101 (29.7)	8 (7.9)	
AB RhD Positive	26 (7.7)	0 (0.0)	
B RhD Negative	12 (3.5)	0 (0.0)	
B RhD Positive	12 (3.5)	1 (3.9)	
O RhD Negative	4 (1.2)	1 (8.3)	
O RhD Positive	2 (0.6)	0 (0.0)	

Table (3) shows that at 8.8% were reactive for any of TTIs tests and the most prevalent TTI markers was anti-malaria (3.2%) followed by HBsAg (2.5%). Only one donor sample had reactive results of multiple pathogens (co. infection).

Table 3
Seroprevalence of Transfusion Transmitted Infections
markers among blood donors, National Blood Transfusion
and Research Center, Sana'a City, 2017

TTIs markers	Reactive		Non-Reactive	
	No.	%	No	%
HBsAg	10	2.9	330	97.1
Anti- HCV	4	1.2	336	98.8
HIV 1,2	1	0.3	339	99.7
Syphilis Ab	4	1.2	336	98.8
Anti-Malaria	11	3.2	329	96.8
Total (TTIs)	30*	8.8	311	91.2
* Only one donor had co-infection (HBV with HIV)				

Table (4) shows the significant associated factors with HBV, Malaria and syphilis. Multivariable analysis identified only past history of cupping [OR = 4.8 (1.3– 17.6), $p < 0.05$], history of jaundice [OR = 7.7 (2.1 – 27.8), $p < 0.01$] and donating blood more than three times [OR = 10.7 (1.3 – 85.3), $p < 0.01$] found to be significantly associated with HBV infection.

Table 4
Significant factors associated with HBV, malaria and syphilis reactivity among blood donors,
National Blood Transfusion and Research Center, Sana'a City, 2017

Factors	No.	%	OR	CI	χ^2	<i>P-Value</i>
HBV (HBsAg)						
History of jaundice N=43 (13%)	5	11.6	7.68	2.1-27.8	9.76	<0.01
Cupping* N=84 (85%)	6	7.14	4.84	1.33–17.6	17.6	<0.05
Donate blood >3 times N= 129 (38%)	9	7	15.75	1.9 – 125.8	9.69	<0.01
Malaria antibodies						
Endemic N= 107	8	7.5	6.2	1.6-23.8	7.3	<0.01
Non- endemic N= 233	3	1.3				
Syphilis						
Urethrovaginal excretion N=10 (3%)	2	20	40.75	5.08-326.8	16.8	<0.001
OR: Odd Ratio		CI: Confidence Interval			χ^2 : Chi-squared test	
* Cupping: an operation of drawing blood from the body by scarification and cupping glass						

Being from endemic area was significantly associated with reactivity for malaria [OR = 6.2 (1.6 – 23.8), p < 0.01].

Regarding syphilis cases, urethrovaginal excretion is significantly associated [OR = 40.75 (5.08–326.8), P < 0.001].

Discussion

TTIs remain an important cause of transfusion morbidity and mortality. Despite the advances that have been made in the testing of blood donations for infectious diseases, the risk of transmitting viral,

bacterial, and parasitic diseases still exists. Thus, infectious complications of transfusion remain an important area of concern in transfusion medicine [1].

In our study, the majority of the blood donors (95%) were males, which is mostly similar to the studies done in Yemen and Saudi Arabia [12, 16]. This gender imbalance might be due to the fact that in these societies' men are more proactive and independently make decisions. In addition, there may be misconceptions that donating blood by women may have a negative impact on their health due to their physiological repeated blood loss e.g. during pregnancy, menstruation etc. Thus, blood transfusion services authorities need to overcome such misconception through targeting women with clear health education messages on benefits of blood donation even for women.

Thirty-four percent of donors in our study was 26–35 years that is similar to previous studies in Yemen [9, 17] as well as neighboring countries such as Ethiopia [4]. However, this differs from the figures published by the WHO that reported 45% of donors were aged 25 or less [18]. This may be attributed to lack of awareness among younger age group in the Yemeni population.

WHO advocates for developing national blood transfusion services based on VNR regular blood donation to ensure safe and adequate blood supply [19]. Our finding showed only 27% of blood donors are VNR that is similar to previous reported from Sana'a 27.4% [20] but contrasting the 100% VNR reported from Oman, Iran, and Qatar [21]. Such difference may reflects poor awareness and negative attitude among the Yemeni community regarding voluntary donation.

ABO blood distribution in this study showed that 53.8% of donors were O Rh positive that is quite similar with that reported from Ethiopia [22]. However, no significant association was found between ABO and TTIs.

In addition, our finding revealed that nearly half of the donors from Sana'a city which may be attributed to the location of NBTRC in Sana'a city. There is also no significant association was found between residence and TTIs.

This study showed that 29 units (8.8%) of donated blood had serological evidence of TTIs compared to 5.8% in Pakistan and 4.09% in India [23, 24]. However, this increase in the prevalence of TTIs in our study may be attributed to using of malaria antibody in testing for malaria while the Pakistani and Indian studies used malaria antigen that usually gives lower prevalence.

Our study showed HBsAg prevalence of 2.5%, which is similar to previous results reported from Yemen that was ranging from 2.1–2.4% [9–11, 17]. However, higher rates (5.1% and 6.7%) have previously been reported among Yemeni blood donors [9, 25] which may be either attributed to poor selection of donors or using fewer specific tests e.g. chromatography. Lower prevalence HBsAg rates was reported among Saudi blood donors (0.7%), Iraq (0.78) and Jordon (1.4%), respectively [26–28] that may be attributed to differences in the HBV epidemiology. Moreover, strong blood donor mobilization, selection, and retention

and care system in blood banks in those countries may play more important role on such lower HBV prevalence.

Our study showed HCV prevalence 1.2% which is similar to previous studies in Yemen that was ranging between 0.8%- 1.2% [9–11, 16]. However, our result was higher than reported from Saudi Arabia (0.4%), Iraq (0.2) and Jordan (0.9%) [26–28] which may reflect differences in HCV epidemiology.

The prevalence of HIV in our study (0.3%) is slightly higher than reported from Hodeidah, Yemen: 0.14% [11] and neighboring Saudi Arabia: 0.07% [26]. However, it is slightly lower than reported from Sana'a: 0.5% [17]. More research is still needed to explore reasons behind such differences.

Syphilis is a serious sexually transmitted disease that can be transmitted through blood transfusions [29]. In our finding, the prevalence of syphilis was 1.2% however, lower prevalence 0.34% was reported in Hodeidah, Yemen and from Saudi Arabia that may reflect geographical variation or in the testing methodology [11, 30]. Nevertheless, much higher prevalence 6.8% was reported among Sudanese blood donors [31] that may relate to differences in behavioral risk factors. Our result revealed that past history of urethrovaginal excretion is significantly associated with higher syphilis prevalence among blood donor (OR = 40.75; 95% CI = 5.08–326.8, $P < 0.001$). Such result is not unexpected considering that syphilis is a sexually transmitted disease that is frequently manifested by urethrovaginal excretion.

Asymptomatic carriers of malaria are generally the source of transfusion-transmitted malaria infection. Asymptomatic infections may persist for five years especially in asymptomatic *Plasmodium falciparum* and vivax infections [32]. Our result showed the overall malaria antibody prevalence of 3.2%, which is higher than reported in Pakistan (0.07%) and India (0.03%) where malaria antigen tests were used [23, 24]. Nevertheless, our results is lower than the overall prevalence of 7.6%, reported from Saudi Arabia [33] that could be attributed to use Eliza antibody tests while we used the rapid antibody test method. Our result showed significant difference in malaria antibody among donors from endemic vs. non-endemic areas (7.5% vs. 1.3% respectively) which is consistent with findings from Saudi Arabia (9.1% vs. 4.8%).

This study showed that 29 units (8.8%) of donated blood had serological evidence of TTIs compared to 5.8% in Pakistan and 4.09% in India [23, 24]. However, this increase in the prevalence of TTIs in our study may be attributed to using of malaria antibody in testing for malaria while the Pakistani and Indian studies used malaria antigen that usually gives lower prevalence.

TTIs was slightly progressively increasing with age, higher among males, married, illiterates and not employed where the differences are statistically insignificant ($p > 0.05$). These findings are consistent with previous reports from Yemen and other countries [9, 15, 17].

Regarding associated factors with HBV, our finding showed HBsAg was significantly higher among blood donors who had previous history of cupping or jaundice. Similar result was previously reported among blood donors in Sana'a city [17]. Furthermore, donating blood more than three times found to be significantly associated with HBV infection, which may be an indication for possible healthcare-

associated infection [34]. Furthermore, higher frequency of blood donation is related to paid donation – which is not uncommon in Yemen [35]- that was found to be associated with higher rates of HBV markers [36].

We did not find any associations between HCV or HIV and any of potential factors e.g. blood transfusion. This is may be due to lower prevalence of these infections in this study. Further studies with larger sample size should be considered.

Conclusions

the overall prevalence of viral infections among blood donors was drop compared with previous years and slightly increased for syphilis infections. While the prevalence of TTIs is low, it remains an important problem in blood transfusion. Therefore, establishment of TTIs surveillance system, improving donor motivation procedures and increase the proportion of regular and voluntary donation together with using more sensitive screening methods are recommended. Increase public health awareness regarding TTIs and encouraging more research should be considered. Further studies over longer period and with larger sample size should be also considered.

Abbreviations

BT: Blood transfusion, χ^2 : Chi-squared test, FRD: Family Replacement Donors, ECLIA: electro-chemi-luminescence immunoassay, HBV: Hepatitis B Virus, HCV: Hepatitis C Virus, HIV: Human Immunodeficiency Virus (HIV 1,2), NBTRC: National Blood Transfusion and Research Center, OR: Odd Ratio, TTIs: Transfusion Transmitted Infections, VNRD: Voluntary Non-Remunerated Donors

Declarations

Ethics approval and consent to participate

The study was approved by the Ethical Committee at the Ministry of Health and Population. Permission of the NBTRC was secured and verbal consent was taken from blood donors. Privacy was maintained during interviews, questionnaires kept in a lockable cabinet and data entered in a password-protected file in computer with specific entrance code.

Consent for publication

Not applicable.

Availability of data and materials

The data presented in this paper are available from the corresponding author on request.

Competing interests

The authors declare that they have no competing interests.

Funding

This work was supported by TEPHNET, the funder had role only in data collection.

Authors' contributions

All authors have read and approved the manuscript. Conceived and

designed the experiments: Yasser Ghaleb and Abdulwahed Al Serouri,.

Analyzed the data: Mohammed Abdullah Al Amad and Yaser Ghaleb.

Contributed reagents/materials/analysis tools: Aymn Zaid Alshahari, Majdi Abdullhabeeb Ali Wrote the paper: Yasser Ghaleb and Abdulwahed Abduljabbar Al Serouri,

Acknowledgment

Authors would like to acknowledge the TEPHNET for their support. They would also like to acknowledge the support of Y-FETP, EMPHNET, CDC and WHO.

References

1. Manzoor I, Hashm NI, Daud S, Ajmal S, Fatima H, Rasheed Z, et al. Seroprevalence of transfusion transmissible infections (TTIS) in blood donors. *Biomedica*. 2009;25 (10):154–158.
2. United States General Accounting Office. Report to the Ranking Minority Member, CommiRee on Commerce, House of representative. Blood supply, transfusion-associated risks. GAO/PEMD. 1997;97-102.
3. Strategic framework for blood safety and availability 2016–2025. Cairo: World Health Organization Regional Office for the Eastern Mediterranean; 2017 (http://applications.emro.who.int/dsaf/EMROPub_2017_EN_19608.pdf?ua=1, accessed 11 January 2020).
4. Mohammed Y, Alemayehu B. Seroprevalence of transfusion transmitted infection among blood donors at Jijiga blood bank, Eastern Ethiopia: retrospective 4 years study. *BMC Res Notes*. 2016; 9: 129.
5. Wairimu KM, Herbert K, John M. Prevalence of (TTIs) among Blood Donated at Nyeri Satellite Transfusion Centre In Kenya. *IOSR Journal Of Pharmacy*,2016; 6(2): 20-30.

6. Blood safety and availability. Fact sheet. Geneva: World Health Organization: 2017 (<http://www.who.int/mediacentre/factsheets/fs279/en/>, accessed 2 February 2018).
7. World malaria report. Geneva: World Health Organization: 2017 (<http://www.who.int/malaria/en/>, accessed 5 February 2018).
8. Kumar A, Valecha N, Jain T, Dash AP. Burden of malaria in India: retrospective and prospective view. *The American journal of tropical medicine and hygiene* 2007; 77 (6):69-78.
9. Alodini A.Q. Prevalence of Hepatitis B Virus (HBV) and Hepatitis C Virus (HCV) Infections among Blood Donors at AlThawra Hospital Sana'a City Yemen. *Yemeni journal for medical sciences*, 2014: 6, 16 - 20.
10. Al-Waleedi A.A and Khader Y.S. Prevalence of hepatitis B and C infections and associated factors among blood donors in Aden city, Yemen. *Eastern Mediterranean Health Journal*, 2012; 18(6):624-629.
11. Saghir S.A, Al-Hassan F.M, Alsalahi O.S, Abdul-Alaziz A.E and Baqir H.S. Frequencies of HBV, HCV, HIV, and Syphilis Markers Among Blood Donors: A Hospital-Based Study in Hodeidah, Yemen. *Tropical Journal of Pharmaceutical Research* February. 2012; 11 (1): 132-136.
12. Sultan A. M. Saghir , Omar S. A., Abdulrahman A. M. Zabad, Al-Hassan M. HIV and Syphilis among Blood Donors in Sana'a, Yemen. *Biohealth Science Bulletin* 2012, 4(1), 24 – 27.
13. Nada S, Alhweesh M, Al-harazi T, Alkadasi M, Zaid AA. Diagnostic study on plasmodium in blood bags at Taiz City, Yemen. *Int J Curr Microbiol App Sci*. 2014; 3 (7):635-43.
14. Guidelines on Assessing Donor Suitability for Blood Donation. Geneva: World Health Organization: 2012 (https://www.who.int/bloodsafety/publications/guide_selection_assessing_suitability.pdf, accessed 28 January 2020).
15. Roche Diagnostics. Products and solutions, 2015. Available at: (<http://www.cobas.com/content/dam/cobas.com/pdf>, accessed 2 January 2018)
16. El-Hazmi M. Prevalence of HBV, HCV, HIV-1, 2 and HTLV-I/II infections among blood donors in a teaching hospital in the Central region of Saudi Arabia. *Saudi Med J* 2004; Vol. 25 (1): 26-33.
17. Amar G. Prevalence of Major viral blood-borne infections among blood donors at National blood transfusion and research center in Sana'a city-Yemen. MSc thesis. Faculty of Medicine and Health Sciences, Sana'a Yemen, 2017.
18. Teo KS, Saparudin MS, Zain Z, Morshidi MA, Metassan N, Jaberudin R, Teo BC, Yakup S, Lim A, Ashikin NW. Transfusion transmissible infections in Brunei Darussalam: a blood donor study. *Brunei Int Med J*. 2011;7(6):321–327.
19. Voluntary blood donation. Geneva: World Health Organization; 2010 (http://www.who.int/bloodSafety/Voluntary_donation/en/. accessed 20 January 2018)
20. Al-Zubiery et al. Sero-prevalence of Anti- HCV among Yemenis Blood Donors Attending National Blood Transfusion and Research Centre in Sana'a: Yemen. *IBRR*, 2017; 7(3):1-6.

21. The regional status report on blood safety and availability. Cairo: World Health Organization Regional Office for the Eastern Mediterranean; 2016
(emro.who.int/docs/EMROPub_2017_EN_18907.pdf accessed 21 February 2018)
22. Wakjira K, Mekonnen Z, Gerbi A, Abebe G. Transfusion-transmissible infection surveillance among blood donors in Southwest Ethiopia. *Asian Pac J Trop Dis* 2017; 7(3): 156-161
23. Arshad, A., Borhany, M., Anwar, N., Naseer, I., Ansari, R., Boota, S & Shamsi, T. 2016 Prevalence of transfusion transmissible infections in blood donors of Pakistan. *BMC hematology*, 2016; 16(1), 27.
24. Sharma, D. C., Rai, S., Bharat, S., Iyenger, S., Gupta, S., Sao, S., & Jain, B. Transfusion Transmissible Infections among Blood Donors at the Blood Bank of Medical College of Gwalior: A 5 Year Study. 246 – 236 : (4)5 ;2014.
25. Haidar NA. Prevalence of hepatitis B and hepatitis C in blood donors and high-risk groups in Hajjah, Yemen Republic. *Saudi Medical Journal*, 2002, 23(9):1090–1094.
26. Elbjeirami WM, Arsheed NM, Al-Jedani HM, Elnagdy N, Hazem M, et al. Prevalence and Trends of HBV, HCV, and HIV Serological and NAT Markers and Profiles in Saudi Blood Donors. *J Blood Disord Transfus*. 2015; 6: 280.
27. Rasheed Hussein N, Mohamad Haj S, Amin Almizori L, Ahmed Taha A. The Prevalence of Hepatitis B and C Viruses Among Blood Donors Attending Blood Bank in Duhok, Kurdistan Region, Iraq, *Int J Infect*. 2017 ;4(1):e39008.
28. Al-Gani FA. Prevalence of HBV, HCV and HIV-1, 2 infections among blood donors in Prince Rashed Ben Al-Hassan Hospital in North Region of Jordan. *Int. J. Biol. Med. Res*. 2011; 2(4):912-916.
29. Elyamany G, Al amro M, Pereira W, Alsuhaibani O. Prevalence of Syphilis among Blood and Stem Cell Donors in Saudi Arabia. *Electronic Physician*, 2016, Volume: 8, Issue: 8: 2747-2751.
30. Kim JK, Choi SR, Lee HJ, Kim DH, Yoon MS, Jo HS. Congenital syphilis presenting with a generalized bullous and pustular eruption in a premature newborn. *Ann Dermatol*. 2011; 23 Suppl 1: 127-30.
31. Bazie EA, Ali MA, Hamza HB, Omer Saeed Magzoub OS, Salih MS, Haroun BE and Malik MK..Sero-Prevalence of HIV and Syphilis Infections among Blood Donors at Kosti Teaching Hospital-White Nile State-Sudan. *Int.J. Curr. Microbiol. App. Sci* , 2015; 4(11): 832-837.
32. Katz LM. Transfusion-induced malaria. In: Brecher ME, ed. *Bacterial and parasitic contamination of blood components*. Bethesda, MD: AABB Press, 2003:127-55.
33. Saeed AA, Al Rasheed AM, Al Nasser I, Al Onaizi M, Al Kahtani S, Dubois L. Malaria screening of blood donors in Saudi Arabia. *Annals of Saudi medicine*. 2002;22(5-6):329-32.
34. Moorman AC, Stramer SL, Schaefer MK, et al. Incident hepatitis among repeat blood donors; a sentinel event signaling possible healthcare associated infection and need for reporting to public health authorities. *Transfusion*. 2015;55(10):2531-2533.
35. Darbandi A, et al. Status of blood transfusion in World Health Organization-Eastern Mediterranean Region (WHO-EMR): Successes and challenges. *Transfusion and Apheresis Science*, 2017, 56.3: 448-

453.

36. Van Der poel, C. L.; Seifried, E.; Schaasberg, W. P. Paying for blood donations: still a risk?. *Vox sanguinis*, 2002, 83.4: 285-293.