ASSESSMENT OF HBV BREAKTHROUGH INFECTION AND ANTI-HBS ANTIBODY DEVELOPMENT AMONG VACCINATED INDIVIDUALS ATTENDING SPECIALIST HOSPITAL SOKOTO

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ABSTRACT

Background: Hepatitis B virus (HBV) vaccination is a critical public health intervention aimed at preventing HBV infection. However, breakthrough infections can occur among vaccinated individuals, raising concerns about the longevity and efficacy of vaccine-induced immunity. This study aims to assess the incidence of HBV breakthrough infections and the development of anti-HBs antibodies among vaccinated individuals attending a specialist hospital in Sokoto.

Methodology: A cross-sectional study design was employed, involving 77 participants who received the complete HBV vaccination series. Blood samples were collected and analyzed using HBV profile test kits to analyses the different antibodies and antigen of hepatitis B in the blood of the participants. Participants' demographic data, vaccination history, and potential factors influencing immune response, such as age, sex, and underlying health conditions, were also collected.

Result: None of the participants had acute hepatitis B infection, but 6 (7.79%) were found to have chronic hepatitis B infection. Additionally, 6 (7.79%) had low viral replication, and 40 (51.95%) showed no evidence of immunity. Comparing the vaccination status based on sociodemographic factors, participants within the age bracket of 25-34 years had the highest vaccine protective immunity (51.7%), although no statistically significant difference was observed among different age groups P=1.012. In terms of gender, females (65.5%) had a higher vaccine protective immunity than males (34.5%), but not statistically significant. Furthermore, individuals with less than 5 years of vaccination history displayed higher protective vaccine immunity compared to those above 5 years but less than 10 years since vaccination. However, no statistically significant difference was observed with P *value*=1.001.

Conclusion: The study found that many individuals remain unprotected after vaccination, emphasizing the need to strengthen immunization programs. It also highlights the importance of monitoring post-vaccination immune status to identify those needing booster doses for long-term protection against HBV infection.

Keywords: Vaccinations, Immune status, Hepatitis B

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INTRODUCTION

Hepatitis is defined as inflammation of the liver which can result from assorted causes such as heavy alcohol usage, autoimmune illnesses, medications, or toxins however the most frequent cause of hepatitis is owing to a viral infection and is referred to as viral hepatitis (Mehta and Reddivari, 2022). The most widespread types of viral hepatitis consist of Hepatitis A, Hepatitis B, and Hepatitis C while the other types of viral hepatitis are hepatitis D and E which are less often encountered, hepatitis can be additionally classified into acute and chronic based on the duration of the inflammation to the liver (Mehta and Reddivari, 2022). If inflammation of the liver occur for less than 6 months, then it is termed as acute hepatitis and if it persists longer than 6 months it is termed as chronic hepatitis (Mehta and Reddivari, 2022). Initial symptoms are nonspecific and may include anorexia, nausea, vomiting, abdominal pain, jaundice and in instances of severe liver damage, patients can develop jaundice, hepatic encephalopathy, ascites, gastrointestinal bleeding secondary to esophageal varices, coagulopathy, or infections (Tripathi and Mousa, 2023). Hepatitis B virus (HBV) infection is a major global health problem leading to severe liver disease such as cirrhosis and hepatocellular carcinoma (HCC) (Song and Kim, 2016). Hepatitis B Virus is endemic in Nigeria and the overall pooled prevalence rate is 9.5% based on a systematic review in the year 2021 in Nigeria and Northwest Nigeria have a high prevalence of 12.1% among Nigeria's six geopolitical zones (Ajawon *et al*., 2021). Isa *et al*., (2014) found a prevalence rate of 14.0% among individuals attending specialist hospital Sokoto and `Erhabor *et al*., (2020) found a prevalence of 14.0% among pregnant women attending antenatal care clinic in specialist hospital Sokoto. Hepatitis B virus is often transmitted via body fluids like blood, semen, and vaginal secretions (HBV) (Tripathi and Mousa, 2023). The majority (more than 95%) of immunocompetent adults infected with HBV can clear the infection spontaneously but if left untreated, chronic HBV infection can progress to end-stage liver disease, such as liver cirrhosis and hepatocellular carcinoma (HCC) (Li *et al*., 2020). Vaccines by their very definition are biological agents that provoke an immune response to a particular antigen derived from a pathogen that causes infectious disease (Czochor and Turchick, 2014). Vaccination involves administering an antigenic substance to stimulate the immune system, guiding the evolution of adaptive immunity to a pathogen. So, vaccines can prevent or decrease morbidity from many infections (Kocourkova *et al*., 2017). Vaccination's core principle is inducing protection against a pathogen by replicating its natural communication with the human immune system (Canouï and Launay, 2019). Vaccine reduces the risk of complications and death after additional exposure to an infectious agent (Canouï and Launay, 2019). One important method to diminish the burden of this illness involves vaccination, prompt, and accurate diagnosis (Song and Kim, 2016). Serological markers for HBV infection include HBsAg, anti-HBs, HBeAg, anti-HBe, and anti-HBc IgM and IgG and recognizing these markers allows: identifying patients with HBV infection; clarifying the natural course of chronic hepatitis B (CHB); assessing the clinical stages of disease; and tracking antiviral remedy (CDC, 2011). HBsAg is the serological hallmark of HBV infection after an immediate exposure to HBV, HBsAg remains in serum within 1 to 10 weeks and continuation of this marker for over 6 months implies chronic HBV infection (Kao, 2008). According to WHO data published in 2020, hepatitis B deaths in Nigeria reaches 1,488 or 0.1% of the total deaths (WHO, 2020). Serological methods that detect serum levels of hepatitis B surface antigen (HBSag), hepatitis B surface antibody (HBab), hepatitis B envelope antigen (HBEag), hepatitis B envelope antibody (HBEab), and hepatitis B core antibody (HBCab) are available (Coffin *et al*., 2019).

Chronic hepatitis B virus (HBV) infection affects about 296 million people worldwide and is the leading etiology of cirrhosis and liver cancer globally. It has a prevalence of 9.5% in Nigeria, with the north-west region having the highest prevalence (12.1%) among Nigeria's six geopolitical zones/regions (Ajuwon *et al*., 2021; Hsu *et al*., 2023). Hepatitis B virus is a significant public health concern worldwide, including in Sokoto, Nigeria. This study assesses serological markers of hepatitis B virus in individuals who received a complete vaccination within the last ten years. The aim is to evaluate the vaccine's efficacy, long-term immunity, and the effectiveness of the vaccination program, while also identifying gaps in vaccine protection. This research provides valuable insights for optimizing vaccination strategies and public health interventions, into the need for additional interventions or booster doses among individuals attending specialist hospital Sokoto.

Scope and Limitation of The Study

The study focused on adults (males and females) who have history of receiving hepatitis B vaccine 10years and below, within the age bracket of 15 to 65years at Specialist Hospital Sokoto. The study was limited by covering only specialist hospital, Sokoto state, Nigeria.

MATERIALS AND METHODS

Study Design

This research is a hospital based cross-sectional study, and data was collected from a sample of 77 vaccinated individuals attending the specialist hospital in Sokoto. Blood samples was collected from participants and tested for hepatitis B infection markers, including HBsAg, anti-HBc, anti-HBs, HBeAg, and HBeAb. Demographic and clinical information, such as age, gender, vaccination history, and potential risk factors, was also collected through semi structured interviews.

Study Area

The study was conducted at the School of Medical Laboratory Sciences in collaboration with Specialist Hospital, Sokoto, Nigeria, a region characterized by extreme heat and an estimated population of 5.49 million as of 2022. The experimental analysis involved individuals who had received the hepatitis B vaccine within the last 10 years.

Sample Size Determination

Samples were collected from 77 individuals who have history of receiving hepatitis B vaccine, in specialist hospital Sokoto North-West Nigeria. The sample size was calculated using the standard formula for calculating minimum sample size using the formula.

$$n = \frac{z^2 p(1-p)}{d^2}$$

Where,

n = Minimum required sample size

z = Standard Normal deviation (1.96)

p = Population of success or prevalence (5.1% or 0.051) (Erhabor *et al*., 2020).

q = 1 – 0.051= 0.949

d = Precision tolerance margin of error (0.05)

$$n = \frac{(1.96)^2(0.051)(1-0.051)}{(0.05)^2}$$

n= 3.8416x 0.051 x 0.949/0.0025 = 74.37

77 samples were collected.

Study Population

The study comprised of 77 apparently healthy individuals with a history of receiving the HBV vaccine attending Specialist Hospital Sokoto. The Study included individuals who have a history of receiving the hepatitis B vaccine below 10 years both males and females, within the age bracket of 15 to 65 years who have consented and agreed to participate in the study in Specialist Hospital Sokoto, North-west Nigeria. The study excluded individuals without history of receiving the hepatitis B vaccine, those who do not complete the vaccination doses, and individuals outside the age bracket of 15 to 65years, those that have taken vaccines for more than 10 years and those that did not consent or agree to participate in the study.

Ethical Clearance and Informed Consent

The ethical clearance and permission to conduct the study was obtained from Ethics Committee of Specialist Hospital, Sokoto, Sokoto State. And informed consent was obtained from each of the participants after explaining to the participant plainly and clearly about the research.

Sample Collection and Handling

Three milliliters (3ml) of venous blood sample was collected aseptically using a sterile needle and vacutainer in an EDTA vacutainer tube via venipuncture from the recruited individuals, the tubes were centrifuged at 3000rpm for 10 minutes and plasma was obtained and stored at minus 20 degrees Celsius which was used to carry out Hepatitis B profile (HBV-5 Rapid test) serological Assay.

Laboratory Analysis

The samples were processed in immunology laboratory of School of Medical laboratory Science Usmanu Danfodiyo University Sokoto, and hepatitis B profile Serological tests was carried out on the samples using Royal care (China) Hepatitis B profile test kit.

Test Kit Preparation and Assay

The kits were brought to room temperature before use, the expiry date was checked on the foil pouch to ensure the kits components are within date. The HBV-5 Rapid Test is lateral flow chromatographic immunoassay consisting of 5 test panel strips assembled in one cassette. Each strip of the panel is composed of a sample pad, colloidal gold conjugate pad, nitrocellulose membrane (NC membrane) strip pre-coated with a control Line (C Line) and test Line (T Line), and absorbent pad. The HBsAg strip is an antibody-based sandwich immunoassay. The conjugate pad contains polyclonal anti-HBsAg antibodies conjugated with colloidal gold and the Nitrocellulose membrane is pre-coated with a monoclonal anti-HBsAg. When an adequate volume of test specimen is applied into the sample well of the strip, the test specimen migrates by capillary action across the test strip. HBsAg if present in the specimen will bind to the anti-HBsAg-gold conjugates. The immunocomplex is then captured on the membrane by the pre-coated anti-HBsAg antibody forming a burgundy-colored Test Line, indicating a HBsAg positive test result. Absence of the Test Line suggests a negative result. The HBeAg strip is also an antibody-based sandwich immunoassay. The test utilizes a pair of anti-HBeAg antibodies to detect HBeAg in the test specimen. A burgundy-colored Test Line indicates a HBeAg positive test result and absence of the Test Line suggests a negative result. The HBsAb strip is an antigen-based sandwich immunoassay: The conjugated pad contains HBsAg conjugated with colloidal gold and the Nitrocellulose membrane is pre-coated with unconjugated HBsAg. HBsAb if present in the patient specimen will bind to the HBsAg-gold conjugates. The immunocomplex is then captured on the membrane by the pre-coated HBsAg forming a burgundy-colored Test Line, indicating a HBsAb positive test result. Absence of the Test Line suggests a negative result. The HBeAb strip is a competitive immunoassay: The conjugate pad contains anti-HBe antibody conjugated with colloidal gold (HBeAb conjugates) and the Nitrocellulose membrane is precoated with HBeAg. If no HBeAb is present or its level in the specimen is below the test sensitivity, the HBeAb conjugates will have enough binding sites to bind to the HBeAg coated on the Nitrocellulose membrane, therefore forming HBeAb conjugates-HBeAg immunocomplex and leading to a burgundy-colored Test Line, indicating a negative result. If the level of HBeAb in the specimen is at or higher than the test sensitivity, it will bind to the HBeAg on the Nitrocellulose membrane preventing the binding of the HBeAb conjugates to the HBeAg. Therefore, absence of the Test Line indicates a positive test result.

The HBcAb strip is also a competitive immunoassay: The conjugate pad contains anti-HBc antibody conjugated with colloidal gold and the Nitrocellulose membrane is pre-coated with HBcAg. A burgundy-colored Test Line suggests a negative result and absence of the Test Line indicates a positive test result. All the panel strips have an internal quality control system consisting of a mouse IgG antibody conjugated with colloidal gold and a Nitrocellulose membrane pre-coated with goat anti-mouse IgG (Control Line). When an adequate volume of test specimen is applied into the sample well of the strip, a burgundy-colored Control Line should always be visible regardless of the color development on the Test Line. If the Control Line does not develop in a panel, the test result is invalid, and the specimen must be retested with another device. An invalid result in one panel does not invalidate the test result in the other panel. The plasma samples and test kits were brought to room temperature prior to assay and the pouch was opened at the notch, the device was removed, the test device placed on a clean flat surface and the device was labelled with sample Identification number. Holding the dropper vertically, 2drops of the plasma sample were dispensed into each of the sample wells avoiding air bubbles, timer was started, and results read in 15 minutes.

Statistics Analysis

The data collected was analyzed using statistical software package for social science (SPSS) version 29.0.2.0 (20) and the results obtained were presented in tables in the form of percentage and frequencies using descriptive statistics. The age, gender, vaccine duration and other socio-demographic details of all the participants were collected using a questionnaire. The statistical significance was assessed using the Chi-square test, and a p-value of less than 0.05 was considered to indicate statistical significance.

RESULTS

Out of 77 participants tested, 29(37.66%) tested positive to HBsAb only, indicating immunity due to vaccination, 2(2.59%) tested positive to HBsAb and HBcAb thus indicating Natural immunity, no participant tested positive to HBsAg with IgM Anti-HBc or with HBeAg markers indicating lack of acute hepatitis B infection 0(0%), 6(7.79%) tested positive to HBsAg alongside HBcAb (IgG), indicating chronic hepatitis B infection, 0(0%) tested positive to HBeAg indicating lack of active viral replication in all the tested positive participants, 6(7.79%) tested positive to HBsAg, HBcAb without HBeAg which indicated low viral replication in these participants and 40(51.95%) tested negative to all the markers (HBsAg, HBsAb, HBeAg, HBeAb, HbcAb) indicating no evidence of immunity or infection. No statistically significant difference in the immune status of the participants was observed (*p*-value 0.087). This study further indicated the proportion of individuals with protective natural immunity (individuals who reacted positive to HBsAb and HBcAb) 2(2.59%) and immunity due to vaccination (Individuals who reacted positive to HBsAb only) 29(37.66%). The immune status of hepatitis B vaccinated individuals was further compared based on sociodemographic factors. The immune status of participants was compared based on age group (years), in which participants within the age bracket of 25-34 years has highest vaccine protective immunity of (51.7%) however there was no statistically significant difference in the ages of the vaccinated participants (*P*-value 0.265). The immune status of hepatitis B vaccinated individuals was also compared based gender in which females (65.5%) have more higher vaccine protective immunity than males (34.5%). There is no statistically significant difference in the gender of participants (*p* value=0.657).

The immune status of hepatitis B vaccinated individuals was compared based on years since vaccination (duration). Individuals with < 5years of vaccination history (65.5%) has higher protective vaccine immunity than those <10years since vaccination. However, there is no statistically significant difference in the years since vaccination of the participants (*P*-value = 0.657).

Table 1: Shows the immune status of hepatitis B vaccinated individuals attending specialist hospital Sokoto.

Category	Frequency (77)	Percentage (100%)
Immunity due to vaccination	29	37.66%
Natural Immunity	2	2.59%
Acute hepatitis B infection	0	0%
Chronic hepatitis B infection	6	7.79%
Active viral replication	0	0%
Non-immune	40	51.95%
Chi-square value		2.922
P-value		0.087

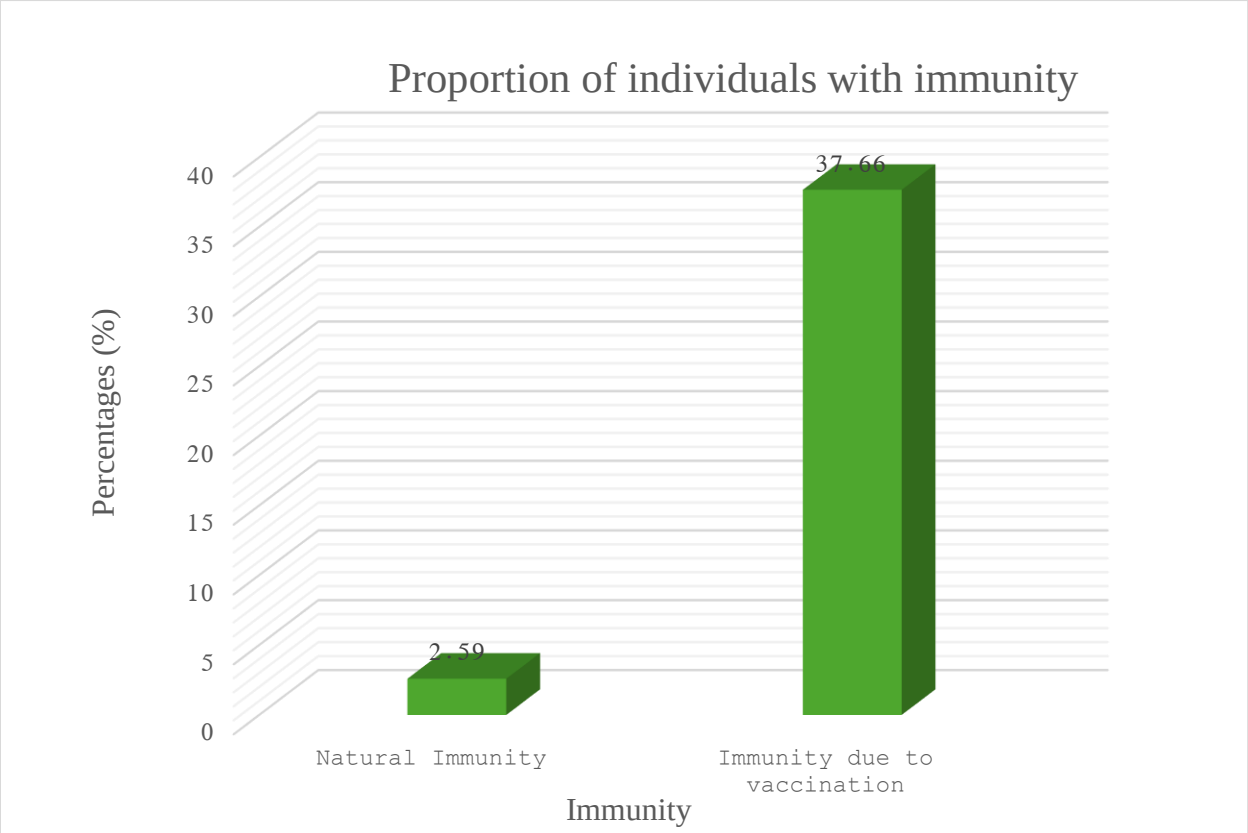

Figure 1: Shows the proportion of individuals with immunity due to vaccination and natural immunity.

Table 2: Shows the immune status of hepatitis B vaccinated individuals based on age.

Variables	**Vaccination status**	
Age groups	Natural Immunity	Immunity due to vaccination
15-24	2(100%)	7(24.1%)
25-34	0(0%)	15(51.7%)
35-44	0(0%)	3(10.3%)
45-54	0(0%)	1(3.4%)
55-64	0(0%)	3(10.3%)
Total	31	
Chi-square value	5.226	
P-value	0.265	

Table 3: Shows the immune status of hepatitis B vaccinated individuals based on gender.

Variables	**Vaccination status**	
Gender	Natural Immunity	Immunity due to vaccination
Male	1(50%)	10(34.5%)
Female	1(50%)	19(65.5%)
Total	31	
X^2-value	0.197	
P-value	0.657	

Table 4: Shows the vaccination status of hepatitis B vaccinated individuals based on years since vaccination.

Variables	**Vaccination status**	
Age groups	Natural Immunity	Immunity due to vaccination
15-24	2(100%)	7(24.1%)
25-34	0(0%)	15(51.7%)
35-44	0(0%)	3(10.3%)
45-54	0(0%)	1(3.4%)
55-64	0(0%)	3(10.3%)
Total	31	
Chi-square value	5.226	
p-value	0.265	
Variables	**Vaccination status**	
Time since vaccination (Duration)	Natural Immunity	Immunity due to vaccination
<5 years	1(50%)	19(65.5%)
< 10years	1(50%)	10(34.5%)
Total	31	
Chi-square value	0.197	
p-value	0.657	

DISCUSSION

Hepatitis B viral infection is a disease that can be prevented through vaccination (Chitnis and Wong, 2022). The gold standard for determining vaccination status is the presence of three doses of hepatitis B vaccine on the vaccination card (Nobrega *et al*., 2016). However, in this study, out of the total of 77 participants, only few had documented evidence of receiving the complete three doses of the hepatitis B vaccine, while the remaining provided verbal confirmation of receiving the complete doses during an oral interview. Out of 77 participants tested 29(37.66%) have Immunity due to vaccination, 2(2.59%) has Natural Immunity, 0(0%) has acute hepatitis B infection, 6(7.79%) has Chronic hepatitis B infection, 0(0%) has active viral replication, and 40(51.95%) has no evidence of immunity. This 7.79% findings of chronic hepatitis B infection among hepatitis B vaccinated individuals that is worrisome agrees with the findings of Amaral *et al*, 2019 who reported a higher percentage of 8.2% among hepatitis B vaccinated community health workers in the Midwest region of Brazil (Amiral *et al*., 2023). It also agrees with study of Castro *et al*, 2023who reported a slightly higher rate of 11.8% among vaccinated children and adolescents in northern Brazil (Castro *et al*., 2023). This could be because HBV is hyper endemic in those regions and some of these individuals work in health-related settings where they encounter infected body fluids or have had previous blood transfusions. It could also be attributed to individuals already being infected and in the window period, which may be a result of errors from pre-vaccination testing as most vaccination centers use only one strip HBsAg test strip, which is less sensitive in detecting HBsAg compared to methods like enzyme-Linked immunosorbent assay. However, it is worth noting that the percentage rate of chronic hepatitis B in this study is lower than the earlier reported rate of hepatitis B infection of 14% among individuals attending specialist hospital in Sokoto, Nigeria (Isa *et al*., 2014). This study is however in disagreement when compared to that of Thomas *et al*, who reported a low rate of 2% among a group of vaccinated individuals in Bauchi, Nigeria (Thomas *et al*., 2021). Additionally, Olusanya *et al*, found a lower rate of 1.3% among vaccinated children in midwestern Nigeria (Odusanya *et al*., 2005). And a rate 4.2% among vaccinated children in Ethiopia was also found (Adugna *et al*., 2023). These low percentage rates can be attributed to successful immunization efforts in those areas. One of the interesting things in this study is that none of the participants has active viral replication which indicates lower risk of transmission within the hepatitis B vaccinated individuals. This study also indicated a lower percentage rate of 37.66% of individuals with protective immunity due to vaccination which is alarming when compared to other studies. This however agrees with the research findings of Castro *et al*, who reported a similar rate 38.9% in children and adolescents in northeastern Brazil (Castro *et al*., 2023). Similar results were also found in a study conducted among hepatitis B vaccinated hemodialysis patients in Iran, where 39.71% was reported (Khamene and Sepehrvand, 2007). The lower rates in this study might be because of the qualitative method (Rapid diagnostic test kit) used in this study which has a detection limit of 20UI and is less sensitive than other methods such as Enzyme-Linked immunosorbent assay (ELISA) method. It is possible that the antibodies of many participants in this study may have declined below the detection limit of the test kit. This decline in antibody levels could be influenced by factors such as improper storage conditions and the lack of proper cold chain transportation, which may have rendered the vaccines less effective in inducing immune responses. The high environmental temperature in Sokoto state could have also affected the potency of the vaccines.

The lack of post-vaccination testing and other factors such as smoking, body mass index, and time intervals between vaccine doses may also have influenced the response to the hepatitis B vaccine of the participants of this study. These findings in this study disagree with the results of Olumuyiwa *et al*., who found higher percentage rates of 84.6% in a rural area in Nigeria, and other studies 93.30% among teenagers aged <20 years in eastern China, and 86.1% among healthcare workers in Jos, Nigeria (Odusanya *et al*., 2011; Abba *et al*., 2014 Huang *et al*., 2015;). The higher rates of hepatitis B vaccine immunity in such areas could be attributed to factors such as proper pre-vaccination testing, appropriate storage conditions for vaccines, potent vaccines, and adherence to immunization schedules. This study also indicated the proportion of individuals with natural immunity and hepatitis B vaccine induced immunity in which participants with immunity due to vaccination (37.66%) are more than those with immunity due to natural hepatitis B infection (2.59%). This finding aligns with the evidence from a study, which reported long-term immune protection from the hepatitis B vaccine among individuals vaccinated as children and young adults (Ocan *et al*., 2022). Moreover, the relevance of vaccination-induced immunity is further supported by the work of Safdar *et al*, who demonstrated that population-level herd immunity can be achieved through a vaccination-boosting strategy, emphasizing the significance of vaccine-derived protective efficacy in achieving herd immunity (Safdar *et al*., 2022). This can be attributed to successful immunization in those participants. The results of this study further assess the vaccination status of hepatitis B vaccinated individuals based on sociodemographic factors. The percentage rate of individuals with immunity due to vaccination among different age groups indicated that participants within the age range of 25-34years had the highest rate of vaccine induced immunity (p-value >0.05). These findings agree with that of Ocan et al who reported a higher rate among individuals aged 26-35years than other age groups (Ocan *et al.,* 2022). Similarly, Sharma *et al* reported highest rates among vaccinated individuals aged 20-35 (Sharma et al., 2019). The rates also agree with that of Mwangi *et al* who indicated highest rates among vaccinated participants aged 26-35years (Mwangi *et al.,* 2023). This might be because participants within this age group are good responders, their immune status is not yet weak as the elderly, and it might be that more individuals within this age group participated in this study. This however disagrees with the study who reported more higher rates among vaccinated participants aged ≥50years than other age groups (Abba *et al*., 2014). And that of da Cunha Rosa *et al.,* who reported higher rates among vaccinated individuals aged 60-97years old than the other age ranges (da Cunha Rosa *et al*., 2023). This might be due to proper vaccination and adherence to immunization schedules. This study also assessed the vaccination status of hepatitis B vaccinated individuals based on gender. The rate of individuals with immunity due to vaccination by gender was higher among females than males but was not gender dependent. These findings agree with the studies of Ocan *et al.,* among hepatitis B vaccinated healthcare workers in northern Uganda, Mwangi *et al*., among vaccinated healthcare workers in a selected hospital in Kenya, and Abba *et al*., among vaccinated healthcare workers in Jos, Nigeria (Abba *et al*., 2014; Ocan *et al*., 2022; Mwangi *et al*., 2023). The higher rates in females could be attributed to their active participation in immunization activities compared to males. However, this study disagrees with the result of Tsaneva-Damyanova *et al*, who reported higher vaccine induced immunity in males, than females (Tsaneva-Damyanova *et al*., 2019). This might be because more males were recruited in the study than females. It might be also because males in such areas have proper and sound knowledge on the importance of hepatitis B vaccination than females.

The vaccination status of hepatitis B vaccinated individuals was further assessed based on years since vaccination. This study showed that participants who have been vaccinated <5years have higher vaccine induced immunity than those <10years ago. These findings agree with the study conducted by Sahana *et al.,* who showed higher percentage rates of vaccine induced immunity in participants with ≤5years vaccination history than those with 6-10years and >10years vaccination history (Sahana *et al.,* 2017). Studies have shown that anti-HBs levels decrease by up to 55% after 5 years of vaccination (Chen *et al*., 2007). This is because antibodies decline as age of vaccination increases. However, several studies have report that hepatitis B vaccine-induced immunity can persist for up to 15-20 years (Leuridan and Van Damme, 2011; Pileggi *et al*., 2017). The reason for that might be due to the high level of antibody productions in such participants thus making the immunity persist for longer periods in healthy individuals. It is important to acknowledge the limitations of this study, such as small sample size and potential selection bias, which may limit the generalizability of the findings. Further research on a larger scale is necessary to validate and expand upon these results.

CONCLUSION

This study demonstrates that a large proportion of hepatitis B vaccinated individuals have inadequate immunity. Factors such as age, gender, and duration since vaccination do not significantly impact immune status. Further research is needed to understand the underlying reasons and improve vaccine effectiveness. Public health interventions should focus on enhancing vaccine coverage and surveillance to prevent chronic hepatitis B infection.

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