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Assessment of Tuberculosis and Hepatitis B Virus Co-Infection Rates and Their Relationship with HIV Viral Load Among HIV Patients in Port Harcourt, Nigeria

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Abstract: *Mycobacterium tuberculosis* causes tuberculosis (TB), primarily affecting the lungs and remaining a significant threat globally. HIV infection accelerates TB progression. Coinfection of TB with hepatitis B virus (HBV) can worsen treatment outcomes, potentially leading to failure. Though TB is treatable, complications from hepatitis can occur, causing liver damage in some cases. This study aims to determine the prevalence and co-infection rate of tuberculosis and hepatitis B as well as its correlation with viral load among HIV patients receiving antiretroviral therapy. Two hundred (200) HIV-infected individuals receiving antiretroviral therapy (ART) at the Rivers State University Teaching Hospital (RSUTH), were enrolled and underwent screening for HBV surface antigens and tuberculosis using rapid diagnostic tests (RDTs). The HIV viral load was determined through Reverse Transcription-polymerase chain reaction (RT-PCR). Questionnaires were administered to gather demographic information and assess risk factors related to HBV and tuberculosis among the participants. The results indicated an overall prevalence of 3.0% for HBV, and 2.5% for TB and no co-infection was observed between tuberculosis and Hepatitis B. A high prevalence of 1.0% for HBV and 4.1% for TB was recorded among individuals aged 49-56 and 41-48, respectively. Among HBV cases, high prevalence rates were observed among males at 3.0%, singles at 4.2%, illiterates at 7.7%, and those with a viral load below 20 copies/ml at 3.6%. Conversely, for TB, higher prevalence rates were found among females 2.9%, married individuals (4.4%), those with primary education 8.7%, and 9.1% for participants with viral load exceeding 1000 copies/ml. However, there was no statistical association between the demographic variables and HBV and TB infection ($p > 0.05$). Conclusively, an overall prevalence of 2.5% and 3.0% was observed in tuberculosis and hepatitis B, respectively, in the studied population. There was no co-infection between tuberculosis and hepatitis B. Statistical analysis did not find significant associations between variables and infection rates. There is a need to carry out routine screening for the hepatitis B virus and TB among HIV-infected individuals for proper disease management and increased treatment success

[Diamreyan, O. O., Okonko, B. J., Cookey, T. I., Kalio, A. J., Frank-Peterside, N. & Okonko, I. O. **Assessment of Tuberculosis and Hepatitis B Virus Co-Infection Rates and their Relationship with HIV Viral Load Among HIV Patients in Port Harcourt, Nigeria**. *Nat Sci* 2026,24(3):7-15]. ISSN 1545-0740 (print); ISSN 2375-7167 (online). http://www.sciencepub.net/nature 02. doi:10.7537/marsnsj240326.02

Keywords: Hepatitis B; TB; HIV; ART; Viral Load

1. Introduction

The impact of tuberculosis (TB) on HIV patients is profound and cannot be overstated. TB remains the leading cause of death among individuals living with HIV, and those co-infected with TB are 30 times more likely to develop active TB compared to those without HIV (Kanu et al., 2018). Mycobacterium tuberculosis is thought to accelerate the progression of HIV to AIDS and remains the most common illness among people living with HIV, even those receiving antiretroviral therapy (ART) (Okonko et al., 2021). Globally, approximately 240 million people are chronic carriers of hepatitis B surface antigen (HBsAg), with endemicity rates varying between regions, from over 8% in high-endemic areas to less than 2% in low-endemic regions. In Africa, the failure to prevent, diagnose, and adequately treat HBV infection is a significant contributor to the growing burden of cirrhosis and HCC (Spearman et al., 2023).

Co-infections of TB and viral hepatitis may worsen the quality of life and treatment outcomes for people living with HIV/AIDS (PLWHA) compared to those with only HIV. Although advancements in ART

have significantly lowered mortality rates among PLWHA and transformed HIV/AIDS into a manageable chronic condition, the increasing rates of TB, hepatitis B (HBV), and hepatitis C (HCV) co-infections pose a serious threat to the health of these individuals (Zhang et al., 2017). According to the World Health Organization (WHO), TB has become the leading cause of death among PLWHA, including those on ART (Furin et al., 2015). There is evidence that co-infections with viral hepatitis and TB may exacerbate health outcomes and survival rates in PLWHA compared to those with HIV mono-infection (Zhang et al., 2017). This study focuses on evaluating the co-infection of TB and hepatitis B virus among HIV patients receiving ART in Port Harcourt.

2. Materials and Methods

2.1. Study Area

This study aimed to assess the rates and correlates of tuberculosis (TB) and hepatitis B virus (HBV) co-infection among HIV patients receiving antiretroviral therapy (ART) at the HIV clinic of the Rivers State University Teaching Hospital (RSUTH), formerly known as Braithwaite Memorial Specialist Hospital (BMSH). RSUTH is a government-owned institution located in Old GRA, Rivers State, and was initially a General Hospital before being upgraded to serve as the teaching hospital for the College of Medical Services at Rivers State University.

2.2. Study Design

A hospital-based cross-sectional study design was employed. The methodology involved obtaining informed consent from participants and collecting blood samples through venipuncture. A structured questionnaire was administered to gather socio-demographic information such as age, sex, marital status, and educational background.

2.3. Sample Collection

Venipuncture was used to collect blood samples. A soft tourniquet was applied to the patient's upper arm, and the puncture site was disinfected with methylated spirit. Using a 3 ml syringe, blood was drawn, after which the tourniquet was released, and the needle removed. Approximately 3 ml of blood was collected into EDTA BA Vacutainer™ anti-coagulant tubes (BD, Franklin Lakes, USA), labeled with the patient's details. The plasma was then separated by centrifugation at 3,000 rpm for 5 minutes.

2.4. Serological Analysis

The plasma samples were tested for HBsAg at the Virus & Genomics Research Unit, Department of Microbiology, University of Port Harcourt. HBsAg test strips were used to detect the presence of HBsAg in the plasma. The procedure was conducted according to the manufacturer's guidelines, and the results were interpreted accordingly. Viral load analysis was carried out using the Abbott Real-Time protocol.

2.5. Data Analysis

Data collected from the study were analyzed using Excel and SPSS software. Statistical significance was determined at a 5% significance level for all analyses.

2.6. Ethical Consideration

Ethical approval for the study was obtained from the Rivers State University Teaching Hospital Health Research Ethics Committee.

3. RESULTS

3.1. Study Population Characteristics

A total of 200 confirmed HIV patients attending the HIV Clinic of Rivers State University Teaching Hospital, Port Harcourt, Rivers State participated in the study. Of the total number of individuals tested, 6.0% were below 18 years old, 15% were aged 18-32, 51.5% were aged 33-48, and 27.5% were above 49 years old. In terms of gender, 31.0% were male and 69.0% were female. Regarding marital status, 35.5% were single, 46% were married, and participant separated were 18.5%. For educational status, 7.5% were illiterate, 11.5% had primary education, 54% had secondary education, and 27% had tertiary education. Finally, for viral load, 74% had a plasma viral load (PVL) of less than 20 copies/ml, 20.5% had a viral load between 20-999 copies/ml, and 5.5% had a viral load above 1000 copies/ml. Characteristics of the study group are highlighted in Table 1.

Table 1. Patients Characteristics

Variables	No tested	Percentage (%)
AGE GROUP		
3 ≤17	12	6.0
18-32	30	15
33-48	103	51.5
≥49	55	27.5

GENDER		
Male	62	31
Female	138	69
MARITAL STATUS		
Single	71	35.5
Married	92	46
Separated	37	18.5
EDUCATIONAL STATUS		
Illiterate	15	7.5
Primary	23	11.5
Secondary	108	54
Tertiary	54	27
VIRAL LOAD		
Less than 20	148	74
20-999	41	20.5
More than 1000	11	5.5
Total	**200**	**100**

3.2. Overall Prevalence of HBV and Tuberculosis among the participants.

Of the 200 HIV-infected participants tested for TB and HBV, 2.5% were positive for TB and 3% for HBV (Figure 1).

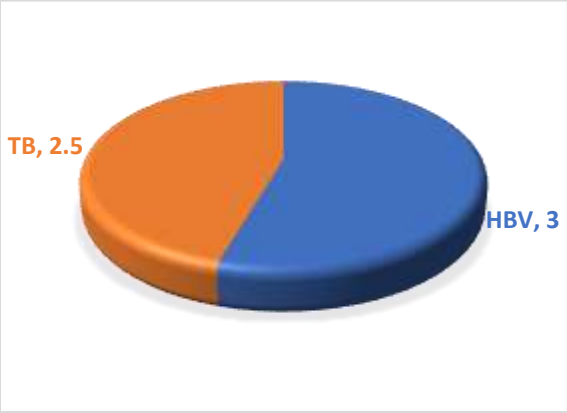

Figure 1: **Overall Prevalence of TB and HBV among the participants**

Table 2: Prevalence of TB and HBV among the participants based on their sociodemographic characteristics.

Variables	No tested	TB +ve (%)	HBV +ve (%)	P-value (TB)	P-value (HBV)
Age group					
≤17	12	0(0)	0 (0)		
18-32	30	0(0)	1(3.3)	0.574	0.590
33-48	103	4(3.9)	2(1.9)		
≥49	55	1(1.8)	3(5.5)		
GENDER					
Male	62	1(1.6)	3(4.8)	0.590	0.307
Female	138	4(2.9)	3(2.2)		
MARITAL STATUS					
Single	71	1(1.4)	3(4.2)		
Married	92	4(4.4)	2(2.2)	0.291	0.751
Separated	34	0(0)	1(4.0)		
EDUCATIONAL STATUS					
Illiterate	15	0	1(7.7)		

Primary	23	2(8.7)	0	0.232	0.679
Secondary	108	2(1.9)	3(2.8)		
Tertiary	54	1(1.9)	2(3.7)		
VIRAL LOAD					
Less than 20	148	2(1.4)	4(2.7)		
20-999	41	2(4.9)	2(4.9)	0.156	0.643
More than 1000	11	1(9.1)	0(0)		

3.3 The Prevalence of TB with the Sociodemographic Characteristics of the Participants

Of the 12 individuals tested who were below 18 years old, none were positive for TB. In the 18-32 age group, out of 30 individuals tested, there were no positive cases. In the 33-48 age group, 3.9% of the 103 individuals tested were positive for TB. Among those aged 49 and above, out of 55 individuals tested, 1.8% (one case) tested positive for TB. Out of 62 males tested, 1 (1.6%) was positive for TB, while among the 138 females tested, 4 (2.9%) were positive.

Among 71 single individuals tested, 1 (1.4%) was positive for TB. In the group of 92 married individuals, 4 (4.4%) tested positive. None of the 3 divorced individuals tested positive, and none of the 9 separated individuals tested positive for TB. Similarly, none of the 25 widowed individuals tested were positive for TB.

Of the 15 illiterate individuals tested, none (0%) were positive for TB. In the primary education group, 2 out of 23 individuals (8.7%) tested positive. Among the 108 individuals with secondary education, 2 (1.9%) were positive for TB. In the tertiary education group, 1 out of 53 individuals (1.9%) tested positive, while in the "Others" category, which included 1 individual, no cases of TB were found.

For individuals with a viral load of less than 20, out of 148 tested, 2 (1.4%) were positive for TB. Among those with a viral load between 20 and 999, 2 out of 41 individuals (4.9%) tested positive for TB. In the group with a viral load above 1000, 1 out of 11 individuals (9.1%) was positive for TB. There was no statistical association between the demographic variables and TB infection ($p > 0.05$) (Table 2)

3.4 The Prevalence of HBV with the Sociodemographic Characteristics of the Participant

Of the 12 individuals tested who were below 18 years old, none were positive for HBV. In the 18-32 age group, out of 30 individuals tested, 3.3% were positive for HBV. In the 33-48 age group, 103 individuals were tested, with 5.3% testing positive for HBV. Among those aged 33-40, out of 54 individuals tested, 1.9% were positive for HBV. In the 49 years and above age group, 5.5% of the 55 individuals tested were positive for HBV. Out of 62 males tested, 3 (4.8%) were positive for HBV, while among the 138 females tested, 3 (2.2%) were positive. Among 71 single individuals tested, 3 (4.2%) were positive for HBV. In the group of 92 married individuals, 2 (2.2%) tested positive for HBV. Among the 34 separated individuals tested, 1 (4.0%) was positive for HBV.

Among 15 illiterate individuals tested, 1 (7.7%) was positive for HBV. In the primary education group, none of the 23 individuals tested were positive for HBV. Among the 108 individuals with secondary education, 3 (2.8%) were positive. In the tertiary education group, 2 out of 54 individuals (3.7%) tested positive for HBV.

Among the 148 individuals with a viral load of less than 20, 4 (2.7%) were positive for HBV. In the group with a viral load between 20 and 999, 2 out of 41 individuals (4.9%) tested positive for HBV. None of the 11 individuals with a viral load above 1000 tested positive for HBV. However, there was no statistical association between the demographic variables and HBV infection ($p > 0.05$) (Table 2)

4. Discussion

The overall prevalence of *Mycobacterium tuberculosis* (MTB) infection in this study was 2.5%, which is slightly lower than the national average of 2.6%, as reported by the World Health Organization (WHO) in 2022. In comparison, Adhikari et al. (2022) found a higher TB prevalence of 9.9% among people living with HIV (PLHIV) in Nepal, while George et al. (2022) reported a prevalence of 9.79% in a study on TB prevalence and treatment compliance in Rivers State, South-South Nigeria, from 2010 to 2020. On the other hand, Patrick (2021) observed a much lower prevalence of 0.0527% in the same region. Okonko et al. (2018) reported a TB prevalence of 14.0% among HIV-infected patients in Port Harcourt, but in a later study in Cross River State, Nigeria, in 2020, the prevalence was found to be significantly lower at 1.4%. The variation in these figures could be due to the different populations studied, as some of these studies were conducted in hospital settings or communities where advanced AIDS cases were more common. Additionally, the differences in prevalence between studies may also be influenced by the diagnostic tools

or methodologies used for detecting HIV and *Mycobacterium tuberculosis* (Okonko et al., 2020).

Interestingly, Alex-Wele et al. (2021) recorded a much higher TB prevalence of 61.2% during the pandemic in Rivers State, which is substantially greater than the findings of this study. Regarding hepatitis B, this study found a prevalence of 3.0%, which is higher than the 2.0% prevalence reported by Okonko et al. (2020).

A recent meta-analysis on HBV and HIV co-infection rates in sub-Saharan Africa indicated that prevalence ranges from 0.0% to as high as 28.0%, with higher rates reported in West Africa (11.5%) and lower rates in East Africa (4.1%) (Stabinski et al., 2015; Boateng et al., 2019). In Lagos, Nigeria, Odukoya et al. (2022) reported a lower HBV prevalence of 2.1%, while Cookey et al. (2021) recorded a slightly higher prevalence of 3.1% in Port Harcourt, Nigeria. However, this is still lower than the 3.6% prevalence found by Ihongbe et al. (2022) in Ogun State, Nigeria.

The findings of this study do not align with those of Peebles et al. (2015), who reported a 10.0% HBV prevalence in Africa, or Boateng et al. (2019), who reported a rate of 12.5% in Kumasi, Ghana. In Vietnam, Huy et al. (2014) documented a general HBV prevalence of 8.4%. These variations in HBV prevalence may be attributed to regional differences, population characteristics, and diagnostic techniques used.

In terms of age, this study found a higher TB prevalence (3.9%) among individuals aged 33-48 years. This aligns with Okolo et al. (2023), who reported the highest TB prevalence (3.92%) in the 26-35 age group, followed by 1.59% among those aged 36-45. However, this contrasts with Okonko et al. (2020b), who observed that TB infections were more prevalent among patients over 45 years old. The age range identified in this study corresponds to a period of high occupational and sexual activity, which may elevate the risk of TB and other infections (Ayobami et al., 2022). There was no significant correlation between age and TB infection.

Concerning gender, this study found a higher TB prevalence among females (2.9%) compared to males (1.6%), in agreement with Fenta et al. (2020), who reported a 54% prevalence among women. The higher TB rate among women could be linked to riskier social behaviours and greater hospital attendance. This is consistent with WHO reports, which indicate that 51% of HIV-infected adults are women and that women in sub-Saharan Africa are particularly vulnerable to HIV infection, making up over 50% of the global HIV-infected population (Oko-Jaja & Igbigbi, 2017). The elevated prevalence among females may also stem from sociocultural and economic factors that lead to riskier sexual behaviours (Okonko et al., 2021). However, Kooffreh et al. (2016) observed a higher prevalence in males (44.6%) compared to females (29.0%). Gender is not significantly associated with TB infection. , (Table 2).

This study recorded the highest TB prevalence (4.4%) among married individuals, with singles having a prevalence of 1.4%, and no cases found among the separated. These findings align with Okonko et al. (2020b), who also reported the highest prevalence (2.3%) among married individuals. In contrast, Fenta et al. (2020) found a higher prevalence (49.2%) among the unmarried. A Chi-square test in this study showed no significant association between TB and marital status, consistent with the findings of Banda et al. (2021). However, this contradicts studies by Okolo et al. (2023) and Fenta et al. (2020), which found a significant link between marital status and TB prevalence.

A high TB prevalence (8.7%) was observed among patients with only primary education. Previous research has shown that TB infection is more common among HIV-positive patients with little or no formal education (Molaeipoor et al., 2014). However, this contrasts with Okonko et al. (2020b), who found the highest TB prevalence among individuals with tertiary education. Education status is not significantly associated with TB infection.

The highest TB prevalence (9.1%) was recorded among participants with a viral load exceeding 1,000 copies/ml, consistent with Okonko et al. (2020b), who observed the highest prevalence among patients with viral loads of fewer than 40 copies/ml. TB infections negatively impact immune response in HIV patients, accelerating the progression to AIDS, and leading to long-term immune suppression, increased viral load, and potential treatment failure. Individuals with a viral load of ≥ 1,000 copies/mL in two consecutive measurements, three months apart, after six months on a new antiretroviral regimen, are considered to have virological failure (Getaneh et al., 2022). A viral load exceeding 10,000 copies/ml increases the likelihood of TB-HIV co-infection by 12.1 times compared to those with viral loads below 10,000 copies/ml (Widiyanti et al., 2023). Viral load is not significantly associated with TB infection.

The highest prevalence of HBV (5.5%) was found among participants aged 49 years and above. This agrees with the findings of Omotala et al. (2019), who reported a seropositivity rate of 14.3% in the 40–49 age group, and Ekanem et al. (2013), who observed the highest prevalence (19%) among individuals aged 40-49 in Uyo. Okonko et al. (2023) also reported a prevalence of 2.2% among those 41 years and above.

However, these findings differ from Wasa and Maigana (2013), who documented a higher prevalence (18.2%) among individuals aged 16-30 years. While this study found no significant statistical association between age and HBV infection, the findings are consistent with Omotala et al. (2019), who also reported no significant association between age and HBV infection. This contradicts Demarchi et al. (2022) and Odita et al. (2023), who found higher HBV prevalence among younger age groups (21-30 and 14-16 years, respectively). There was no significant correlation between age and HBV infection.

The male HIV patients had a higher HBV infection rate (1.6%) than females (0.0%). This aligns with Okonko et al. (2020a), who reported a higher prevalence among males (2.3%) than females (1.8%), as well as Ekanem et al. (2013), who found that males were more likely to be co-infected (55.2%) than females (44.8%). Other studies, including Zafrin et al. (2019), Omatola et al. (2020), and Odita et al. (2023), have also reported higher male HBV prevalence. However, these findings contrast with Avwioro et al. (2014), who reported that females had a higher prevalence (5.0%) compared to males (3.5%), and Aliyu et al. (2013), who observed higher prevalence rates in females (11.5%-14.8%). There was no significant statistical association between gender and HBV infection in this study, which contradicts Okonko et al. (2015), who found a significant association between gender and HBV infection.

Regarding marital status, this study found the highest HBV prevalence among singles (4.2%), followed by separated individuals (4.0%) and married participants (2.2%). This is consistent with Agabi et al. (2024), who reported a higher prevalence among singles (3.8%), and Olayinka et al. (2016), who also found a higher prevalence among singles. Demarchi et al. (2022) and Innocent-Adiele (2021) similarly reported higher HBV prevalence among unmarried individuals in Brazil and Uyo, respectively. However, this contradicts Omotala et al. (2019), who found a higher prevalence (9.5%) among married individuals. No significant statistical association was found between marital status and HBV infection in this study, which aligns with Omotala et al. (2019) but contradicts findings that have reported significant associations between marital status and HBV infection.

The highest prevalence of HBV (7.7%) was observed among illiterate participants in this study. This agrees with Omotala et al. (2019), who reported a 16.7% prevalence among individuals with no formal education. Similar findings were reported by Omotala et al. (2020), who observed a higher prevalence among illiterate individuals. However, these findings differ from Agabi et al. (2024), which reported a higher prevalence (5.3%) among participants with tertiary education. Ihongbe et al. (2022) and Katamba et al. (2020) also found a higher prevalence among tertiary and primary school attendees, respectively. This study found no significant statistical association between educational level and HBV infection, which is consistent with Agabi et al. (2024) and Omotala et al. (2019), but contradicts Okonko et al. (2015), who found a significant association between education and HBV infection.

This study found a higher HBV prevalence (4.9%) among participants with viral loads of 20-999 copies/ml, compared to 0.0% among those with viral loads above 1,000 copies/ml, and 2.7% among participants with less than 20 copies/ml. These findings are consistent with Okonko and Shaibu (2023), who reported similar trends. However, they contradict Ugwu et al. (2023), who observed higher HBsAg prevalence among participants with undetectable viral loads (19.1%) and those with viral loads exceeding 1,000 copies/µl (17.1%). This study also found no significant association between HBV infection and increased viral load, in contrast to Ugwu et al. (2023), who reported significant associations between viral load and HBV infection.

5. Conclusion

The majority of the participants were within the age range of 33-40 years, predominantly females married, secondary education, and with viral load less than 20 copies/ml 74%. This study's findings demonstrated that the population is free of HCV. However, a high proportion of the participants had *H. pylori*, indicating endemicity in the study area. There was no co-infection between *H, pylori* and Hepatitis C. The current study's findings serve as a baseline for further research into *H. pylori* infection in the South-South region of Nigeria. Across all viral load ranges, the prevalence of the specific outcome appears to be relatively consistent indicating despite the difference in counts, the prevalence within each range is quite similar.

Acknowledgement

The authors appreciate everyone who agreed to participate in the study and the administration of the Rivers State University Teaching Hospital, Rivers State, Nigeria, for their approval.

Disclosure of conflict of interest

The authors claim that there are no conflicting interests.

Statement of ethical approval

All authors declare that all experiments have been examined and approved by the Rivers State University Teaching Hospital Health Research Ethics Committee. Therefore, the study is performed following the ethical standards.

Statement of informed consent

All authors declare that informed consent was obtained from all individual participants included in the study.

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