Websites:
http://www.nbmedicine.org
http://www.sciencepub.net/nurse

Emails:
editor@sciencepub.net
nbmeditor@gmail.com

Biomedicine and Nursing

MARSLAND PRESS
Multidisciplinary Academic Journal Publisher

Serological Prevalence of Malaria and Hepatitis coinfection among HIV-Infected Patients presenting at a Tertiary Hospital in Port Harcourt, Rivers State, Nigeria

Okonko IO, Jerry GA, Baeka GB, Okonko BJ

[1]Virus & Genomics Research Unit, Department of Microbiology, University of Port Harcourt, Port Harcourt, Nigeria
[2]Virology & Immunology Research Unit, Department of Applied Microbiology, Ebonyi State University, Abakaliki, Nigeria
[3]Virology Research Unit, Department of Microbiology, Rivers State University, Nkpolu Oroworukwo, mile 3, Port Harcourt, Nigeria
E-mail: iheanyi.okonko@uniport.edu.ng; Tel: +2347069697309

ABSTRACT: Hepatitis B virus (HBV) and *Plasmodium falciparum* are two of developing nations' most prevalent infectious illnesses. This study sought to ascertain the incidence of Plasmodium falciparum and HBV coinfection in HIV-positive individuals in locations where both diseases are widespread and to evaluate the risk factors associated with this coinfection, which could then be used to track the disease's trajectory. HIV-positive individuals who visited the River State University Teaching Hospital (RSUTH) in Port Harcourt, Nigeria, had blood samples taken. Hepatitis B surface antigen (HBsAg) and malaria *Plasmodium falciparum* serological prevalence were examined in these samples. Malaria was not a problem for any of the patients. However, 3.0% did have HBsAg, and 97.0% had HIV mono-infection. Hepatitis B seroprevalence was highest in age groups 31 to 40, where it was 5.3%, and lowest in age groups 41 to 50, where it was 2.9%. There was no hepatitis seroprevalence in the other age groups. HBV was more common in females (3.6%) than males (2.2%). This study found that those with HIV were substantially more likely to also have HBV infection (3.0%), and vice versa, among HIV-infected patients in Port Harcourt, Nigeria, with a seroprevalence of 0.0% for malaria and malaria/HBV coinfection. The results of the current study confirmed the zero coinfection of HBV and *Plasmodium falciparum*. The absence of malaria *Plasmodium falciparum* and low HBV rates (3.1%) could be attributed to increased public awareness in the area. Though *Plasmodium falciparum* was absent, the results of the current study showed that HBV is seroprevalent, which will aid in understanding coinfection and developing treatment plans. To recognise the dual burden of these two illnesses, control *Plasmodium* spp. parasites and the healthcare communities regularly administering HBV immunisations can benefit from the study's findings. Further research examining the relationship between *Plasmodium falciparum* and HBV is advised.
[Okonko IO, Jerry GA, Baeka GB, Okonko BJ. (2023). **Serological Prevalence of Malaria and Hepatitis coinfection among HIV-Infected Patients presenting at a Tertiary Hospital in Port Harcourt, Rivers State, Nigeria**. *Biomedicine and Nursing* 2023; 9(1):1-12]. ISSN 2379-8211 (print); ISSN 2379-8203 (online). http://www.nbmedicine.org. 01. doi:10.7537/marsbnj090123.01.

Keywords: Coinfection, HBV, Malaria, mono-infection, *Plasmodium falciparum*, Nigeria

INTRODUCTION

Malaria is a life-threatening disease caused by parasites protozoan parasites of blood-*Plasmodium species* that are transmitted to people through the bites of infected female Anopheles mosquitoes (WHO, 2022). Protozoan parasites of the blood-Plasmodium species, responsible for the potentially fatal malaria, infect people by biting them with their female Anopheles mosquito hosts (WHO, 2022). It can be avoided and treated. Almost half of the world's population was susceptible to malaria in 2021. (WHO, 2022). The simultaneous infection of a host by several pathogenic species—which may or may not coexist—is known as coinfection. Most coinfections are spread by bodily fluids (saliva, blood, sweat, among others). Hepatitis B Virus (HBV) and malaria coinfections pose a severe hazard to public health in endemic nations in tropical and sub-Saharan Africa (Omatola & Okolo, 2021).

Malaria continues to be a worldwide public health concern (Omatola & Okolo, 2021). Almost 3.2 billion individuals (41.0 per cent of the world's population), according to the most recent estimates from the World Health Organization (WHO), continue to be exposed to this disease (Scotto & Fazio, 2018). According to a 2020 world health report, malaria caused 409 000 deaths and 229 million illnesses worldwide (WHO, 2020a). In 2021, there were 247 million malaria cases, up from 245 million cases in 2020, according to the

most recent Global Malaria Report (WHO, 2022). In 2021, 619 000 malaria fatalities were anticipated, down from 625 000 in 2020 (WHO, 2022). Most malaria cases are found in sub-Saharan African nations and India, accounting for 85.0% of the disease's global burden (Omatola & Okolo, 2021). Globally, Nigeria leads the six nations that collectively accounted for more than half of all malaria cases with a total of 27.0% of cases, followed by the Democratic Republic of the Congo (12.0%), Uganda (5.0%), Mozambique (4.0%), Côte d'Ivoire, Angola, and Niger (3.0% apiece) (WHO, 2020a; Omatola & Okolo, 2021).

Plasmodium falciparum, *Plasmodium vivax*, *Plasmodium ovale*, *Plasmodium malariae*, and *Plasmodium knowlesi* are the five *Plasmodium* species can infect humans and cause malaria (Singh et al., 2004). Among these, *P. falciparum* and *P. vivax* offer the most significant threat (WHO, 2022). The most dangerous and common malaria parasite on the African continent is *P. falciparum*, while the most common malaria parasite outside of sub-Saharan Africa is *P. vivax* (WHO, 2022). Malaria is spread by being bitten by an infected female Anopheles mosquito (WHO, 2019a).

People worldwide continue to experience an endemic level of malaria, particularly in the WHO South-East Asia and African regions (2018). The most recent Global Malaria Report estimates 228 million malaria cases in 2019, with an estimated 405,000 deaths, most of whom were children under five (67.0%) (WHO, 2019b). The six African nations of Nigeria (25.0%), the Democratic Republic of the Congo (12.0%), Uganda (5.0%), Côte d'Ivoire (4.0%), Mozambique (4.0%) and Niger (4.0%) recorded the majority of malaria cases (WHO, 2019b).

Sub-Saharan Africa accounts for most malaria cases (88%) with South-East Asia, Central America, and South America following (WHO, 2015). Several infectious diseases, such as hepatitis B virus (HBV) and human immunodeficiency virus (HIV) infections, are endemic infections in these nations. As a result, despite having different transmission modes, malaria and HBV are prevalent in several places, primarily in SSA (Aernan et al., 2011). In 2015, an estimated 257 million people were living with chronic HBV infection worldwide, with the majority of cases occurring in the WHO African Area and the Western Pacific Region (WHO, 2017). Following the introduction of the hepatitis B vaccination in 2015, there was a decrease in the prevalence of HBV among children to 1.3% (WHO, 2017).

The most common cause of avoidable liver illness and mortality worldwide is hepatitis B (HBV) (Omatola et al., 2020a,b; WHO, 2020b). With a global annual death rate estimated at 887 000, HBV was to blame for over 257 million carrier cases, including active and inactive chronic forms (WHO, 2020b). According to the Ministry of Health, HBV infection has become the leading silent killer in Nigeria with a national prevalence of 11.0% in 2018 (Omatola & Okolo, 2021). This observation is because more than half of the population has never been tested and is not exhibiting symptoms, making it impossible to detect the virus (Abutu, 2018). According to the 2020 World Health Report, around 20 million people in Nigeria have HBV (WHO, 2020c). Exposure to infectious blood or blood products or percutaneous exposure to sharp contamination increases the risk of viral transmission in the nation (Omatola et al., 2020a,b).

Hepatitis B virus (HBV) and HIV coinfection are widespread, with 70.0% to 90.0% of HIV-infected people in the United States showing signs of prior or current HBV infection (Chun et al., 2014). Even though>90% of immunocompetent people spontaneously eliminate adult-onset HBV, HIV-infected people have a 50% lower chance of doing so than HIV-uninfected people. Thus, chronic HBV infection occurs ten times higher than the general population in 5–10% of HIV-infected people exposed to HBV (Rajbhandri et al., 2016; Crowell et al., 2015). Men who have sex with other men (MSM) and injectable drug users have the most significant incidence of HIV/HBV coinfection in the United States. In contrast, the prevalence of HBV among people living with HIV is higher in Asia and sub-Saharan Africa, where vertical and early childhood exposure are the most frequent means of transmission, respectively, and overall HBV prevalence is high. This prevalence ranges from 20 to 30%. (Coffin et al., 2013).

In impoverished nations where both infectious illnesses are endemic, HIV-related malaria and HBV coinfection may constitute a severe public health issue (Kotepui & Kotepui, 2020). While having separate modes of transmission, the geographical coincidence or overlapping endemicity of both illnesses makes residents of the endemic zone more susceptible to coinfection (Kotepui & Kotepui, 2020). Only some research has been done on malaria/HBV coinfection, and those that have primarily focused on the epidemiological aspects. The interactions between the two pathogens, malaria and HBV (symptomatic or asymptomatic illness), are still little understood. Recently, it has been proposed that the co-occurrence of infections may influence the advancement of HBV

infection and be linked to the natural history of both diseases because these two infections share some of their developmental stages within the liver (Braga et al., 2005).

Due to their geographic coincidence, *Plasmodium* spp. and HBV infections are prone to co-infect people living in the same places where they are both endemic (Andrade et al., 2011; Freimanis et al., 2012; Kotepui & Kotepui, 2020). Both infections use the liver as their host during the developmental phases in people with *Plasmodium* spp. and HBV coinfection, which can cause liver damage and increase mortality and morbidity (Aernan et al., 2011). An earlier study showed that HBV infections could decrease the liver's capacity to eradicate *Plasmodium* parasites (Thursz et al., 1995; Aernan et al., 2011). *P. falciparum* modulates HBV viremia in individuals with chronic HBV infection, according to a study in patients with *Plasmodium* spp. and HBV coinfection (Brown et al., 1992). Although the overall risk of death was not noticeably greater in patients with concurrent HBV and P. falciparum malaria infections, a study from Asia suggested that chronic HBV infection may cause *P. falciparum* malaria to multiply synergistically (Barcus et al., 2002). While a prior study showed that Plasmodium and HBV coinfection dramatically increased the density of malaria parasites (Cruz et al., 2019), a subsequent study suggested that HBV infection may reduce the density of *Plasmodium* parasites in malaria patients without organ failure (Andrade et al., 2011).

Given this context, accurate estimates of the prevalence of HIV/HBV/Malaria coinfection are necessary to guide evidence-based policy decisions (such as scaling up screening programs). Resource allocation, as well as positively impacting general prevention and treatment strategies for HBV/HIV/Malaria coinfection, especially regarding the use of highly active antiretroviral therapy (HAART) agents that also possess the anti-HBV activity and its attendant symptoms (Afolabi et al., 2018). This study aims to determine the serological prevalence of *Plasmodium falciparum* and HBV coinfection among HIV-positive patients who visit the River State University Teaching Hospital (RSUTH) in Port Harcourt, Rivers State, Nigeria. This information will then be used to track the disease's progression.

2. MATERIALS AND METHODS

2.1. Study area

The study was conducted by enrolling HIV-infected patients presenting at the Retroviral clinic of the Rivers State Teaching Hospital (UPTH) in Port Harcourt, Rivers State, South-South Nigeria. As the sole major metropolis in the state, Port Harcourt City is very crowded. Eight local governments comprise the Greater Port Harcourt urban region, including the local governments of Port Harcourt, Okirika, Obio/Akpor, Ikwerre, Oyigbo, Ogu/Bolo, Tai, and Eleme. The climate in Port Harcourt is tropical monsoon, with long, intense rainy seasons and brief dry seasons (Afolabi et al., 2018). In the city, only December and January fall under the category of the dry season. Port Harcourt experiences less of the harmattan, which impacts many West African towns due to its meteorological characteristics. With an average rainfall of 370 mm, September is the wettest month in Port Harcourt. With an average annual rainfall of 20 mm, December is typically the driest month of the year. The city experiences very stable temperatures throughout the year with little seasonal change. The usual range of temperatures in the city is between 25 to 28 degrees Celsius.

2.2. Study Design

A hospital-based cross-sectional survey design was adopted for the present study. The study involves the collection of blood samples from HIV-infected patients presenting at the Retroviral clinic of the Rivers State Teaching Hospital (RSUTH) in Port Harcourt, Rivers State and analysing the samples for the serological prevalence of malaria and hepatitis amongst HIV-infected patients using RDTs and ELISA kits.

2.3. Subject/Setting

A population of 100 subjects, including HIV-infected individuals, were enrolled for this prospective study. The serological analysis was conducted at the Virus and Genomics Research Unit of the Department of Microbiology, University of Port Harcourt, Port Harcourt, Rivers State, South-South Nigeria and was limited to HIV-infected patients accessing Rivers State University Teaching Hospital (RSUTH). The occurrence of malaria *Plasmodium falciparum* and HBV in HIV-infected patients was investigated using RDTs and ELISA kits, respectively. An informed constant was obtained from all participants.

2.4. Blood Collection

A specimen of 5ml venous blood was aseptically extracted from the participating subjects and placed into sterile EDTA tubes. An EDTA container was filled with blood. Samples were explicitly identified using codes. The plasma was separated by centrifugation from the haemolysed and hyperlipemia samples, which were discarded because they might produce erroneous results. Samples that cannot be promptly analysed are kept at 2-8°C until ready for use.

2.5. Preparation of Specimen

Plasma or serum was prepared using conventional procedures for sample preparation for clinical laboratory analysis after blood was taken aseptically by venipuncture. Samples that were hemolysed ("red") or hyperlipemic ("milky") were rejected because they would produce inaccurate results. Samples with fibrin residue, heavy particles, microbial filaments, or bodies were eliminated because they might produce erroneous results. After collection, sera and plasma were kept at +2° to 8°C for up to five days. Centrifugation at 2,000 rpm for 20 minutes if there were any particles. Samples were frozen at -20°C for several months for longer storage times.

2.6. Serological Analysis of Malaria *Plasmodium falciparum* Antigen

A malaria test was conducted on each of the already known HIV samples collected from Rivers State University Teaching Hospital using the procedure stated in the test kit. One to 2 drops of the separated plasma were added to the test well of the test kit and 2-3 drops of the diluent were added to the well. The kit was allowed to stand for about 10 minutes, and the result was recorded. A single line at the control indicates a negative result. A double line with one line at the test line and one at the control line indicates a positive result, while no line on the kit indicates a false result.

2.7 Serological Analysis of Hepatitis B Surface Antigen (HBsAg)

Serum samples were analysed for Hepatitis B Virus surface antigens (HBsAg) using rapid diagnostic kits. ELISA test was also used and performed according to the manufacturer's instructions. Serum samples were analysed *in vitro* for HBsAg using DIA's Enzyme-Linked Immunosorbent Assay (ELISA) kit. PRO Diagnostic Bioprobes, (Milano) Italy. The Elisa test and interpretation of results were made according to the manufacturer's instructions.

2.8 Data Analysis

The data were recorded and analysed using a Microsoft Excel spreadsheet (Microsoft Corporation). Data were analysed using the Statistical Package for Social Science (SPSS) version 22.0. The seroprevalence was calculated as the number of serologically positive samples divided by the total number of samples tested**.** The serological prevalence for *Plasmodium falciparum* and HBV coinfection was expressed as a percentage. Chi-square or Fisher's exact was used where appropriate to test association. A p-value of <0.05 was considered significant.

3. RESULTS

3.1 Patients characteristics

The total number of populations included in this study was 100. The demographic data for these populations were stratified into age bracket and sex. The age ranged from 9 to 87 years. Fifty-five per cent (55.0%) were females, and 45.0% were males (Table 1).

3.2 Overall Prevalence

The prevalence of hepatitis B virus and malaria *Plasmodium falciparum* was done, and none (0.0%) of the patients had malaria, but 3.0% of the total population tested positive for HBV. In comparison, 97.0% tested negative for HBV. Ninety-seven per cent had HIV infection only (Table 1).

Table 1: Overall Seroprevalence of Malaria and HBV among HIV-Infected Patients in a Tertiary Hospital in Port Harcourt, Nigeria

Test	Method	No. Tested	Positive (%)	Negative (%)
Malaria	RDT	100	0 (0.0)	100 (100.0)
HBV	ELISA	100	3 (3.0)	97 (97.0)
Malaria/HBV coinfection	RDT/ELISA	100	0 (0.0)	100 (100.0)
HIV only	ELISA	100	97 (97.0)	3 (3.0)

3.3 Age-Related Prevalence of HBV

A higher age-related prevalence of HBV occurred among age groups 31- 40 years (5.3%) than other age groups, which were 2.9% for $\geq$41 years and 0.0% for $\leq$30 age groups (Table 2). These age differences were not statistically significant ($p = 0.46$), as shown in Table 2.

3.4 Sex-Related Prevalence of HBV

Among Genders, females had a higher prevalence of HBV (3.6%) than their male counterparts (2.2%), as shown in Table 2. These sex differences were not statistically significant ($p = 0.68$), as shown in Table 2.

Table 2: Age- and Sex-Related Prevalence of HBV among HIV-Infected Patients in a Tertiary Hospital in Port Harcourt, Nigeria

Variables	Number Tested	HBV Positive (%)	Chi-square Analysis
Age groups (years)			
≤30	28	0 (0.0)	P = 0.46
31-40	38	2 (5.3)	
≥ 41	34	1 (2.9)	
Sex			
Females	55	2 (3.6)	P = 0.68
Males	45	1 (2.2)	
Total	**100**	**3 (3.0)**	

4. DISCUSSION

In endemic countries, diagnosing, preventing, and controlling *Plasmodium* spp. and HBV coinfection may be easier with a better understanding of the general incidence of Plasmodium spp. and HBV coinfection and the relevant risk factors in infected persons. To investigate the impacts of demographic profiles, including age and gender, on the risks of Plasmodium spp. and HBV coinfection, the current study used an ELISA method approach to synthesise the data regarding *Plasmodium* spp. and HBV coinfection. Prior research has been done in Nigeria (Aernan et al., 2011; Omalu et al., 2012; Adeleke et al., 2013a,b; Dabo et al., 2015; Oyeyemi & Amugo, 2015; Sharif et al., 2016; Yohanna et al., 2016; Afolabi et al., 2018; Kolawole & Kana, 2018; Wokem & Amacree, 2018; Abah, 2019; Abah et al., 2019). Earlier research revealed that estimates of the prevalence of *Plasmodium* spp. and HBV coinfection ranged substantially, from 1.0 to 41.0%. According to Aernan et al. (2011), most (41.0%) of *Plasmodium* spp. and HBV coinfections were detected among Nigerian blood donors. *Plasmodium* spp. and HBV coinfection were estimated to be present in 6.0% of the population (Kotepui & Kotepui, 2020).

Of the 100 patients enrolled in Rivers State University Teaching Hospital (RSUTH) in this study, 3.0% tested positive for hepatitis B, while none tested positive for malaria. Thus, the study's malaria and HBV coinfection rate is 0.0%. In a semiurban community in north-central Nigeria, HBV mono-infection and HBV/*Plasmodium falciparum* coinfection were reported to occur at rates of 2.5% and 0.5%, respectively (Omatola & Okolo, 2021). Also, it supports research from Afolabi and Bakare (2022) who found 3.8% of Akure, Nigerians have HBV mono-infection. In contrast to the current study, coinfection with Plasmodium spp. and HBV was common in most tropical and sub-Saharan African countries, especially Nigeria (Aernan et al., 2011; Omalu et al., 2012; Adeleke et al., 2013a,b; Dabo et al., 2015; Oyeyemi & Amugo, 2015; Sharif et al., 2016; Yohanna et al., 2016; Afolabi et al., 2018; Kolawole & Kana, 2018; Wokem & Amacree, 2018; Abah, 2019; Abah et al., 2019), Ghana (Freimanis et al., 2012; Helegbe et al., 2018; Anabire et al., 2019a,b), Central African Republic (Gadia et al., 2017), and The Gambia (Thursz et al., 1995).

This lack of malaria parasites and the low HBV infection incidence (3.0%) could be attributed to increased public awareness in the area. The significant seasonal, interannual, and geographical variability among the research locations may be a feasible explanation for these variances (Omatola & Okolo, 2021). The population of Port Harcourt and other endemic locations knows the numerous preventive measures for the two diseases. Dengue et al. (2013) at the medical wards of the University of Maiduguri Teaching Hospital in Nigeria revealed a low frequency of 12.3% for hepatitis B virus among HIV-positive patients, supporting the low prevalence of hepatitis B recorded in the study location.

The study by Obi et al. (2006) and Onakewhor et al. (2001) observed a prevalence of 2.8% and 2.19% in Port Harcourt and Benin city, respectively. It is also comparable with the 2.5%, 2.6% and 2.7% reported in some earlier studies in Nigeria and New York, respectively (Toussi et al., 2007; Okonko et al., 2012; Mbaawuaga et al., 2014). Also, it is comparable to the 3.0% HBV/HIV coinfection reported in Osogbo, Nigeria (Adeleke et al., 2013a, b), the 3.1% HBV/HIV coinfection reported in Port Harcourt, Nigeria (Cookey et al., 2021) and the 3.5% HBV/HIV coinfection rate in Anyigba, Nigeria (Omatola et al., 2019). Also, a total of 3.0% HBV, considered a low prevalence per the WHO (2010) classification recorded in this study area, concurs with the findings of Afolabi and Bakare (2022), who reported a 3.8% prevalence in Akure, Nigeria.

The 3.0% HBV prevalence identified here among HIV-positive individuals is also greater than other studies' findings of 1.2%, 1.13%, and 1.8% prevalence rates for HIV-positive patients in Tanzania, Mali, and Iran, respectively (Telatela et al., 2007; Toussi et al., 2007; Tounkara et al., 2009; Moradi et al., 2011; Mbaawuaga et al., 2014). That exceeds the 1.8% of our earlier study conducted in Warri, Nigeria (Okonko et al., 2023a). In contrast to the high endemicity of 12.3% and 13.3% seen in Niger State (Ndams et al., 2008) and Zaria, Kaduna State, respectively, our study found a low incidence of hepatitis B. (Jatau & Yabaya, 2009). Also, it is lower than the 8.0% recorded in Port Harcourt, Nigeria, in our earlier study (Okonko et al., 2023b) and the 6.3% observed in Uyo, Nigeria (Innocent-Adiele et al., 2021). Ekuma et al. (2014) noted that hepatitis B virus seroprevalence should be considered highly endemic when it exceeds 7.0% in an adult population in a specific place. In a prior study, Anaedobe et al. (2015) hypothesised that variations in the prevalence of the hepatitis B virus follow a trajectory from a low prevalence in the southern parts of Nigeria to a higher prevalence in the northern portions of Nigeria.

The increased burden of morbidity, particularly in HIV infection, may be exacerbated by common risk factors such as other opportunistic infections (Anabire et al., 2019b). Chronic HBV and *P. falciparum* infections frequently co-occur in endemic areas, and the prevalence of this coinfection has increased (from 0.7% to 1.7%) in Nigeria and Ghana (Helegbe et al., 2018; Abah, 2019; Anabire et al., 2019a; Omatola & Okolo, 2021). In endemic areas, chronic HBV and malaria frequently co-occur. However, it is unknown if this coinfection may have a negative impact on clinical and immunological responses (Anabire et al., 2019b). When compared to hepatitis B and HIV/AIDS, malaria has a higher prevalence (77.0%), indicating that it is the most prevalent disease in the Akure metropolis, according to Afolabi et al. (2018) study on malaria, hepatitis B, and their coinfection among patients visiting health centres in Akure, Nigeria.

The study further revealed the coinfection rate of malaria/HBV among HIV-infected patients to be 0.0%. This value is less than the 2.2% reported by Afolabi and Bakare (2022) in Akure, Nigeria, and the 1.0% in Adeleke et al. (2013a, b) findings on the coinfection between malaria and HBV. Also, it is lower than the 5.0% in our earlier study in Port Harcourt, Nigeria (Okonko et al., 2021) and the 7.0% in a study by Njunda et al. (2016) in Yaounde, Cameroon. However, the prevalence found in this study is lower compared to similar studies carried out in other sub-Saharan African nations, such as Ghana (11.75%), Cameroon (34.0%), and other regions of Nigeria (18.5%) (Ojurongbe et al., 2014; Tay et al., 2015). These studies do not support our existing conclusion. Helegbe et al. (2018) showed that Malaria/HBV coinfection was 0.7% and Mal/HIV was 0.1% in Ghana, comparable to the 0.0% reported for Malaria/HBV and Malaria/Malaria/HIV in this study. Also, it supports the 0.5% reported *P. falciparum*/HBV coinfection rate in a semiurban community in North-Central Nigeria (Omatola & Okolo, 2021). The prevalence rates of 4.3%, 6.0%, and 0.7% were previously reported in various locations of Nigeria (Abah, 2019), the Gambia (Kotepui & Kotepui, 2020), and Ghana (Helegbe et al., 2018), respectively, are lower than the value observed in the current study. It differs from the findings of Anabire et al. (2019a), who similarly recorded opposing values in their study and found that 14.1% of patients had *P. falciparum* mono-infection, 7.9% had HBV mono-infection, and 1.9% had *P. falciparum*/HBV coinfection. Several investigations in Brazil also revealed that both the general population and those at risk had remarkably low rates of coinfection, emphasising the prevalence of both types of HBV infection (Braga et al., 2005, 2006; Scotto & Fazio, 2018). Asia has been reported as having a very varied situation, with Vietnam having a coinfection rate of 23.8% and Nepal having a coinfection prevalence of 0.0% (Barcus et al., 2002; Shrestha et al., 2009; Scotto & Fazio, 2018).

The zero coinfection of HBV and the malaria parasite identified in this study contrasts the findings of a study conducted in Kano, Nigeria, by Sharif et al. (2016). According to scientists, the severity of HBV and malaria as a mono-infection in Kano is lessened by the presence of HBV and malaria coinfection. There was no evidence of malaria in the study (Sharif et al., 2016). Contrary to our findings, other studies have found substantially higher parasitemia rates for malaria in Nigeria (58.0%) and Ghana (42.0%), respectively (Nwagha et al., 2009; Berry et al., 2018). However, there have also been noticeable variations in the prevalence of coinfection in same Nigeria (Fairley et al., 2012). According to WHO, this is most likely caused by a decline in malaria and HBV infections (Scotto & Fazio (2018).

Demographic profiles of patients, including age and gender, might explain the possible risks for coinfection, as suggested by earlier research showing that most *Plasmodium* spp. and HBV coinfection cases occurred in patients aged 20 to 50 years (Dabo et al., 2015; Afolabi et al., 2018; Kotepui & Kotepui, 2020); however, a different study showed a higher proportion of *Plasmodium* spp. and HBV coinfection cases among patients who are above 50 years of age (Braga

et al., 2005; Kotepui & Kotepui, 2020). Age groups 31 to 40 years had a greater age-related prevalence of HBV (5.3%) than other age groups (2.9% for age groups over 41 and 0% for age groups under 30). The findings demonstrated no age-specific difference in the risk of HBV.

The high prevalence of HBV among patients aged 31 to 40 agreed with Omatola and Okolo's findings from their study in a semiurban community in North-Central Nigeria in 2021, which indicated a higher prevalence in the 31-to-40-year age range. Additionally, it concurs with research we conducted in Port Harcourt and Warri, Nigeria, in the past (Okonko et al., 2023a, b). In contrast, Afolabi and Bakare (2022) found that the 41–45 age range in Akure, Nigeria, had a greater prevalence of HBV. This observation contradicts the results of previous earlier investigations conducted in Port Harcourt, Nigeria. According to Okonko et al. (2020b), HBV infection only affects people in Port Harcourt, Nigeria, between the ages of 16 and 20.

In a separate study in Port Harcourt, Nigeria, Cookey et al. (2021) discovered a higher rate of HBV infection in the age group >59 years. Their higher propensity could explain this observation for HIV, HBV, and *Plasmodium* spp. infection, which includes sexual promiscuity and trendy tattooing (Abah, 2019; Omatola & Okolo, 2021). These ages fall within the range of *Plasmodium* spp. and HBV coinfection peak ages, as determined by Kotepui and Kotepui's meta-analysis study in 2020. Immunity, which is typically developed against malaria parasites, or a decrease in the propensity for sexual promiscuity and other risky behaviours to become infected with HBV may be responsible for the fall in mono-infection with ageing (Okolo et al., 2017; Omatola et al., 2019; Omatola & Okolo, 2021).

A study by Kotepui and Kotepui (2020) revealed no significant difference between participants' ages and the risk of coinfection with *Plasmodium* spp. and HBV. In research by Omatola and Okolo (2021) in a semiurban community of North-Central Nigeria, single and concurrent infections peaked around ages 31 to 40 but decreased with older ages.

Among genders, females had a higher prevalence of HBV (3.6%) than their male counterparts (2.2%). This finding is consistent with earlier findings by other researchers in Port Harcourt and other parts of Nigeria. At Port Harcourt, Nigeria, Cookey et al. (2021 & 2022) likewise noted that females were more likely than males to have HBV infection. In Port Harcourt, Nigeria, there was a higher prevalence of HBV among females, per Okonko et al. (2022). At Warri, Nigeria, Okonko et al. (2023a) reported HBV only among females. Omatola et al. (2019) found that females in Anyigba, Nigeria, had higher HBsAg seropositivity than males. In any case, it disagrees with others both inside and outside of Nigeria. Males in Bangladesh are more likely than females to have HBV, according to Zafrin et al. (2019). In Lokoja, North Central Nigeria, the Omatola et al. (2020) study discovered that males were likelier than females to have HBV. In Port Harcourt, Nigeria, males were more likely than females to have HBV infection, according to Okonko et al. (2020b & 2023b).

The risk of coinfection with HBV and *Plasmodium* spp. was examined by gender. In this study, the findings demonstrated no gender-specific difference in the risk of coinfection with *Plasmodium* species and HBV. According to Aernan et al. (2011), blood donors had the most significant percentage of males. Given that a higher proportion of males than females were reported to have coinfections with *Plasmodium spp*. and HBV in the study by Aernan et al. (2011), it is essential further to investigate the relationship between gender and risk of coinfection.

4.2. Conclusion

The current investigation showed that coinfection with Plasmodium spp. and HBV was found. This study found that those with HIV were substantially more likely to also have HBV infection (3.0%), and vice versa, among HIV-infected patients in Port Harcourt, Nigeria, with a seroprevalence of 0.0% for malaria/HBV coinfection. To recognise the dual burden of these two pathogens, control of *Plasmodium* spp. parasites, and regular administration of HBV immunisations, the healthcare communities can benefit from the study's findings.

REFERENCES

[1]. Abah AE, Onoja H, Amadi FI. Prevalence of malaria and hepatitis B virus infections among pregnant women attending Federal Medical Center, Owerri. South Asian J Parasitol. 2019;3:1–5.

[2]. Abah AEUI. Coinfection of malaria and hepatitis B virus in Port Harcourt, Rivers State Nigeria. Int J Infect. 2019;6:e97033

[3]. Abutu A. Nigeria's complicated hepatitis burden. *The Lancet Gastroenterology & Hepatology.* 2018;3(10):669. doi: 10.1016/s2468-1253(18)30279-6.

[4]. Adeleke, M. A., Adebimpe, W. O., Sam-Wobo, S. O., Wahab, A., Akinyosoye, L. S. & Adelowo, T. O. (2013b). Sero-prevalence of malaria, hepatitis B and syphilis among

pregnant women in Osogbo, Southwestern Nigeria. Journal of Infectious Diseases and Immunity, 5(2):13–17.

[5]. Adeleke, M. A., Adebimpe, W. O., Sam-Wobo, S. O., Wahab, A., Akinyosoye, L. S. & Adelowo, T. O. (2013a). Sero-Prevalence of Malaria, Hepatitis B and Syphilis Among Pregnant Women. American Journal of Microbiology, *4*(1), 20-23. https://doi.org/10.3844/ajmsp.2013.20.23

[6]. Aernan PT, Sar TT, Torkula SH. Prevalence of Plasmodia and hepatitis B virus coinfection in blood donors at Bishop Murray Medical Centre, Makurdi, Benue State Nigeria. Asian Pac J Trop Med. 2011;4:224–6.

[7]. Afolabi O, Aremo A, Oluwabunmi H, Itansanmi I, Anuoluwa I. Malaria, hepatitis B and HIV /AIDS, and their coinfection among patients visiting health centres Akure Nigeria. J Biomed Transl Res. 2018;2:22–6.

[8]. Afolabi, O. J. & Bakare, T. P. (2022). Malaria, Hepatitis B and their Coinfection among Pregnant Women Visiting Maternity Centers in Akure, Nigeria. Research Square, pp. 1-10. DOI: https://doi.org/10.21203/rs.3.rs-1465630/v1

[9]. Anabire NG, Aryee PA, Abdul-Karim A, Abdulai IB, Quaye O, Awandare GA, et al. (2019a). Prevalence of malaria and hepatitis B among pregnant women in Northern Ghana: comparing RDTs with PCR. PLoS ONE. 2019;14:e0210365.

[10]. Anabire, N. G., Aryee, P. A., Abdul-Karim, A., Quaye, O., Awandare, G. A., & Helegbe, G. K. (2019b). Impact of malaria and hepatitis B coinfection on clinical and cytokine profiles among pregnant women. *PloS one*, *14*(4), e0215550. https://doi.org/10.1371/journal.pone.0215550

[11]. Anaedobe CG, Fowotade A, Omoruyi CE, Bakare RA. Prevalence, socio-demographic features and risk factors of Hepatitis B virus infection among pregnant women in Southwestern Nigeria. Pan Afr Med J. 2015;20:406.

[12]. Andrade BB, Santos CJN, Camargo LM, Souza-Neto SM, Reis-Filho A, Clarêncio J, et al. Hepatitis B infection is associated with asymptomatic malaria in the Brazilian Amazon. PLoS ONE. 2011;6:e19841.

[13]. Barcus MZ, Hien TT, White NJ, Laras K, Farrar J, Schwartz IK, et al. Short report: hepatitis B infection and severe *Plasmodium falciparum* malaria in Vietnamese adults. Am J Trop Med Hyg. 2002;66(2):140-142.

[14]. Berry, I., Walker, P., Tagbor, H., Bojang, K., Coulibaly, S. O., Kayentao, K., Williams, J., Oduro, A., Milligan, P., Chandramohan, D., Greenwood, B., & Cairns, M. (2018). Seasonal Dynamics of Malaria in Pregnancy in West Africa: Evidence for Carriage of Infections Acquired Before Pregnancy Until First Contact with Antenatal Care. *The American journal of tropical medicine and hygiene*, *98*(2), 534–542. https://doi.org/10.4269/ajtmh.17-0620

[15]. Braga WSM, Batista da Silva E, Botelho de Souza RA, Tosta CE. Sero-prevalence of hepatitis B and malaria infection in Lábrea, Brazilian western Amazon: estimates of coinfection rates. Rev Soc Bras Med Trop . 2005;38(3):218-223.

[16]. Braga WSM, Botelho de Souza RA, Batista da Silva E, Ferraz da Fonseca JC, Tosta CE. Coinfection between hepatitis B virus and malaria: clinical, serologic and immunologic aspect. Rev Soc Bras Med Trop. 2006;39(1):27-31.

[17]. Brown AE, Mongkolsirichaikul D, Innis B, Snitbhan R, Webster HK. Falciparum malaria modulates viremia in chronic hepatitis B virus infection. J Infect. 1992;166:1465–6.

[18]. Chun, H. M., Mesner, O., Thio, C. L., Bebu, I., Macalino, G., Agan, B. K., Bradley, W. P., Malia, J., Peel, S. A., Jagodzinski, L. L., Weintrob, A. C., Ganesan, A., Bavaro, M., Maguire, J. D., Landrum, M. L., & Infectious Disease Clinical Research Program HIV Working Group (2014). HIV outcomes in Hepatitis B virus coinfected individuals on HAART. *Journal of acquired immune deficiency syndromes (1999)*, *66*(2), 197–205. https://doi.org/10.1097/QAI.0000000000000142

[19]. Coffin, C.S., Osiowy, C., Myers, R.P. & Gill, M.J. (2013). Virology and clinical sequelae of long-term antiviral therapy in a North American cohort of hepatitis B virus (HBV)/human immunodeficiency virus type 1 (HIV-1) co-infected patients. *Journal of Clinical Virology*. 57:103–108.

[20]. Cookey TI, Odenigbo KC, Okonko BJ & Okonko IO. (2022). Prevalence of HBsAg among patients attending a tertiary hospital in Port Harcourt, Nigeria. *International Journal of Life Science Research Archive, 03(02), 125–134*

[21]. Cookey, T. I., Okonko, I. O., & Frank-Peterside, N. (2021). HIV and HBV Coinfections in the Highly HIV-infected Population of Rivers State, Nigeria. *Asian*

Journal of Advanced Research and Reports, 15(6): 1-10.

[22]. Crowell, T.A., Berry, S.A., Fleishman, J.A., LaRue, R.W., Korthuis, P.T. and Nijhawan, A.E. (2015). HIV Research Network. Impact of hepatitis coinfection on healthcare utilisation among persons living with HIV. *Journal of acquired immune deficiency syndrome*. 68: 425–431.

[23]. Cruz LAB, Moraes MOA, Queiroga-Barros MR, Fukutani KF, Barral-Netto M, Andrade BB. Chronic hepatitis B virus infection drives changes in systemic immune activation profile in patients coinfected with *Plasmodium vivax* malaria. PLoSNegl Trop Dis. 2019;13:e0007535.

[24]. Dabo NT, Sharif AA, Muhammed Y, Sarkinfada F. Malaria and Hepatitis B coinfection in patients with febrile illnesses attending general outpatient unit of the Murtala Muhammed Specialist Hospital, Kano, Northwest Nigeria. Bayero J Pure ApplSci. 2015;8:89–95.

[25]. Denue, B. A., Gashau, W., Bello, H. S., Kida, I., Bakki, B. & Ajayi, B. (2013). Relationship between some Hematological Abnormalities, Degree of Immunosuppression and Viral Load in Treatment-naïve HIV Infected Patients Eastern Nigeria. *East Mediterranean Health Journal*, 19(5): 362–368.

[26]. Ekuma OO, Mawak JD, Uwakwe A, Ogbu O, Okoh FN, Agah MV, Nnachi AU. (2014). Prevalence of Hepatitis B surface antigen among the newly admitted students of University of Jos, Nigeria. American Journal of Life Sciences. 2014: 2(1): 35 – 9.

[27]. Fairley, T. L., Kilpatrick, C. W. & Conn, J. E. (2012). Intragenomic Heterogeneity of Internal Transcribed Spacer Rdna in Neotropical Malaria Vector *Anopheles aquasalis* (Diptera: Culicidae). *Journal Medicine Entomology*, 42: 795–800.

[28]. Freimanis GL, Owusu-Ofori S, Allain JP. Hepatitis B virus infection does not significantly influence *Plasmodium* parasite density in asymptomatic infections in Ghanaian transfusion recipients. PLoS ONE. 2012;7:e49967.

[29]. Gadia CLB, Manirakiza A, Tekpa G, Konamna X, Vickos U, Nakoune E. Identification of pathogens for differential diagnosis of fever with jaundice in the Central African Republic: a retrospective assessment, 2008–2010. BMC Infect Dis. 2017;17:735.

[30]. Helegbe, G. K., Aryee, P. A., Mohammed, B. S., Wemakor, A., Kolbila, D., Abubakari, A. W., Askanda, S., Alhassan, R., Barnie, C., Donkoh, A. A., & Ofosu, E. (2018). Seroprevalence of Malaria and Hepatitis B Coinfection among Pregnant Women in Tamale Metropolis of Ghana: A Cross-Sectional Study. *The Canadian journal of infectious diseases & medical microbiology = Journal Canadien des maladies infectieuses et de la microbiologie medicale*, *2018*, 5610981. https://doi.org/10.1155/2018/5610981

[31]. Innocent-Adiele, H.C., Michael, B.B.T., Okonko, I.O. & Ogbu O. (2021). Seroprevalence Of Hepatitis B Virus Infection among HIV Infected Individuals in Uyo, Akwa Ibom State, Nigeria. *medRxiv preprint for Health Sciences. Cold Spring Harbor Laboratory and BMJ Yale. doi: https://doi.org/10.1101/2021.03.06.21253060*

[32]. Jatau ED, Yabaya A. Seroprevalence of hepatitis B virus in pregnant women attending a clinic in Zaria, Nigeria. Sci World Journals. 2009;4:7–9.

[33]. Kolawole OM, Kana SN. Hepatitis B virus and malaria coinfection causing significant changes in hematological and liver function indices in a cohort of subjects in Ilorin Nigeria. Int J Infect. 2018;5:e81528.

[34]. Kotepui, K.U., Kotepui, M. Prevalence of and risk factors for *Plasmodium* spp. Coinfection with hepatitis B virus: a systematic review and meta-analysis. *Malar J* 19, 368 (2020). https://doi.org/10.1186/s12936-020-03428-w

[35]. Mbaawuaga EM, Christian UI, Anthony CI, Godwin TAJ. Studies on prevalence, coinfection and associated risk factors of hepatitis B virus (HBV) and human Immunodeficiency virus (HIV) in Benue State, Nigeria. *Sci J of Public Health.* 2014;2(6):569–576.

[36]. Moradi, A., Khodabakhshi, B., Sadeghipour, M., Besharat, S., & Tabarraei, A. (2011). Concurrent infections of hepatitis C and HIV in hepatitis B patients in the north-east of Iran. *Tropical doctor*, *41*(3), 129–131. https://doi.org/10.1258/td.2011.100418

[37]. Ndams IS, Joshua IA, Luka SA, Sadiq HO. Epidemiology of hepatitis B infection among pregnant women in Minna, Nigeria. Sci World J. 2008;3(3):5–8.

[38]. Njunda AL, Njumkem C, Nsagha DS, Asorb JCN, Kwenti TB. The prevalence of malaria in people living with HIV in Yaounde, Cameroon. BMC Public Health. 2016; 16:964.

[39]. Nwagha, U. I., Ugwu, V. O., Nwagha, T. U., & Anyaehie, B. U. (2009). Asymptomatic Plasmodium parasitaemia in pregnant Nigerian women: almost a decade after Roll Back Malaria. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *103*(1), 16–20. https://doi.org/10.1016/j.trstmh.2008.07.016

[40]. Obi RK, Umeh SC, Okurede OH, Iroagba II. Prevalence of hepatitis B virus infection among pregnant women in an antenatal clinic in Port Harcourt, Nigeria. Afr J Clin Experimental Microbiol. 2006;7:78– 82.

[41]. Ojurongbe O, Oyeniran OA, Alli OAT, Taiwo SS, Ojurongbe TA, et al. Prevalence of Plasmodium falciparum Parasitaemia and Its Correlation with Haematological Parameters among HIV-Positive Individuals in Nigeria. J Trop Med. 2014; 161284:6.

[42]. Okolo M. O., Omatola C. A., Ezugwu A. I., Adejo P. O., Abraham O. J., Chukwuma O. J. T. Prevalence of malaria among pregnant women attending antenatal clinic in Grimard catholic hospital, Anyigba in Kogi state, Nigeria. *Nature and Science*. 2017;15(9):113–117. [

[43]. Okonko IO, Asagba OH, Okonko BJ, Baeka GB. (2023a). Prevalence of Hepatitis B Virus Coinfection Amongst HIV-Infected Patients in Capitol Hill Hospital, Warri, Delta State, Nigeria. *Cancer Biology*, 13 (1): in press

[44]. Okonko IO, Ejukwu C, Okonko BJ, Baeka GB. (2023b). Serological Prevalence of Hepatitis B Virus Among Patients Attending O. B. Lulu Briggs Health Centre in Port Harcourt, Rivers State, Nigeria. *Academia Arena*, 15(2): in press

[45]. Okonko, I.O., Okobia VC, Cookey TI, & Innocent-Adiele HC. (2022). Dual Positivity of Human Immunodeficiency Virus (HIV) and Hepatitis B Virus (HBV) In the Highly Infected Population of Rivers State, Nigeria. *Report & Opinion, 14(10):1-9*

[46]. Okonko, I. O., Onwubuche, K., Cookey, T. I., Agbagwa, O. E., & Chijioke-Nwauche, I. N. (2021). Dual Infection of HIV and Malaria among HIV-Infected Individuals in Port Harcourt, Nigeria. *South Asian Journal of Parasitology 5(1): 26-31*

[47]. Okonko, I. O., Udo, O.L., Cookey, T.I. & Adim, C.C. (2020a). Prevalence of Hepatitis B Virus among Women of Child-Bearing Age in Port Harcourt, Nigeria. *Asian Journal of Immunology, 4(4): 1-7,*

[48]. Okonko, I.O., Adewuyi, S.A., Omatsone, C. & Cookey, T.I. (2020b). Detection of Hepatitis B Virus Among HIV Positive Fresh Undergraduate Students in Port Harcourt, Nigeria. *Asian Journal of Research and Reports in Gastroenterology, 3(3): 8-13*

[49]. Okonko IO, Okerentugba PO, Akinpelu AO. Prevalence of HBsAG among Attendees of Reproductive Family and Health (ARFH) center in Ibadan, Southwestern Nigeria. *American-Eurasian J of Sc Res.* 2012;7(3):100–105.

[50]. Omalu ICJ, Jibrin A, Olayemi IK, Hassan SC, Mgbemena C, Mgbemena A, Adeniran LA. Seroprevalence of malaria and hepatitis B (HBsAg) with associated risk factors among pregnant women attending antenatal clinic in General Hospital Minna, north-central Nigeria. Annu Rev Res Biol. 2012;2:83–8.

[51]. Omatola C. A., Onoja B. A., Agama J. (2020a). Detection of hepatitis B surface antigen among febrile patients in Ankpa, Kogi state, Nigeria. *Journal of Tropical Medicine*, 2020:6. doi: 10.1155/2020/5136785.5136785

[52]. Omatola CA, Okolo M-LO, Adaji DM, Mofolorunsho CK, Abraham Oyiguh J, Zige DV, Akpala NS, Ocholi Samson S. (2020b). Coinfection of Human Immunodeficiency Virus-Infected Patients with Hepatitis B Virus in Lokoja, North Central Nigeria. Viral Immunology, 33(5):391–395. Available: https://doi.org/10.1089/vim.2019.0157

[53]. Omatola, C. A., & Okolo, M. O. (2021). Hepatitis B and Asymptomatic Malaria Infection among Pregnant Women in a Semiurban Community of North-Central Nigeria. *Journal of environmental and public health*, *2021*, 9996885. https://doi.org/10.1155/2021/9996885

[54]. Omatola, C. A., Idofe, J., Okolo, M. O., Adejo, P. O., Maina, M. M., & Oyiguh, J. A. (2019). Seroprevalence of HBV among people living with HIV in Anyigba, Kogi State, Nigeria. *African health sciences*, *19*(2), 1938–1946. https://doi.org/10.4314/ahs.v19i2.17

[55]. Onakewhor JUE, Offor E, Okonofua FE. Maternal and neonatal seroprevalence of Hepatitis B surface antigen (HBsAg) in Benin City. J Obstet Gynaecol. 2001;21(6):583–6.

[56]. Oyeyemi O, Amugo A. *Plasmodium falciparum* and hepatitis B virus infection in Nigerian urban population. Braz J Infect Dis. 2015;19:666–7.

[57]. Rajbhandari, R., Jun, T., Khalili, H., Chung, R.T. & Ananthakrishnan, A.N. (2016). HBV/HIV coinfection is associated with poorer

outcomes in hospitalised patients with HBV or HIV. *Journal of Viral Hepatitis*. 23:820–829.

[58]. Scotto, G., & Fazio, V. (2018). Hepatitis B and asymptomatic malaria coinfection in Sub-Saharan African immigrants: epidemiological and clinical features of HBV infection. *Revista da Sociedade Brasileira de Medicina Tropical*, *51*(5), 578–583. https://doi.org/10.1590/0037-8682-0430-2017

[59]. Sharif AA, Getso MI, Yusuf MA, Yusuf I, Muhd IZ, Ahmad IM. (2016). Liver function biomarkers in malaria and hepatitis B coinfection among patients with febrile illness. International Journal of Medical Research and Health Sciences, 5(1):29–322.

[60]. Shrestha AC, Ghimire P, Tiwari BR, Rajkarnikar M. Transfusion-transmissible infections among blood donors in Kathmandu, Nepal. J Infect Dev Ctries. 2009;3(10):794-7.

[61]. Singh B, Kim Sung L, Matusop A, Radhakrishnan A, Shamsul SS, Cox-Singh J, et al. A large focus of naturally acquired *Plasmodium knowlesi* infections in human beings. Lancet. 2004;363:1017–24.

[62]. Tay S, Badu K, Mensah AA, Gbedema SY. The prevalence of malaria among HIV seropositive individuals and the impact of the coinfection on their haemoglobin levels. Ann Clin Microbiol Antimicrob. 2015; 14:10.

[63]. Telatela, S. P., Matee, M. I., & Munubhi, E. K. (2007). Seroprevalence of hepatitis B and C viral coinfections among children infected with human immunodeficiency virus attending the paediatric HIV care and treatment center at Muhimbili National Hospital in Dar-es-Salaam, Tanzania. *BMC public health*, *7*, 338. https://doi.org/10.1186/1471-2458-7-338

[64]. Thursz MR, Kwiatkowski D, Torok ME, Allsopp CE, Greenwood BM, Whittle HC, et al. Association of hepatitis B surface antigen carriage with severe malaria in Gambian children. Nat Med. 1995;1:374–5.

[65]. Tounkara, A., Sarro, Y. S., Kristensen, S., Dao, S., Diallo, H., Diarra, B., Noumsi, T. G., & Guindo, O. (2009). Seroprevalence of HIV/HBV coinfection in Malian blood donors. *Journal of the International Association of Physicians in AIDS Care* (Chicago, Ill.: 2002), *8*(1), 47–51. https://doi.org/10.1177/1545109708330118

[66]. Toussi, S. S., Abadi, J., Rosenberg, M., & Levanon, D. (2007). Prevalence of hepatitis B and C virus infections in children infected with HIV. *Clinical infectious diseases: an official publication of the Infectious Diseases Society of America*, *45*(6), 795–798. https://doi.org/10.1086/521169

[67]. World Health Organisation (WHO), author *Prevalence of hepatitis virus in the world by country*. 2010. http://www.who.int/csr/disease/hepatitis/en/ Date accessed online (June 2011)

[68]. World Health Organisation (WHO, 2019a). Guidelines for Malaria Vector Control [Internet]. Geneva: World Health Organization; 2019. https://www.who.int/malaria/publications/atoz/9789241550499/en/. Accessed 29 April 2020.

[69]. World Health Organisation (WHO, 2019b). World malaria report 2019 [Internet]. Geneva: World Health Organization; 2019. https://www.who.int/malaria/publications/world-malaria-report-2019/en/. Accessed 30 April 2020.

[70]. World Health Organisation (WHO, 2020b) Factsheet on Hepatitis B, 2020, https://www.who.int/news-room/fact sheets/detail/hepatitis-b.

[71]. World Health Organisation (WHO, 2020c). World Hepatitis Day-In Nigeria, 2020, https://www.afro.who.int/news/world-hepatitis-day-nigeria-estimated-20-million-people-are-chronically-infected.

[72]. World Health Organization (WHO, 2020a). *World Malaria Report 2020: 20 Years of Global Progress and Challenges.* Geneva, Switzerland: World Health Organization; 2020.

[73]. World Health Organization (WHO, 2022). Malaria. https://www.who.int/news-room/fact-sheets/detail/malaria. Accessed 28 February 2023.

[74]. World Health Organization African Region and the WHO South-East Asia Region World Health Organisation (WHO, 2018). Malaria [Internet]. Geneva: World Health Organization; 2018. https://www.who.int/news-room/fact-sheets/detail/malaria. Accessed 29 April 2020.

[75]. World Health Organisation (WHO, 2017). Global hepatitis report 2017. https://www.who.int/hepatitis/publications/global-hepatitis-report2017-executive-summary/en/.

[76]. World Health Organization (WHO, 2015). World Malaria report. Genève: WHO. P. 280

[77]. Wokem GN, Amacree MA. Malaria and hepatitis-B coinfection in relation to selected haematological parameters among attendees of two health facilities in Port Harcourt, Nigeria. Int J ApplSci Res Rev. 2018;5:54.

[78]. Yohanna JA, Iorkyaa AA, Rotimi JI, Nwibari BMW, Igavo PA, Dakul DA. Prevalence of malaria parasites and Hepatitis-B virus in patients attending two hospitals in Jos, Plateau State. Nigeria. Niger J Parasitol. 2016;37:87.

[79]. Zafrin N, Sarkar M.A.S., Rahman Md. M, Salma U, Mahbub T, & Azhar M.A. (2019). Hepatitis B Virus Infection: Knowledge and Awareness Among the Patients Admitted in a Tertiary Care Hospital in Bangladesh. Viral Hepatitis Journal 25(1):6–13.

3/16/2023