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Asymptomatic *Plasmodium falciparum* and HBV coinfections among inmates at Owo Correctional Facility, Nigeria

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Abstract

Background Malaria and hepatitis B are significant public health infections in Nigeria. Coinfection with both pathogens is common where both diseases are endemic. Epidemiological surveys are essential for determining the burden of diseases and possible coinfection with multiple pathogens in vulnerable populations. There has been a lack of reports on HBV/malaria coinfection, particularly among marginalized groups in Ondo State. Thus, we used malaria microscopy and the HBsAg serological test to examine the prevalence of asymptomatic malaria parasitemia and HBV infections respectively among inmates at the Nigerian Correctional Center in Owo, Ondo State, Nigeria.

Results Out of the 126 prisoners and staff members who were evaluated, 20.6% and 7.9% tested positive for malaria and HBV infections, respectively. It was discovered that 1.6% of the individuals were coinfecting with malaria and HBV. *Plasmodium falciparum* was the only malaria species recovered in malaria-infected individuals. Except for HBV, where gender was found to differ considerably with the proportion of HBV infection, variations in single infections with either pathogen did not vary with demographic characteristics.

Conclusion We suggest that the prison system should be considered in healthcare programs to improve the health of inmates.

Keywords Malaria, Hepatitis B virus, Prison inmates, Owo, Coinfection

Background

Hepatitis B virus (HBV), caused by the *Hepadnavirus* that infects liver cells, is an infectious disease of public health significance in Nigeria, with an estimated 10.7% prevalence in rural settings (Ajuwon et al. 2021). The disease results in complications such as cirrhosis and liver cancer, leading to an estimated 125,000 deaths annually in Africa (WHO 2023a). Despite the huge burden of the

disease, about 90% of Nigerians infected with the virus are unaware of their infection status (Ajuwon et al. 2021).

Malaria remains the most significant public health problem in Nigeria, with 97% of the population at risk of infection (WHO 2023a). There are approximately 97 million cases and 300,000 deaths reported annually, involving 11% and 30% maternal and child (under-five) mortality (WHO 2023b). Most malaria cases in Nigeria are caused by *Plasmodium falciparum*, transmitted by the *Anopheles* species of mosquitoes (WHO 2023a). In areas with moderate-to-high transmission of malaria, infection with *P. falciparum* could be asymptomatic. Asymptomatic malaria refers to the detection of *Plasmodium species* in peripheral blood in the absence of malaria-related symptoms (Kimenyi et al. 2019).

HBV/malaria coinfection occurs worldwide, particularly in areas where both infections are endemic. This is

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a major public health issue in underdeveloped nations, particularly in Africa and Latin America (Kotepui and Kotepui 2020). While malaria is mainly transmitted by the bite of an infected *Anopheles* mosquito, HBV is contagious and spreads through contact with the blood and body fluids of infected people. Both infections can be acquired through similar modes of transmission, such as blood-to-blood contact, needle sharing, and blood transfusions (Scotto et al. 2019; Omatola and Okolo 2021). Different rates of malaria/HBV coinfections have been reported across the country in varied populations (Scotto et al. 2019; Omatola and Okolo 2021; Abah and Udoigang 2019; Oyeyemi and Amugo 2015; Yohanna et al. 2016; Afolabi et al. 2018). However, epidemiological studies of HBV/malaria coinfection are still insufficient, and the mutual interactions between HBV and malaria are still understudied. Overlapping HBV/malaria is believed to be more frequent, with a possible influence on the natural history of both diseases (Omatola and Okolo 2021).

Disease coinfections are widespread in impoverished and vulnerable populations, such as prison inmates, and can have a wide range of effects on coinfecting hosts, either directly or indirectly using the hosts' resources or immune system. The health of inmates is critical to the overall well-being of the residents of a community. Although it is frequently neglected, the growing mobility of people in and out of correctional facilities poses potential health risks to the general public (WHO 2023c). Even though correctional facilities are known to have a higher transmission and burden of parasitic, bacterial, and viral diseases (ECDC 2017), there is still a scarcity of reliable data on the epidemiology of these diseases. However, to interrupt transmission cycles and control and/or eliminate infectious diseases, vulnerable people must be diagnosed and treated (Ellwanger et al. 2021). In prisoners' health, the spread of HIV, HBV and tuberculosis are predominant due to unsafe practices of needle sharing, drug use, and sex, in addition to malaria, in developing countries (CDC 2023). Though there are several reports on malaria parasites and hepatitis B virus single infections in Nigeria, there are few studies on the concomitant occurrence of these two pathogens, especially in vulnerable populations. HBV infection has been suggested to lower the intensity of malaria infection in individuals from an endemic area in Brazil (Scotto and Fazio 2018). There has been a dearth of epidemiological research on HBV/malaria coinfection, particularly among marginalized groups in Ondo State. Previous research suggests that HBV is endemic in Ondo State, with a prevalence rate of 11.0% (Ajayi et al. 2021). There is a need to generate epidemiological data to determine the possible associations between these infectious agents and improve the well-being of the populace. As a result, this study explores

the prevalence of malaria and hepatitis B virus infection among asymptomatic inmates at Owo Correctional Facility in Ondo State, Nigeria.

Methods

Study area

The study site is the Nigerian Correctional Center in Owo, Ondo State. Owo is a local government area in Ondo State (7° 11' 46" N and 5° 35' 12" E) with a population of 222,262 people based on the 2006 population census. The average temperature typically varies from 18 to 31 °C (Adewunmi and Anifowose 2017). The town is a major collecting point for various agricultural products such as cocoa, yams, cassava, maize, rice, cotton, and teak. The correctional center houses two blocks of rooms for male and female inmates and a small health center.

Sample size determination

The sample size was calculated using the formula $n = Z^2P(1-P)/d^2$ at a 95% confidence level and 0.05 precision (Althubaiti 2022) based on the expected prevalence of 7% for malaria and HBV coinfection in Nigeria (Kotepui and Kotepui 2020). To cater for nonresponse or missing data, we added 20% of the computed sample size to obtain the minimum required sample size of 121.

Sampling procedure

A total of 126 blood samples were collected from inmates. The inclusion criteria were willingness to participate in the study, absence of apparent chronic diseases, and willingness to provide informed consent in the presence of prison staff. Exclusion criteria included restricted inmates and an unwillingness to provide consent in the presence of prison staff. All sampling activities were done under strict monitoring by the correctional facility authorities.

Malaria microscopy

We prepared thick and thin blood films by the WHO malaria microscopy standard operating procedures (WHO 2016). All blood smears were stained with Giemsa stain and examined under the microscope with 40× and 100× oil immersion objective lenses. Before a thick film was certified negative, a minimum of 100 fields were checked. The presence and species of parasites were documented on a predesigned epidemiology form. Each slide was read by two technicians for confirmation.

Detection of serological hepatitis B surface antigen (hbsag)

The KNOWIT HBsAg Test Kit (Civic Pharmaceuticals) was used to screen for serological hepatitis B surface antigen (HBsAg). The test strip is a quick direct binding test based on the sandwich immunoassay principle

for determining HBsAg in human serum specimens. We conducted and evaluated the test according to the manufacturer’s instructions. A micropipette was used to collect a few drops of blood, which were then placed in the sample well. A drop of buffer solution was added, and the result was analyzed after 15 min. When the result was positive, the strip produced two bands, the control region (C) and the test region (T), and when the result was negative, the strip produced a single band in the control region. When the control band is absent, the test is considered invalid. Invalid tests were repeated using new test kits.

Data analysis

The data were analyzed using R software. The Fisher’s exact and Chi-square tests were used to compare prevalence about age group and gender at the $P < 0.05$ level of significance.

Results

Study population characteristics

A total of 126 inmates were recruited for this study, with the majority of the participants (65.9%) aged between twenty-one and forty years of age. Less than 10% of the study population was below twenty years of age and above sixty years of age, respectively. The mean (SD) age of the study population was 34.6 (11.3) years. Only 20.6% of the participants were found to be malaria-positive, though asymptomatic, while 7.9% were found to be seropositive for the hepatitis B virus. Malaria and HBV coinfection were observed in 1.6% of the participants (Table 1).

Distribution of infections

The highest rates of malaria were found among those 21–40 years of age (24.1%) and females (28.6%). No malaria infection was observed among participants below 20 years of age and above 60 years of age. The variation in malaria infection rates was not significantly associated with age or gender ($P > 0.05$, Table 2).

For HBV, the infection rate was higher among those below twenty years of age (14.3%), 41–60 years of age (12.1%), and females (42.9%) compared to participants 21–40 years of age (6.0%) and males (5.9%). There

Table 1 Demographic and clinical characteristics of the study population

Characteristic	Levels	n (%)	95% CI
Gender	Males	119 (94.4)	
	Females	7 (5.6)	
Age group	< / = 20	7 (5.6)	
	21—40	83 (65.9)	
	41—60	33 (26.2)	
	> 60	3 (2.3)	
Age	Mean age ± SD	34.6 ± 11.3	
Infection prevalence	Malaria	26 (20.6)	13.9–28.6
	Hepatitis B	10 (7.9)	3.9–14.1
	Malaria/HBV	2 (1.6)	0.2–5.6

CI confidence intervals

Table 2 Distribution of malaria, HBV, and malaria/HBV infection in sociodemographic characteristics of the study population

Characteristic	Malaria		P value	HBV	P value	Malaria/HBV coinfection	P value
	Overall	Positive					
	N = 126	N = 26					
Age group			0.3		0.6		5.7
< / = 20	7	0 (0.0%)		1 (14.3%)		0 (0.0%)	
21–40	83	20 (24.1%)		5 (6.0%)		0 (0.0%)	
41–60	33	6 (18.2%)		4 (12.1%)		2 (6.1%)	
> 60	3	0 (0.0%)		0 (0.0%)		0 (0.0%)	
Sex			0.6		0.0004		0.006
F	7	2 (28.6%)		3 (42.9%)		1 (14.3%)	
M	119	24 (20.2%)		7 (5.9%)		1 (0.8%)	

was no HBV infection among the older age groups (>60 years of age). Gender was observed to vary significantly with the rate of HBV infection ($P=0.0004$) (Table 2). Malaria and HBV coinfection were observed in 2 (1.6%) participants (Tables 1 and 2). Coinfection varied significantly with the gender of the participants ($P=0.006$) (Table 2).

Discussion

This study, which investigates the prevalence of malaria and HBV infection among prison inmates, is crucial for improving inmates' health and reintegrating incarcerated people into society. A study by (Uggen et al. 2022) showed that the rate of former prisoners increases diseases that are poorly addressed in the prison health care system and vice versa, and suggested that improving prisoners' health can enhance the health of the communities to which they return. The high number of males in this study is not unusual, given that male prisoners predominate in prisons. According to national data, the male-to-female inmate ratio in Ondo state prisons is 49 to 1. The average age of participants in this study matches that of earlier studies among prisoners (Table 1). The age range of 21–40 has been regarded as an active and productive stage of life (Otuu and Shu 2019). Individuals at this time are at their physiological peak and most at risk for involvement in violent crimes and substance abuse.

Malaria is a common infection in Nigerian prisons (Abah et al. 2018). The malaria prevalence of 20.6% in this study is equivalent to that reported by (Audu et al. 2014) in Kaduna State but lower than in earlier studies among inmates in different parts of Nigeria (Otuu and Shu 2019; Abah et al. 2018; Alo et al. 2015; Ahmed et al. 2016; Yahaya and Oti 2020). Our findings also contrast with those of other researchers who found greater levels of malaria infections in different locations of Nigeria (Omatola et al. 2021; Oyeyemi and Amugo 2015; Awosolu et al. 2021). This is most likely due to the clean prison environment seen during the investigation. The prison housing was devoid of bushes or stagnant water, both of which are necessary conditions for mosquito breeding (Norbert et al. 2020). Inmates reported not using insecticide-treated bed nets, which might have reduced malaria prevalence even further. *P. falciparum* was observed as the primary cause of malaria in the study participants. Other studies have found different *Plasmodium* species among convicts (Ahmed et al. 2016). The high frequency of asymptomatic *P. falciparum* infection observed in this study is not uncommon. Asymptomatic malaria infection is frequent among Africans; a recent study of African migrants found that 67.8% had an asymptomatic malaria infection (Corbacho-Loarte et al. 2022). Several factors, including parasite pathogenicity, parasitemia level, and

host features have the potential to alter the clinical presentation of malaria infections. People in malaria-endemic countries often develop immunity to the parasite as a result of constant exposure and may have low levels of parasitemia without symptoms (Kimenyi et al. 2019; Dan-Nwafor et al. 2021).

The seroprevalence of hepatitis B observed in the study (7.9.0%) is lower compared to the national prevalence (9.9%) and other studies conducted among prisoners in the Federal Capital Territory, Nasarawa, and Borno, with a prevalence of 13.7%, 23.0%, and 16.3%, respectively. This could be due to the comparable lower number of inmates. However, it is larger than the 0.04% found among inmates in Sao Paulo (Ajuwon et al. 2021; Adooga et al. 2009; Lawan et al. 2021; do Nascimento et al. 2020; Vessellee et al. 2023). This study also found a gender difference in HBV seroprevalence, with females having a greater seroprevalence rate (42.9%) than males (5.9%) ($p=0.0004$, Table 2). The study by do Nascimento et al. (2020) discovered a comparable pattern. However, our findings contrast those of Abah and Udoidang (2019), who discovered that males had a higher prevalence of HBsAg. Women could be more predisposed to HBV infection due to their vulnerability to sexual violence, beauty-enhancement procedures such as body piercing and tattoos, homosexuality, drug injection, and sharing sharp objects (Taura et al. 2021; Smith et al. 2017; Rezende et al. 2020). Infection was more prevalent in the less than twenty-year-old and 41–60 years age groups. The higher prevalence in these age groups is not uncommon in HBV epidemiological studies conducted among prison inmates since these age groups fall within the active sexual and social age range and are thus more likely to become infected with the disease (Abah and Udoidang 2019; Anabire et al. 2019).

Malaria/HBV coinfection is a severe health concern since both parasites affect the liver and can result in death, particularly in pregnant women and immunocompromised people (Scotto and Fazio 2018). The pooled prevalence estimate of *Plasmodium* spp. and HBV coinfection in Nigeria is 7%, according to a recent review by (Kotepui and Kotepui 2020). The review also suggested that there was no significant difference in gender or risk of *Plasmodium* spp. and HBV coinfection. However, we found that 1.6% of our study individuals had malaria and HBV coinfection, which varied significantly with gender. In Keffi, Nigeria, inmates had a prevalence of 9.3% (Yahaya and Oti 2020). Our observed HBV/malaria coinfection rate was higher than that reported by Omatola and Okolo (2021) among pregnant women in North Central Nigeria, but lower than that reported by Oyeyemi and Amugo (2015) in the Nigerian urban population. Variations in geographic locations, the stage of

both parasite life cycles at the time of investigation, and host features have all been proposed as reasons for the heterogeneity in epidemiological findings (Scotto et al. 2019). Previous research indicates that in cases of silent malaria and HBV coinfection, the malaria parasite has no substantial effect on the course of viral infection (Scotto et al. 2018).

There are some limitations to our study. Firstly, the hepatitis B surface antigen (HBsAg) test kit cannot differentiate between a current and long-standing infection. Secondly, we were not able to confirm the presence of viral DNA with PCR due to a limitation of funds, as test kits could sometimes give false positives or negatives depending on their sensitivity and specificity. Thus, our prevalence estimates may not be an exact representation of the current burden of HBV among the inmates.

Conclusions

P. falciparum and HBV infections are of public health concern. Our findings provide further evidence of the risk of coinfection with both diseases among prisoners. Although prisoners are confined, they are capable of transmitting parasites to the external world, either passively or actively, when released. Continuous epidemiological surveillance of infectious diseases among prisoners is essential for controlling the spread of diseases. Routine medical checks for inmates will facilitate early diagnosis and could potentially reduce the spread of diseases.

Abbreviations

HBV	Hepatitis B virus
HIV	Human immunodeficiency virus
HBsAg	Hepatitis B surface antigen
DNA	Deoxyribonucleic acid
PCR	Polymerase chain reaction

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Author contributions

A.O.G conceived and designed the study. A.O.G and O.A.A carried out the field survey. A.O.G and O.A.A performed the experiments and A.O.G analyzed the data. A.O.G wrote the paper with contributions from O.A.A. All authors read and approved the final manuscript.

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Availability of data and materials

All data generated or analyzed during this study are included in this article.

Declarations

Ethics approval and consent to participate

Ethical approval and permission to conduct this study were obtained from the Ethical Review Board of the Department of Animal and Environmental Biology, Adekunle Ajasin University, Akungba Akoko (REF: AAUA/FSC/AEB/19/03/2021b) and the Nigerian Correctional Services State Headquarters

Office (Approval No. CHOND-57/VOL-I/212). Informed consent was obtained from each voluntary participant.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interest.

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