IJID Regions 10 (2024) 168–173

Contents lists available at ScienceDirect

IJID Regions

journal homepage: www.elsevier.com/locate/ijregi

Hepatitis B virus infection, associated factors, knowledge and vaccination status among household contacts of hepatitis B index cases in Mwanza, Tanzania

Ivon Mangowi[1], Mariam M. Mirambo[2,*], Semvua B. Kilonzo[3], Mathias Mlewa[2], Helmut Nyawale[2], David Majinge[4], Fredy Hyera[4], Hyasinta Jaka[3], Conjester Mtemisika[4], Fausta Michael[5], Stephen E. Mshana[2]

[1] School of Public Health, Catholic University of Health and Allied Sciences, Mwanza, Tanzania
[2] Department of Microbiology and Immunology, Catholic University of Health and Allied Sciences, Mwanza, Tanzania
[3] Department of Internal Medicine, Catholic University of Health and Allied Sciences- Bugando, Mwanza, Tanzania
[4] Bugando Medical Centre, Mwanza, Tanzania
[5] Ministry of Health, Immunization and Vaccine Development Program, Dodoma, Tanzania

ARTICLE INFO

Keywords:
HBV index case
Household contacts
Vaccination status
Prevalence
Tanzania

ABSTRACT

Objectives: To determine the prevalence of hepatitis B virus (HBV) infection, knowledge regarding HBV, vaccination status, and associated factors among household contacts of HBV index cases in Mwanza, Tanzania.
Methods: Between July and August 2023, a cross-sectional study involving 97 index cases and 402 household contacts was conducted. Data were collected using pre-tested structured questionnaire and blood samples were collected from household contacts for HBV surface antigen (HBsAg) testing.
Results: The prevalence of HBV among household contacts was 5.4% (95% confidence interval, 2.9-9.0) with a significantly high proportion observed in > 45 years (16.6%) and in males (9.9%). A total of 40.0% of the household contacts had completed the full HBV vaccination series. On multivariate analysis, being male was significantly associated with HBsAg positivity (odds ratio: 7.16, 95% confidence interval: 1.81-28.2, $P = 0.005$).
Conclusion: About one-tenth of adults' male household contacts were HBsAg positive. In addition, the majority of household contacts had poor to fair knowledge regarding HBV infection with more than half being unvaccinated against HBV. There is a need to enhance awareness and education regarding HBV infection among household contacts in Tanzania and other low- and middle-income countries.

Introduction

Hepatitis B virus (HBV) infection can lead to chronic liver disease, liver failure, and hepatocellular carcinoma and is the second leading cause of cancer-related deaths worldwide [1]. The symptoms of HBV infection can vary depending on the severity of the infection and with individual's immune status. Some people with HBV infection may not have any symptoms, thus increasing the likelihood of transmitting the infection to others, particularly those who are in contact with the infected person [2].

Despite having a reliable vaccine and effective treatment for HBV, there are approximately 296 million people chronically infected with the virus worldwide while nearly 1.5 million new cases of HBV infection occur annually [3]. Chronic HBV infection is common in low and middle-income countries (LMICs), particularly in Asia and Africa where 5-10% of the adult population is chronically infected [4]. HBV is 100 times highly contagious than Huma Immunodeficiency virus (HIV) and can survive for more than a week on dry surfaces complicating its epidemiology and increasing the risk of horizontal intra-familial transmission [5,6]. The virus can spread horizontally by blood and bodily fluids (semen, saliva, nasopharyngeal secretions, and vaginal fluids), but also spread via parenteral injection, during pregnancy, and during birth [7,8]. Previous studies in Oman and Indonesia showed that HBV carriers in the household significantly increase the risk of intrafamilial transmission [8,9] and the majority of individuals in the communities have low knowledge regarding this. Furthermore, even in low prevalence areas, certain populations such as drug abusers, men who have sex with men, and people living with HIV have high proportions of chronic HBV infection [10]. In addition, a recent systematic review has revealed that children between 15 and 17 years in Africa have

* Corresponding author:
E-mail address: mmmirambo@gmail.com (M.M. Mirambo).

https://doi.org/10.1016/j.ijregi.2023.12.007
Received 11 December 2023; Received in revised form 27 December 2023; Accepted 29 December 2023

lower hepatitis B vaccine seroprotection rate than children below 15 years [11].

To end the global HBV epidemic, the World Health Organization (WHO) recommends increasing vaccine availability and targeting HBV infection at the community level in areas with limited resources. This requires comprehensive epidemic control interventions, services, and investments. Timely and reliable data are needed to identify hotspots, main modes of transmission in a particular area, risk factors, and specific populations that are more vulnerable and at risk, and those who are already affected [12]. In Tanzania, less than 10% of the population is screened for HBV surface antigen (HBsAg) [13]. The National Viral Hepatitis Strategic Plan (NVHSP 2018/19-2022/2023) has set a goal to ensure that screening, diagnostic, care, and treatment services are available, trustworthy, and reasonably priced within the framework of a continuum of care and in compliance with universal health coverage. Different studies recommended testing and vaccinating the general population in settings where HBV infection is high [14,15]. However, this has been difficult in most of the LMICs due to financial constraints. Contact tracing as recommended by the WHO can be a good alternative for targeting high-risk groups including contacts of HBV index cases (sexual partners, children, and household members), however, its implementation has been scarce [16,17] with limited studies from LMICs to support this. This cross-sectional study was conducted in Mwanza, Tanzania with the primary goal of documenting the prevalence of HBV, risk factors, knowledge, and vaccination status among household contacts of HBV index cases. This information might be an eye-opener in efforts to prevent HBV infection in Tanzania and other LMICs.

Methods

Study design, settings, and study population

This cross-sectional study was conducted in Mwanza region of Tanzania among household contacts of HBV index cases from July to August 2023. This region was selected because it is among regions with a high prevalence of HBV infection varying in different populations including healthcare workers, pregnant women, children, and people living with HIV [18–21].

Sample size estimation, sampling procedures, and selection criteria

Convenient sampling was used to choose HBV index cases who were present at the Bugando Medical Centre (BMC) clinic database. The total population of HBV index cases diagnosed with HBsAg who attended BMC hepatitis B clinic from June 2022 to July 2023 was 200 patients. The minimum sample size (n) of 97 index cases was estimated using the Yamane Taro formula. Household contacts of the HBV index cases who were present during the study period and had been in contact with the index case for at least 6 months were eligible to participate in the study. Data regarding vaccination status was obtained and verified using a vaccination certificate and RCH card for children born after 2002. Individuals with a history of HBV and other liver diseases in their families were excluded. From 97 enrolled index cases, 402 household contacts consented to participate in the study and were enrolled.

Data collection, sample collection, and laboratory analysis

Data were collected using a pretested structured questionnaire. All participants or their guardians provided information regarding sociodemographic characteristics, risk behaviors, knowledge of HBV infection, and vaccination status. Blood specimens were collected by a qualified phlebotomist after obtaining informed consent from the participants/guardians. About 3.5 to 4 ml of venous blood was collected by venipuncture from the participants and stored in an EDTA anticoagulant tube (Becton & Dickson Co. Ltd., Nairobi, Kenya). The blood specimens were temporarily stored at 2-8˚C; plasma was separated by centrifugation at 2000 rpm at 4˚C for 20 minutes. After centrifugation using a clean pipette 1.0 ml of plasma was placed in 1.5 ml labeled Eppendorf tube and stored at -20˚C.

Plasma samples were screened for the presence of HBsAg using a rapid immunochromatographic test for the qualitative detection of HBsAg (Bio line HBsAg -Abbott Diagnostics), the test has specificity and sensitivity of 100%. Participants who tested positive for HBsAg were linked to BMC or a nearby health facility for further management. Additionally, all unvaccinated participants were advised to visit health facilities for HBV vaccination.

Data analysis

The data were cleaned and analyzed using SPSS IBM version 25 utilizing descriptive analysis. The main outcome of interest was HBsAg positivity status. Odds ratio (OR) and 95% confidence interval (CI) were calculated to indicate the strength of association. The OR was used to establish the strength of the association with P <0.05 considered statistically significant at 95% CI. Regarding knowledge about HBV, each correct answer from the questionnaires was awarded one point. The participant's scores were then converted to percentages. A score of 50% or less was considered poor, a score of 51-74% was considered fair, and a score of 75% or higher was considered good. Regarding factors associated with HBsAg positivity, all factors with P-value <0.05 on the univariate analysis were subjected to multivariate analysis.

Results

Sociodemographic characteristics

A total of 97 HBV index cases were followed up with 402 household contacts of index cases who provided their consent to participate in this study. The median age of the household contacts was 17 years (interquartile range, 9-29) and more than half, 235 (58.5%) of all participants were female. In this study, it was further observed that (41.3%) of the participants had education level of secondary and above. A total of 99 (24.6%) of all participants were either employed or self-employed. The family members included 74 (18.4) spouses, 12 (3%) parents of the index, 209 (52%) children, and 107 (26.6%) other family members (Table 1).

Prevalence of hepatitis B virus among household contacts of hepatitis index cases

Of 402 household contacts, 241 (60%) were tested for HBsAg, while the remaining were excluded because had completed three doses of the HBV vaccine. The overall prevalence of HBsAg among the household contacts who were tested was 5.4% (95% CI, 2.9-9.0). The proportion of HBsAg positivity varied across age groups, with the highest proportion observed in the age of 45 years and above (16.0%, P = 0.001). Additionally, the proportion of males who tested positive for HBsAg among tested household contacts was higher than that of females (9.9% vs 2.7%, P = 0.035).

Vaccination status among household contacts of hepatitis B index case

The full HBV vaccine series was completed by 40.0% of the 402 household contacts interviewed. Full vaccinated contacts included 18 adults (11.2%) and 143 children (88.8%). All fully vaccinated children were born after 2002 and had proof of having received the childhood vaccine series, making the full vaccination coverage of hepatitis B vaccine among children 143/212 (67.4%). Partial vaccination was observed in 7.7% of individuals while 52.2% had not received HBV vaccination (Table 2).

Table 1
Socio-demographic characteristics of study participants (N = 402).

Variables	Household Contacts (n = 402) N (%)
Gender	
Male	167(41.5)
Female	235(58.5)
Age groups of household contacts	
≤18	212(52.7)
19-24	54(13.4)
25-44	107(26.6)
45+	29(7.2)
Marital status	
Single	292(72.6)
Married	110(27.4)
Education level	
Primary	189(47.0)
Secondary	101(25.1)
College/University	65(16.2)
None	47(11.7)
Occupation	
Employed	45(11.2)
Self-employed	54(13.4)
Unemployed	303(75.4)
Religion	
Christian	354(88.1)
Muslim	48(11.9)
Location	
Nyamagana	130(32.3)
Ilemela	173(43.0)
Misungwi	25(6.2)
Magu	34(8.5)
Kwimba	22(5.5)
Sengerema	18(4.5)
Relationship with index case	
Spouse	74(18.4)
Parent	12(3.0)
Child	209(52.0)
Others	107(26.6)

Table 2
Summary of vaccination status of study participants (N = 402).

Variable	Frequency	Percentage		Total %
Vaccination status		Male	Female	
Fully vaccinated	161	81	80	40.0
Partial vaccination	31	7	24	7.7
Not vaccinated	210	66	144	52.2

Overall knowledge among household contacts of hepatitis B virus index cases

A noticeable disparity was observed, with females exhibiting a significantly higher level of knowledge compared to males (50% vs 23%, P <0.001) respectively. Moreover, knowledge levels exhibited variations across age groups, with individuals aged 25-44 years demonstrating better knowledge. Notably, individuals with high levels of education displayed a more profound understanding of HBV infection compared to others. Within the family member subgroups, the spouse of the index case exhibited a high level of HBV knowledge compared to the rest of the family members (Table 3).

Factors associated with hepatitis B virus infection among household contacts of hepatitis B index cases

Advanced age demonstrated a significant association with positive HBsAg status, with the 45 years and above age group showing the highest HBsAg positivity (P = 0.005). In contrast, male gender had a higher proportion of HBsAg positivity than female (P = 0.035). Sharing sharps or personal items was associated with high HBsAg positivity (P = 0.028). Moreover, having one or more partners with HBV infection is significantly associated with HBsAg positivity (P = 0.001). Additionally, inconsistent condom use was associated with increased HBsAg positivity (P = 0.014). On multivariate logistic regression analysis, only being a male was significantly associated with more odds of being HBsAg positive among household contacts (OR = 7.16; 95% CI: 1.8-28.2; P = 0.005) (Table 4).

Discussion

To the best of our knowledge, this is the first study to determine the prevalence of HBV infection, associated risk factors, knowledge, and vaccination status among household contacts of HBV index cases in Tanzania. The overall prevalence of HBV infection was 5.4%, with males having a significantly higher prevalence than females. Vaccination coverage was high among children under 18 years of age compared to adults with high knowledge observed in females and individuals with high education levels. Advanced age, being male, sharing sharps and personal items, having one or more sexual partners with HBV infection, and inconsistent condom use were all associated with HBV infection.

The prevalence of HBV infection among household contacts of HBV index cases in Mwanza, Tanzania was slightly higher (5.4%) than the prevalence in the general population (3.5%) and pregnant women population (3-3.8%) observed in the same settings [18,19]. This finding is consistent with other studies from different population groups in Tanzania which placed Tanzania in an intermediate endemicity status according to the WHO with prevalence between 2% and 8%. In comparison to other previous studies among healthcare workers (7%) and among the HIV-infected population (6.9%) [20,21] the reported prevalence in the current study is comparable. In comparison to previous studies in other countries that reported prevalence of 11.9% (Zambia) [22], 19.3% (Iran) [23], and 30.5% (Turkey) [24] the reported prevalence in the current study is low. The differences could be attributable to the fact that the previous studies were hospital-based while the current study is community-based. Hospital-based studies are more likely to include people with more advanced diseases, who may have been infected with HBV for longer periods of time and are more likely to transmit the virus to others. Therefore, using population-based studies from the community may be a more accurate way to judge the prevalence of HBV infection among household members of HBV patients.

In the current study increased age was associated with an increased prevalence of HBV infection which was similar to other studies in Beijing China and Iran [23]. Like in many other diseases advanced age was associated with increased exposure to the risk factors and older people are more likely to have close contact with infected individuals, such as their parents, children, or sexual partners. This was evidenced in the current study whereby HBV positivity was found to be zero in children under the age of <18 years. Moreover, this could be attributed to the infantile vaccination program in Tanzania that started in 2002 among children below 5 years of age. This is further supported by high coverage of HBV vaccination programs as evidenced in this study whereby 86% of contacts aged <18 years of age had evidence of being vaccinated with 67% of children below 18 years being fully vaccinated. Similar findings were observed in the study done in Iran which showed high vaccine coverage among children [23]. The observation of the majority of children especially those below 15 years being fully vaccinated is further supported by a recent systematic review from Africa that found a significantly higher proportion of HBV vaccine seroprotection among children under 15 years of age than children 15-17 years, linking this to successful implementation of the HBV vaccine on the extended programs on immunizations in Africa [11].

Furthermore, it was observed that men were more infected with HBV compared to women which is similar to previous reports in China, Gabon, Burkina Faso, and Ghana [25]. The higher prevalence of HBV in males could be attributed to a number of factors, including their greater likelihood of engaging in risky behaviors such as sharing needles or

Table 3
Overall knowledge among study participants (N = 402).

Variable	Total	Knowledge					*P*-value
		Good n (%)	*P*-value	Fair n (%)	*P*-value	Poor n (%)	
Gender							
Male	167	23(13.7)		31(18.5)		113(67.6)	
Female	234	50(21.3)	0.052	50(21.4)	0.2	134(57.3)	0.035
Age							
<18	212	9(4.3)		13(6.1)		190(89.6)	
19-24	54	19(35.2)		16(29.6)		19(35.1)	
25-44	106	37(34.9)		39(36.7)		30(28.3)	
45+	29	8(27.6)	0.001	13(44.8)	0.001	8(27.6)	0.001
Education level							
Primary	189	6(3.1)		25(13.2)		158(85.6)	
Secondary	101	26(25.7)		37(36.6)		38(37.6)	
College/ University	64	41(64.1)		18(28.1)		5(7.8)	
None	47	0(0)	0.001	1(2.13)	0.001	46(97.87)	0.001
Relationship with index case							
Spouse	73	33(45.2)		23(31.5)		17(23.2)	
Parent	12	1(8.3)		8(66.7)		3(25.0)	
Child	209	15(7.2)		16(7.6)		178(85.2)	
Others	107	24(22.4)	0.003	34(31.7)	0.3	49(45.7)	0.001

Table 4
Associated risk factors for hepatitis B infection among tested household contacts (N = 141).

Variable	Total (n)	Univariate			Multivariate		
		Hepatitis B virus surface antigen positive	%	*P*-value	Odds ratio	95% confidence interval	*P*-Value
Age							
<18	97	0	0		1		
19-24	38	2	5.3		1		
25-44	81	7	8.6		0.87	0.11-6.84	0.902
45+	25	4	16	0.005	1.54	0.13-18.38	0.729
Gender							
Male	91	9	9.9		7.16	1.81-28.20	0.005
Female	150	4	2.7	0.035	1		
Sharing sharps/ Personal items							
Yes	59	0	0				
No	182	13	7.1	0.028			
Sexual Partner							
0ne	121	9	7.4		1.32	0.07-21	0.845
More than one	7	3	42.9		4.88	0.10-26.66	0.418
I don't have	113	1	0.9	0.001	1		
Condom use							
Yes	56	7	12.5		1		
No	185	6	3.2	0.014	0.93	0.19-4.57	0.934
Knowledge							
Good	34	2	5.9				
Fair	71	6	8.5				
Poor	136	5	3.7	0.313			
Duration of stay with index case							
>6 Months	225	12	5.3				
<6 Months	16	1	6.3	0.6			

other sharp objects, having multiple sexual partners, and getting tattoos or piercings. Additionally, there is some evidence that genetics may play a role in the increased risk of HBV infection in males. Finally, females may have a better natural immune response to HBV than males [26,27]. These findings suggest that interventions such as education about the risks of HBV infection, prevention, counseling, and testing for people who are at high risk of HBV infection, and vaccination to prevent HBV infection should target this group.

In this study, it was observed that having one or more sexual partners with HBV infection is associated with an increased risk of contracting HBV infection which is similar to a previous report in Beijing. Moreover, the current study shows that sharing sharps and personal items and having one or more sexual partners predispose individuals to HBV infection which is similar to a previous report in Beijing which showed sharing these items among spouses increases the risk of HBV infection [23]. This suggests that couples where one spouse has HBV infection should take steps to prevent the transmission of the virus to the other spouse. The strategies could include using condoms during sexual intercourse, avoiding sharing personal belongings, and getting vaccinated against HBV. Additionally, several studies have found that sharing contaminated materials, such as razors, toothbrushes, towels, and eating utensils, can lead to the spread of HBV among household contacts while the existence of sanitation in the house was found to be protective [28,29]. This is consistent with the findings of this study, which found that there is an association between sharing contaminated sharps and personal items, such as toothbrushes, and towels, and contracting HBV infection.

Regarding the knowledge of HBV, it was observed that knowledge among the household contacts of index cases was generally poor, however, spouses had better knowledge than other family members; this could be due to their close relationship with the index case. This is similar to findings from a study done in Lusaka, Zambia which revealed that the rate of disclosure among family members was low [22]. This suggests that it is important to encourage index patients to inform their household contacts about their HBV status to prevent the risk of fur-

ther spread of HBV within the family members. Index patients can help spread knowledge about HBV infection and lower the risk of transmission by communicating with their household contacts.

Regarding vaccination status, in the current study, it was found that close to one-third of adults within the household had partial vaccination and more than half had no history of vaccination which is similar to a previous report in Iran [23]. This suggests that there is a lack of awareness about the importance of HBV vaccination among family members of patients with HBV infection. The lack of awareness increases the risk of these family members acquiring HBV; therefore, it is important to raise awareness about HBV vaccination among family members of patients with HBV. This can be done through educational campaigns, public health interventions, and by providing access to vaccination services. Moreover, the study also found that more than 85% of children were vaccinated; this high coverage could be related to the effectiveness of the national infantile immunization program which has incorporated the HBV vaccine since 2002. This is further explained by the very low HBsAg positivity among the lower age group underscoring the need to sustain high vaccination coverage across the country. This will cut off HBV transmission within the family members and community at large.

Limitation

The study did not test antibody titer for those household contacts who received a full dose of vaccination to ensure immunity before they were excluded from HBsAg testing.

Conclusion

The study found that a significant proportion of male household contacts of HBV index cases in Mwanza, Tanzania were HBsAg positive. This suggests that preventive interventions should specifically target men. Moreover, the study also found that the majority of household contacts had poor to fair knowledge of HBV infection and that more than one-third were not vaccinated against HBV. There is a need to enhance awareness and education regarding HBV infection among household contacts to ensure that the majority of the contacts are fully vaccinated.

Declarations of competing interest

The authors have no competing interests to declare.

Funding

This study received no external funding. The article processing charges have been provided by the Catholic University of Health and Allied Sciences.

Ethics approval and consent to participate

Ethical clearance to carry out this study was sought from the joint Catholic University of Health and Allied Sciences/BMC Research Ethics and Review Committee (CREC), with a permit number CREC/686/2023. Permission to conduct the study was granted by the Regional Administrative Secretary's office with reference number GB47/333/03. All participants were informed about the study and its importance, and each was enrolled after signing a consent form. For the participants <18 years the guardians/parents provided informed consent to participate in the study. Confidentiality was maintained throughout. Positive cases and unvaccinated individuals were linked to respective health centers/hospitals offering the services. All data were treated as confidential.

Acknowledgment

The authors are grateful and acknowledge the support of the study participants and their families. The authors also are grateful to the members of the Department of Microbiology and Immunology and the Bugando Medical Centre for their support.

Author contributions

IM, MMM and SEM were involved in the conception and design of the study; IV, HN, DM, FH, FM, and HJ participated in the data collection; IM, MMM, SBK, and DM were involved in the data analysis and interpretation of the data; IM, MMM, and SEM drafted the paper; all authors revised it critically for intellectual content and provided the final approval of the version to be published.

Data availability of data and materials

All generated data are included in the manuscript, and they can be available upon request from the Director of Research and Innovation-CUHAS.

Consent to publish

Not applicable.

References

[1] Nguyen VTT, Law MG, Dore GJ. An enormous hepatitis B virus-related liver disease burden projected in Vietnam by 2025. *Liver Int* 2008;**28**:525–31. doi:10.1111/j.1478-3231.2007.01646.x.
[2] World Health Organization *Guidelines for the prevention care and treatment of persons with chronic hepatitis B infection: Mar-15*. Geneva: World Health Organization; 2015.
[3] World Health Organization *Hepatitis B virus infection 2023*; 2023. [accessed 9 September 2023] *https://www.who.int/news-room/fact-sheets/detail/hepatitis-b*.
[4] Schweitzer A, Horn J, Mikolajczyk RT, Krause G, Ott JJ. Estimations of worldwide prevalence of chronic hepatitis B virus infection: a systematic review of data published between 1965 and 2013. *Lancet* 2015;**386**:1546–55. doi:10.1016/S0140-6736(15)61412-X.
[5] GBD 2013 Mortality and Causes of Death CollaboratorsGlobal, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990–2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2015;**385**:117–71. doi:10.1016/S0140-6736(14)61682-2.
[6] Weinbaum CM, Mast EE, Ward JW. Recommendations for identification and public health management of persons with chronic hepatitis B virus infection. *Hepatology* 2009;**49**:S35–44. doi:10.1002/hep.22882.
[7] World Health Organization *WHO guidelines on hepatitis B and C testing*. Geneva: WHO; 2017.
[8] Al-Busafi SA, Al-Harthi R, Al-Naamani K, Al-Zuhaibi H, Priest P. Risk factors for hepatitis B virus transmission in oman. *Oman Med J* 2021;**36**:e287. doi:10.5001/omj.2021.99.
[9] Gunardi H, Iskandar MY, Turyadi Ie, Ie SI, Dwipoerwantoro PG, Gani RA, et al. Hepatitis B virus infection in children of HBV-related chronic liver disease patients: a study of intra-familial HBV transmission. *Hepatol Int* 2017;**11**:96–104. doi:10.1007/s12072-016-9764-z.
[10] Katamba C, Philippe OO. *Epidemiology of Hepatitis B Virus*. IntechOpen; 2021 *http://dx.doi.org/10.5772/intechopen.101097*.
[11] Muwanda F, Sendagire H, Mboowa G, Kateete DP, Achan B, Mupere E, et al. A systematic review reveals that African children of 15–17 years demonstrate low hepatitis B vaccine seroprotection rates. *Sci Rep* 2023;**13**:22182. doi:10.1038/s41598-023-49674-1.
[12] World Health Organization *Global hepatitis report 2017*. Geneva: World Health Organization; 2017.
[13] MOHCDGEC *National strategic plan for the control of viral load 2018/19–2022/3*. Kampala, Uganda: MOHCDGEC; 2018.
[14] Shi Y, Wu YH, Wu W, Zhang WJ, Yang J, Chen Z. Association between occult hepatitis B infection and the risk of hepatocellular carcinoma: a meta-analysis. *Liver Int* 2012;**32**:231–40. doi:10.1111/j.1478-3231.2011.02481.x.
[15] Kusi KA, van der Puije W, Asandem DA, Baba-Adam R, Agbevey H, Asare B, et al. World Hepatitis day 2021 -screening and vaccination against hepatitis B virus in Accra, Ghana. *BMC Public Health* 2023;**23**:1164. doi:10.1186/s12889-023-16108-6.
[16] Ferrante JM, Winston DG, Chen PH, de la Torre AN. Family physicians' knowledge and screening of chronic hepatitis and liver cancer. *Fam Med* 2008;**40**:345–51.
[17] Kwon SY, Lee CH. Epidemiology and prevention of hepatitis B virus infection. *Korean J Hepatol* 2011;**17**:87–95. doi:10.3350/kjhep.2011.17.2.87.
[18] Ministry of Health – Singapore *Tanzania HIV Impact Survey (THIS), 2016–2017*; 2016. [accessed 22 March 2023] https://phia.icap.columbia.edu/wp-content/uploads/2019/03/Tanzania-Final-Report.pdf

[19] Mirambo MM, Mbena PB, Mushi MF, Mtebe M, Moremi N, Seni J, et al. Prevalence of hepatitis B surface antigen among pregnant women attending antenatal clinic at Nyamagana District Hospital Mwanza, Tanzania. *Tanzania J Hlth Res* 2016;**18**:110327. doi:10.4314/thrb.v18i1.10.

[20] Geffert K, Maponga TG, Henerico S, Preiser W, Mongella S, Stich A, et al. Prevalence of chronic HBV infection in pregnant woman attending antenatal care in a tertiary hospital in Mwanza, Tanzania: a cross-sectional study. *BMC Infect Dis* 2020;**20**:395. doi:10.1186/s12879-020-05096-2.

[21] Mirambo MM, Ernest R, Allilah D, Mushi M, Mtebe M, Moremi N, et al. Treponema pallidum and hepatitis B virus co-infection among HIV infected patients in Mwanza city. *East Afr J Public Health* 2015;**12**:997–1000.

[22] Franklin S, Mouliom A, Sinkala E, Kanunga A, Helova A, Dionne-Odom J, et al. Hepatitis B virus contact disclosure and testing in Lusaka, Zambia: a mixed-methods study. *BMJ Open* 2018;**8**:e022522. doi:10.1136/bmjopen-2018-022522.

[23] Hatami H, Salehi M, Sanei E, Khosravi S, Alavian SM. Intra-familial transmission of hepatitis B virus infection in Zahedan. *Iran Red Crescent Med J* 2013;**15**:4–8. doi:10.5812/ircmj.2282.

[24] Ucmak H, Faruk Kokoglu OF, Celik M, Ergun UG. Intra-familial spread of hepatitis B virus infection in eastern Turkey. *Epidemiol Infect* 2007;**135**:1338–43. doi:10.1017/S0950268807008011.

[25] Allain JP, Owusu-Ofori S, Ye X, Bisseye C, Chaar ME, Li C. Hepatitis B virus chronic infection in blood donors from Asian and African high or medium prevalence areas: comparison according to sex. *Viruses* 2022;**14**:673. doi:10.3390/v14040673.

[26] Giefing-Kröll C, Berger P, Lepperdinger G, Grubeck-Loebenstein B. How sex and age affect immune responses, susceptibility to infections, and response to vaccination. *Aging Cell* 2015;**14**:309–21. doi:10.1111/acel.12326.

[27] Klein SL, Marriott I, Fish EN. Sex-based differences in immune function and responses to vaccination. *Trans R Soc Trop Med Hyg* 2015;**109**:9–15. doi:10.1093/trstmh/tru167.

[28] Ben-Alaya-Bouafif N, Bahri O, Chlif S, Bettaieb J, Toumi A, Bel Haj HNB, et al. Heterogeneity of hepatitis B transmission in Tunisia: risk factors for infection and chronic carriage before the introduction of a universal vaccine program. *Vaccine* 2010;**28**:3301–7. doi:10.1016/j.vaccine.2010.02.101.

[29] Mansour-Ghanaei F, Joukar F, Yaseri M, Soati F, Atrkar-Roushan Z. Intrafamilial spread of hepatitis B virus in Guilan Province-North of Iran. *Int J Mol Epidemiol Genet* 2013;**4**:250–7.