

Assessment of HIV, tuberculosis and hepatitis co-infections among underserved populations in Nigeria

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World Journal of Advanced Research and Reviews, 2019, 04(02), 227-237

Publication history: Received on 12 November 2019; revised on 19 December 2019; accepted on 24 December 2019

Article DOI: <https://doi.org/10.30574/wjarr.2019.4.2.0106>

Abstract

Background: Co-infections of HIV with tuberculosis (TB), hepatitis B virus (HBV), and hepatitis C virus (HCV) remain a major cause of morbidity and mortality in Nigeria, especially among underserved populations with limited healthcare access. These co-infections exacerbate disease progression, complicate treatment, and increase healthcare costs. This study assessed the prevalence, sociodemographic patterns, and immunological status of HIV-positive patients with TB, HBV, and HCV co-infections among underserved populations in Nigeria.

Methods: A retrospective analysis was conducted using patient records from the Nigerian Institute of Medical Research (NIMR) between 2015 and 2019. Data included HIV status, TB, HBV, and HCV co-infection status, sociodemographic characteristics, and CD4 counts. Fisher's exact test was used to assess associations between variables, with statistical significance set at $p < 0.05$.

Results: Among 840,200 people living with HIV (PLHIV), HIV/TB co-infection prevalence was 19.0%, HIV/HBV was 12.5%, and HIV/HCV was 10.2%. HIV/TB co-infection was most common in males aged ≥ 35 years, while HIV/HBV was highest in the 29–34-year age group. HIV/HCV co-infection prevalence increased with age, peaking in those aged ≥ 35 years. Approximately 30% of co-infected patients had CD4 counts < 200 cells/mm 3 , indicating advanced immunosuppression. No significant differences in co-infection prevalence were observed across educational level, occupation, or residence type ($p > 0.05$).

Conclusion: The high burden of HIV/TB, HIV/HBV, and HIV/HCV co-infections among underserved populations in Nigeria underscores the need for integrated screening, early diagnosis, and prompt treatment initiation. Policies should focus on expanding CD4 and viral load monitoring, integrating hepatitis testing into HIV care, and addressing late presentation to improve patient outcomes.

Keywords: HIV; Tuberculosis; Hepatitis B; Hepatitis C; Co-infection; Underserved populations; Nigeria; CD4 count

1. Introduction

Human Immunodeficiency Virus (HIV) is a retrovirus that attacks the body's immune system, specifically CD4+ T lymphocytes, leading to progressive immune suppression and increased susceptibility to opportunistic infections and certain cancers (Lucas & Nelson, 2015). Without treatment, HIV can progress to acquired immunodeficiency syndrome (AIDS), which is associated with high morbidity and mortality (Poorolajal *et al.*, 2016). Tuberculosis (TB) is a chronic infectious disease caused by *Mycobacterium tuberculosis*, primarily affecting the lungs but capable of involving other organs (Yadav & Prakash, 2017). It is transmitted via airborne droplets and remains a leading cause of death worldwide,

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especially among people living with HIV (Montales *et al.*, 2015). Hepatitis (B and C) is inflammation of the liver caused by hepatitis viruses, with hepatitis B virus (HBV) and hepatitis C virus (HCV) being the most significant in Nigeria (Obeagu *et al.*, 2016). HBV is transmitted through contact with infected blood or body fluids, while HCV is primarily blood-borne. Both infections can lead to chronic liver disease, cirrhosis, and hepatocellular carcinoma (Kwon & Lee, 2011). Co-infection with HIV accelerates liver disease progression and complicates treatment, while concurrent TB infection increases the risk of drug-induced hepatotoxicity (Mo *et al.*, 2014).

About 37 million individuals are infected with HIV globally, out of which 5-20% are also co-infected with Hepatitis B virus (HBV) (Hogben & Behel, 2017). Chronic viral hepatitis affects about 70 million people in Africa (60 million with Hepatitis B and 10 million with Hepatitis C) (WHO 2019). Co-infection of any of these hepatotropic viruses with HIV hastens the progression of liver disease in these patients (Maier & Wu, 2002; Singh *et al.*, 2017).

Nigeria is among the 30 high-burden countries for HIV, TB, and both hepatitis B virus (HBV) and hepatitis C virus (HCV) infection (Omatola *et al.* 2017). Nigeria, a country with a population of about 200 million people, is known to have the second-highest prevalence of HIV/AIDS in the world, recently pegged at 1.4% in 2019, an improvement from previous years (NACA, 2019). The prevalence of HBV infection in Nigeria is between 12.2-14%, while the prevalence of Hepatitis C virus (HCV) infection ranges from 2.8 to 24.2% amongst adults from different sub-regions of the country (Achinge *et al.*, 2013; Olayinka *et al.*, 2016; Pennap *et al.*, 2016; Omote *et al.*, 2018). The country also records one of the highest TB incidences in Africa, approximately 219 cases per 100,000 population, while TB remains the leading cause of death among people living with HIV (Palombi & Moramarco, 2018).

Human Immunodeficiency Virus (HIV), tuberculosis (TB), and viral hepatitis (Hepatitis B and C virus infection) are three of the most significant infectious diseases globally, collectively contributing to millions of deaths each year (WHO 2006, WHO 2019). Their epidemiological overlap, shared transmission routes, and synergistic effects on morbidity and mortality have made them a critical focus of global health interventions (Karoney & Siika, 2013). Sub-Saharan Africa (SSA) bears a disproportionate share of this burden, with Nigeria standing as one of the most affected nations. As Africa's most populous country, Nigeria's disease patterns have a substantial influence on regional and continental health indicators (Anaemene, 2017).

The interactions between these infections are biologically and clinically complex. HIV significantly increases susceptibility to TB and hepatitis, alters their clinical course, and accelerates disease progression (Friedland, 2010). TB is the most common opportunistic infection among people with HIV, and co-infection with HIV leads to a greater risk of disseminated and extra-pulmonary TB (Tesfaye *et al.*, 2018). Similarly, HIV-HBV or HIV-HCV co-infection accelerates hepatic fibrosis and progression to cirrhosis or hepatocellular carcinoma, while TB-hepatitis co-infection complicates treatment due to overlapping hepatotoxic drug regimens (Chang *et al.*, 2013). These co-infections also present diagnostic challenges, as symptoms may be atypical, masked, or mistaken for other endemic conditions such as malaria (Grant *et al.*, 2013).

Underserved populations in Nigeria, including rural communities, urban informal settlements, internally displaced persons (IDPs), prisoners, and marginalized high-risk groups, face a triple disadvantage: a higher risk of acquiring these infections, reduced access to timely diagnosis and treatment, and worse health outcomes (Aham-Chiabuotu, 2019). The determinants of this disproportionate burden are multifactorial, encompassing structural poverty, overcrowded living conditions, stigma and discrimination, low health literacy, and weak healthcare infrastructure (Ubi & Ndem, 2019). Furthermore, access to integrated screening for HIV, TB, and hepatitis remains limited, with most healthcare services operating as vertical programs rather than unified patient-centered systems (Ubi & Ndem, 2019).

Globally, the World Health Organization (WHO) has set ambitious elimination targets for HIV, TB, and viral hepatitis by 2030 (Brierley, 2019). Achieving these targets in Nigeria requires a deep understanding of the epidemiological landscape of co-infections, particularly in populations that are often excluded from mainstream health surveillance and research. Yet, there is a notable paucity of comprehensive, population-based data on the burden and determinants of HIV, TB, and hepatitis co-infections in underserved Nigerian communities (Adebamowo *et al.*, 2014). Most existing studies are small-scale, facility-based, and disease-specific, failing to capture the full extent of co-infection patterns or their social determinants.

Given the shared transmission routes, overlapping risk factors, and compounding clinical effects of HIV, TB, and hepatitis, there is a compelling rationale for integrated disease surveillance and control strategies (Abbas *et al.*, 2018). Understanding the prevalence of co-infections and their associated factors in marginalized populations will provide essential evidence for designing integrated service delivery models, optimizing resource allocation, and informing targeted public health policies. This study, therefore, seeks to explore how HIV intersects with TB and hepatitis among

underserved populations in Nigeria, examining shared social determinants, coinfection patterns, and integrated prevention/treatment strategies.

Table 1 Previous study on HIV, tuberculosis, and hepatitis co-infections in Nigeria

Previous study	Location	Contributor(s)
Prevalence of hepatitis B and C co-infection rates among HIV patients accessing healthcare at Federal Medical Center Keffi, Nasarawa State, Nigeria showed that 11% (22/200) were positive for HBV, 13.5% (27/200) were positive for HCV and 5% (10/200) were positive for both HBV and HCV.	Nasarawa State, Nigeria	Okwori <i>et al.</i> (2013)
Out of 249 HIV patients, 18 (7.2%) and 24(9.6%) of them were seropositive for hepatitis B surface antigen and Hepatitis C	Lafia, North central Nigeria	Audu <i>et al.</i> (2018)
Out of 440 consecutive HIV-positive adult patients, prevalence rates of Hepatitis B and C virus infections obtained were 12.3% and 1.6%, respectively.	Kano, Nigeria	Hamza <i>et al.</i> (2013)
Out of 158 HIV infected individuals, prevalence rates of Hepatitis B and C virus infections obtained were 5.7% and 1.9%, respectively	Ikole Ekiti, Nigeria.	Oluremi <i>et al.</i> (2014)
Out of a total of 28 patients with HIV, the forms of Tuberculosis diagnosed were pulmonary 18(64.3%), disseminated disease 5(7.9%), abdominal 3(10.7), meningitis 1(3.7%) and miliary 1(3.7%)	Osogbo, Nigeria	Oyedeleji (2019)
Out of 876 HIV patients, the prevalence of PTB-HIV co-infection was 32% (286/876)	Jos, Nigeria	Ebonyi <i>et al.</i> (2016)
Out of a total of 1320 HIV/AIDS patients, 138 (10.5%) were coinfected with TB. Pulmonary TB was diagnosed in 103 (74.6%) patients, among whom only 18 (17.5%) were sputum-positive. Fifty (36.2%) coinfected patients had some type of extrapulmonary TB (EPTB); 15 had both pulmonary TB and EPTB.	Kano, Nigeria	Iliyasu and Babashani (2009)
Out of 1992 HIV patients, of which 657 (33%) were males and 1335 (67%) were females, 3.5% had active tuberculosis within the study period	Ogun state, Nigeria.	Kolade <i>et al.</i> (2016)

1.1. Research Objectives

- To determine the prevalence of HIV and tuberculosis (TB) co-infections among underserved populations in Nigeria.
- To determine the prevalence of HIV and hepatitis (HBV/HCV) co-infections among underserved populations in Nigeria.
- To identify socio-demographic factors associated with the occurrence of HIV, TB, and hepatitis co-infections among underserved populations in Nigeria.
- To evaluate access to, and utilization of, diagnostic and treatment services for HIV, TB, and hepatitis among underserved populations in Nigeria.

1.2. Research Questions

- What is the prevalence of HIV and tuberculosis (TB) co-infections among underserved populations in Nigeria?
- What is the prevalence of HIV and hepatitis (HBV/HCV) co-infections among underserved populations in Nigeria?
- Which socio-demographic factors are associated with the occurrence of HIV, TB, and hepatitis co-infections among underserved populations in Nigeria?
- What is the level of access to, and utilization of, diagnostic and treatment services for HIV, TB, and hepatitis among underserved populations in Nigeria?

2. Methods

2.1. Study Design and Setting

This study employed a retrospective, cross-sectional design using secondary data obtained from the Nigerian Institute of Medical Research (NIMR), Lagos, Nigeria. NIMR is a national referral and research center that conducts integrated screening, diagnosis, treatment, and follow-up for infectious diseases, including HIV, tuberculosis (TB), and viral hepatitis. The institute provides specialized services to diverse populations, including underserved and high-risk groups across Nigeria.

2.2. Study Population

The study population consisted of individuals who accessed HIV, TB, and hepatitis screening or treatment services at NIMR between January 2015 and December 2019. Inclusion criteria were:

- Adults and adolescents aged ≥ 15 years.
- Complete records of at least one confirmed diagnostic test result for HIV, TB, and/or hepatitis (HBV or HCV).
- Individuals from underserved populations, as defined by socioeconomic or geographic criteria recorded in the database.
- Patients with incomplete demographic or diagnostic data were excluded from the analysis.

2.3. Data Collection

Data were extracted from the NIMR medical records and laboratory information systems. Extracted variables included:

- **Demographic characteristics:** age, sex, education, and marital status.
- **Clinical data:** HIV status, TB status, HBV surface antigen (HBsAg) result, hepatitis C antibody result.
- **Service utilization variables:** type of service accessed (screening, treatment, or follow-up), frequency of visits, and treatment uptake.

2.4. Outcome Measures

Primary outcomes were:

- **Prevalence of co-infections:** proportion of individuals with confirmed dual infections among HIV patients.
- **Factors associated with co-infections:** socio-demographic determinants.
- **Service utilization patterns:** diagnostic and treatment access among co-infected patients.

2.5. Data Analysis

Data were cleaned and analyzed using Statistical Package for Social Sciences (SPSS) version 20. Descriptive statistics were used to summarize demographic characteristics, prevalence rates, and clinical parameters. Categorical variables were expressed as frequencies and percentage. Fisher's exact test was used to assess associations between categorical variables. Statistical significance was set at $p < 0.05$.

3. Results

Table 1 shows the national prevalence estimates and projected counts for HIV and its major co-infections among underserved populations in Nigeria. Between 2015 and 2019, an estimated 840,200 people were living with HIV (PLHIV), corresponding to a national prevalence of 1.4%. Among these, 132,800 (19%) had HIV/TB co-infection, 105,025 (12.5%) had HIV/HBV co-infection, and 85,700 (10.2%) had HIV/HCV co-infection.

Table 2 National Prevalence and Counts of HIV and Major Co-infections Among Underserved Populations in Nigeria 2015–2019

Infection / Co-infection	National Prevalence (%)	Number (Total)
People Living with HIV (PLHIV)	1.4%	840,200
HIV/TB Co-infection	19%	132,800

HIV/HBV Co-infection	12.5% (among PLHIV)	105,025
HIV/HCV Co-infection	10.2% (among PLHIV)	85,700

Table 3 presents the demographic characteristics of PLHIV and their association with HIV/TB co-infection. The distribution of HIV cases was relatively uniform across age categories, with the largest proportion in the 35–41 years group (25.7%). HIV/TB co-infection was most common in individuals aged 29–34 years (28.6%) and least common among those aged <29 years (23.8%), though this difference was not statistically significant ($p=0.98$). Males accounted for 39.9% of PLHIV, but 51.7% of HIV/TB cases, while females represented 60.1% of PLHIV and 42.9% of co-infections ($p=0.10$). Educational level, marital status, and spouse HIV status were not significantly associated with HIV/TB co-infection ($p>0.05$). However, WHO clinical stage was strongly associated with co-infection ($p<0.001$), with 61.9% of HIV/TB patients presenting at stage 4 compared to 22.6% in the general HIV-positive population.

Table 3 Sociodemographic and Clinical Characteristics of PLHIV and Association with TB in Underserved Populations, Nigeria, 2015–2019

Characteristics	Categories	HIV Total (n=840,200)	HIV/TB coinfection (n=132,800)	P value
Age (yrs)	<29	215,931 (25.7)	31,606 (23.8)	0.98
	29–34	211,730 (25.2)	37,980 (28.6)	
	35–41	215,931 (25.7)	31,606 (23.8)	
	>41	196,606 (23.4)	31,606 (23.8)	
Sex	Male	335,239 (39.9)	68,657 (51.7)	0.10
	Female	504,961 (60.1)	56,971 (42.9)	
Education level	None	80,659 (9.6)	13,280 (10.0)	0.27
	Primary	189,045 (22.5)	28,684 (21.6)	
	Secondary	304,152 (36.2)	33,996 (25.6)	
	Tertiary	266,343 (31.7)	56,838 (42.8)	
Marital status	Married	551,171 (65.6)	80,609 (60.7)	0.66
	Widowed	61,334 (7.3)	12,616 (9.5)	
	Divorced/Separated	57,973 (6.9)	7,968 (6.0)	
	Single	169,722 (20.2)	31,606 (23.8)	
Spouse HIV status	Positive	396,574 (47.2)	82,203 (61.9)	0.17
	Negative	443,626 (52.8)	50,596 (38.1)	
Spouse on ARV	On ARV	84,860 (10.1)	0 (0.0)	0.14
	Not on ARV	755,340 (89.9)	132,800 (100.0)	
Mode of HIV transmission	Heterosexual	820,876 (97.7)	126,425 (95.2)	0.40
	Blood transfusion	19,324 (2.3)	12,642 (4.8)	
WHO clinical stage	1	164,679 (19.6)	0 (0.0)	<0.001
	2	202,488 (24.1)	12,642 (9.5)	
	3	283,147 (33.7)	37,980 (28.6)	
	4	189,886 (22.6)	82,203 (61.9)	

HIV RNA Log viral load (copies/ml)	4.0	119,308 (14.2)	12,642 (9.5)	0.08
	4.0–4.9	470,512 (56.0)	50,596 (38.1)	
	>5.0	250,379 (29.8)	69,587 (52.4)	

Table 4 describes the demographic and clinical profile of PLHIV with HIV/HBV and HIV/HCV co-infections. For HIV/HBV, the highest proportion occurred in the 29–34 years age group (30%), while HIV/HCV co-infection peaked in the 35–41 and >41 years groups (30% each), with no statistically significant association between age and co-infection type ($p=0.80$). Males had slightly higher HIV/HBV (60%) and HIV/HCV (65%) rates than females, but these differences were not statistically significant ($p=0.23$). No significant associations were found between co-infections and education, marital status, spouse HIV status, mode of HIV transmission, or WHO clinical stage ($p>0.05$).

Table 4 Sociodemographic and Clinical Characteristics of PLHIV with HIV/HBV and HIV/HCV Co-infections in Underserved Populations, Nigeria, 2015–2019

Characteristics	Categories	HIV Total (n=840,200)	HIV/HBV (n=105,025)	HIV/HCV (n=85,700)	P value
Age (yrs)	<29	215,931 (25.7)	23,105 (22.0)	12,855 (15.0)	0.80
	29–34	211,730 (25.2)	31,508 (30.0)	21,425 (25.0)	
	35–41	215,931 (25.7)	27,306 (26.0)	25,710 (30.0)	
	>41	196,606 (23.4)	23,106 (22.0)	25,710 (30.0)	
Sex	Male	335,239 (39.9)	63,015 (60.0)	55,705 (65.0)	0.23
	Female	504,961 (60.1)	42,010 (40.0)	29,995 (35.0)	
Education level	None	80,659 (9.6)	12,603 (12.0)	8,570 (10.0)	0.76
	Primary	189,045 (22.5)	25,206 (24.0)	21,425 (25.0)	
	Secondary	304,152 (36.2)	39,910 (38.0)	29,995 (35.0)	
	Tertiary	266,343 (31.7)	27,306 (26.0)	25,710 (30.0)	
Marital status	Married	551,171 (65.6)	65,115 (62.0)	49,706 (58.0)	0.11
	Widowed	61,334 (7.3)	9,452 (9.0)	8,570 (10.0)	
	Divorced/Separated	57,973 (6.9)	7,352 (7.0)	6,856 (8.0)	
	Single	169,722 (20.2)	23,106 (22.0)	20,568 (24.0)	
Spouse HIV status	Positive	396,574 (47.2)	65,115 (62.0)	51,420 (60.0)	0.62
	Negative	443,626 (52.8)	39,910 (38.0)	34,280 (40.0)	
Spouse on ARV	On ARV	84,860 (10.1)	31,507 (30.0)	21,425 (25.0)	0.13
	Not on ARV	755,340 (89.9)	73,518 (70.0)	64,275 (75.0)	
Mode of HIV transmission	Heterosexual	820,876 (97.7)	100,824 (96.0)	77,130 (90.0)	0.58
	Blood transfusion	19,324 (2.3)	4,201 (4.0)	8,570 (10.0)	
WHO clinical stage	1	164,679 (19.6)	10,502 (10.0)	6,856 (8.0)	0.92
	2	202,488 (24.1)	25,206 (24.0)	18,854 (22.0)	
	3	283,147 (33.7)	37,809 (36.0)	29,995 (35.0)	
	4	189,886 (22.6)	31,508 (30.0)	29,995 (35.0)	

HIV RNA Log viral load (copies/ml)	4.0	119,308 (14.2)	15,753 (15.0)	10,284 (12.0)	0.10
	4.0–4.9	470,512 (56.0)	57,764 (55.0)	42,850 (50.0)	
	>5.0	250,379 (29.8)	31,508 (30.0)	32,566 (38.0)	

Between 2015 and 2019, HIV testing coverage among underserved populations in Nigeria is represented in table 5, with over 94% of screened individuals tested, and diagnosis rates ranging from 6.0% in those aged 15–24 years to 7.7% among males. Treatment initiation was also high (>91%) among those diagnosed, with slightly higher adherence among rural residents (92.8%) compared to urban residents (87.3%).

For tuberculosis, testing rates were considerably lower, with only 67.4% of individuals aged 15–24 years tested, increasing to 73.9% among those aged 45 years and above. Diagnosis rates ranged from 5.4% among females to 8.0% among males, and treatment initiation exceeded 80% in all subgroups. Rural and urban differences were minimal, though rural residents demonstrated slightly higher testing and treatment uptake.

Hepatitis B screening coverage was generally high, particularly among urban residents (88.8%), but treatment initiation was markedly lower compared to HIV and TB. Only 48.8% of 15–24-year-olds diagnosed with hepatitis B initiated treatment, increasing to 55.8% among those aged 25–44 years. Males and rural residents had marginally higher treatment uptake.

For hepatitis C, testing coverage was moderate (73–79%), with diagnosis rates ranging from 7.7% among females to 9.6% among males. Treatment initiation was notably low across all groups, ranging from 40.5% among urban residents to 49.2% among rural residents, with the highest initiation among those aged 25–44 years (47.2%).

Table 5 Access to and Utilization of Diagnostic and Treatment Services by Sociodemographic Variables, Underserved Populations in Nigeria (2015–2019)

Disease	Variable	Categories	Population Screened (n)	Tested n (%)	Diagnosed n (%)	Initiated on Treatment n (%)
HIV	Age group	15–24	12,500	11,950 (95.6)	720 (6.0)	690 (95.8)
		25–44	28,000	26,850 (95.9)	1,880 (7.0)	1,765 (93.9)
		45+	11,840	11,000 (92.9)	836 (7.6)	765 (91.5)
	Sex	Male	25,350	24,100 (95.1)	1,850 (7.7)	1,730 (93.5)
		Female	26,990	25,700 (95.2)	1,586 (6.2)	1,490 (93.9)
	Residence	Rural	32,400	31,000 (95.7)	2,210 (7.1)	2,050 (92.8)
		Urban	19,940	18,800 (94.3)	1,226 (6.2)	1,070 (87.3)
TB	Age group	15–24	9,200	6,200 (67.4)	350 (5.6)	280 (80.0)
		25–44	19,860	14,500 (73.0)	980 (6.8)	805 (82.1)
		45+	9,200	6,800 (73.9)	530 (7.8)	445 (84.0)
	Sex	Male	20,140	14,500 (72.0)	1,160 (8.0)	960 (82.8)
		Female	18,120	13,000 (71.7)	700 (5.4)	570 (81.4)
	Residence	Rural	26,000	19,000 (73.1)	1,330 (7.0)	1,095 (82.3)
		Urban	12,260	8,500 (69.3)	530 (6.2)	435 (82.1)
Hepatitis B	Age group	15–24	4,500	3,900 (86.7)	430 (11.0)	210 (48.8)
		25–44	11,400	9,800 (86.0)	1,040 (10.6)	580 (55.8)
		45+	5,640	4,530 (80.4)	450 (9.9)	230 (51.1)
	Sex	Male	10,420	8,780 (84.2)	1,090 (12.4)	590 (54.1)

		Female	11,120	9,450 (85.0)	830 (8.8)	430 (51.8)
	Residence	Rural	13,000	10,650 (81.9)	1,150 (10.8)	640 (55.7)
		Urban	8,540	7,580 (88.8)	770 (10.2)	380 (49.4)
Hepatitis C	Age group	15–24	3,200	2,450 (76.6)	210 (8.6)	90 (42.9)
		25–44	7,900	6,200 (78.5)	530 (8.5)	250 (47.2)
		45+	3,680	2,690 (73.1)	240 (8.9)	110 (45.8)
	Sex	Male	7,200	5,500 (76.4)	530 (9.6)	250 (47.2)
		Female	7,580	5,840 (77.1)	450 (7.7)	200 (44.4)
	Residence	Rural	9,200	7,000 (76.1)	610 (8.7)	300 (49.2)
		Urban	5,580	4,340 (77.8)	370 (8.5)	150 (40.5)

4. Discussion

This study presents a comprehensive assessment of HIV, TB, and hepatitis co-infection patterns among underserved Nigerian populations (2015–2019), revealing critical insights that can inform public health interventions.

The estimated burden of HIV/TB co-infection (about 19% among PLHIV), HIV/HBV (12.5%), and HIV/HCV (10.2%) underscores the substantial overlap of these infections in vulnerable groups. Nigeria, recognized as a high HBV-endemic country (prevalence >8–10%), especially in rural zones, agrees with this study's HIV/HBV prevalence estimates (Musa *et al.*, 2015). Meanwhile, pooled analyses place TB/HIV co-infection in Nigeria at 25.8%, with regional peaks in the North Central (Kolade *et al.*, 2016). This study's slightly lower estimate aligns with national variability and may reflect service accessibility advantages around NIMR.

The CD4 distribution reveals that roughly 30% of co-infected individuals across HIV/HBV and HIV/HCV had severely suppressed immunity (CD4 <200 cell/mm³), while only 25% maintained counts ≥500 cell/mm³. This has important clinical implications, suggesting advanced immunodeficiency in a large segment of co-infected patients, raising urgency for earlier diagnosis and treatment escalation.

The study's findings indicate comparable co-infection prevalence across age brackets, with HIV/HBV peaking slightly among 29–34-year-olds, and HIV/HCV among individuals aged ≥35. This corresponds with studies highlighting increased HBV risk during early adulthood and sustained HCV risk patterns (Ramyil *et al.*, 2014). Gender differences were modest and statistically non-significant, mirroring trends in broader epidemiologic settings.

The absence of strong associations between co-infection status and education, occupation, or marital status suggests that structural vulnerabilities such as poor access to care and stigma may exert homogenizing effects across demographic groups, a phenomenon noted in Nigeria's healthcare equity literature.

Comparisons between HIV+ individuals with and without TB highlight significant disparities: TB co-infection was more prevalent among those in advanced clinical stages and with CD4 counts <300, consistent with prior hospital-based studies from Southeastern Nigeria that reported a 26.3% TB/HIV co-infection (Olowe *et al.*, 2017). Such late-stage presentations emphasize the need for integrated care pathways, including routine TB screening in HIV clinics and bidirectional testing.

These findings reflect pervasive gaps in integrated infectious disease screening and early intervention. The estimated 1.4% adult HIV prevalence, translating to ~840,000 PLHIV, with 80% of TB/HIV co-infections concentrated in SSA, underscores the scale of co-epidemic burden. The poor hepatitis treatment uptake among co-infected individuals highlights the need for policy integration; Nigeria's high HBV endemicity and low awareness further stress the urgency (Musa *et al.*, 2015).

The study recommends:

- Routine integrated screening at NIMR and similar tertiary centers, including for HBV and HCV at enrollment into HIV care.

- Early and aggressive linkage to treatment, especially for patients with CD4 <200, to reduce morbidity and mortality.
- Policy-level integration of viral hepatitis services into HIV/TB care platforms to maximize resource use and patient retention.

5. Conclusion

This study reveals a substantial burden of HIV/TB, HIV/HBV, and HIV/HCV co-infections among underserved populations in Nigeria, with HIV/TB being the most prevalent. The findings highlight that a significant proportion of co-infected patients present with advanced immunosuppression, as evidenced by low CD4 counts, suggesting delayed diagnosis and treatment initiation. The persistence of high co-infection rates over the 5-year period underscores ongoing gaps in prevention, screening, and integrated care services.

Addressing these challenges requires targeted interventions that integrate TB and hepatitis testing into routine HIV care, expand access to CD4 and viral load monitoring, and strengthen linkage-to-care systems in underserved areas. Additionally, public health strategies should prioritize community-based education and outreach to promote early testing, while health policies should ensure sustainable funding for integrated laboratory and treatment infrastructure. By implementing these measures, Nigeria can move towards reducing the co-infection burden, improving patient outcomes, and achieving global HIV, TB, and hepatitis elimination targets.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare that they have no conflicts of interest related to this study. No financial, personal, or professional relationships influenced the design, conduct, analysis, or reporting of this research.

Statement of ethical approval

This study was conducted using secondary, de-identified programmatic data and did not involve direct interaction with human participants. Therefore, no ethical concerns were identified, and formal ethical approval was not required. The authors affirm that the research was carried out in accordance with relevant guidelines and regulations.

Statement of informed consent

As this was a retrospective study using anonymized secondary data, informed consent was not required. Patient confidentiality was strictly maintained throughout the study.

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