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Association Between Tuberculosis and CD4 T-Cells Among HIV Infected Patients Attending Specialist Hospital Sokoto.

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Abstract

Patients with Human Immunodeficiency Virus (HIV) infection are predisposed to numerous opportunistic infections due to decreased cell mediated immunity. Tuberculosis is the most common opportunistic infections seen in HIV patients that contribute significantly to HIV-related morbidity and mortality throughout the world, especially in developing countries like Nigeria. People living with HIV accounted for 10% of the new TB cases reported worldwide. This cross-sectional study investigated the relationship between tuberculosis (TB) and CD4 T-cell counts among newly diagnosed HIV patients in Sokoto, Nigeria. A total of 154 HIV-positive individuals were enrolled, with 35.7% presenting with CD4 counts below 200 cells/µL, indicating severe immunosuppression. Despite the low CD4 levels, only 5.4% of these patients tested positive for TB, suggesting that factors such as prophylactic treatments or healthcare quality might be mitigating TB incidence. The study also revealed that TB was more prevalent among married individuals and those aged 31-60, highlighting specific demographic vulnerabilities. Socioeconomic factors, including limited formal education and occupation types, were significantly associated with low CD4 counts and TB co-infection, especially among the Hausa/Fulani ethnic group. These findings underscore the need for early HIV detection, integrated healthcare services, and targeted public health interventions that address both medical and social determinants of health to reduce TB burden among HIV-positive populations in Sokoto and similar settings.

Keywords: Tuberculosis, CD4 cells and Human Immunodeficiency Virus

Introduction

Patients with Human Immunodeficiency Virus (HIV) infection are predisposed to numerous opportunistic infections due to decreased cell mediated immunity (Arora *et al*., 2015). Tuberculosis (TB) is the most common opportunistic infections seen in HIV patients, that contribute to significant morbidity and mortality throughout the world, especially in developing countries like Nigeria (Arora *et al*., 2015). Overall, HIV patients have 8-fold higher risk of TB than non-HIV people (Satyanarayan etal., 2018). It is estimated that around 60-70% of patients with HIV infection develop TB in their lifetime (Swaminathan *et al*., 2000). HIV-TB co-infection has become a huge hurdle for achieving tuberculosis control in Nigeria. HIV-TB co-infection is a serious public health issue in Nigeria, where there is an extremely high rate of TB among HIV-positive individuals. According to studies, 19.1% of important groups in Nigeria living with HIV also have TB infection, with differences depending on demographic characteristics including age and region (Bartholomew *et al.,* 2024). About 80% of cases of co-infection have been reported in sub-Saharan Africa, where it is especially common (Ikechukwu *et al.,* 2024). Diagnosing TB in HIV-positive patients is particularly difficult due to unusual presentations caused by the immunocompromised state created by HIV. A compromised immune system can cause non-specific symptoms and extrapulmonary signs of tuberculosis, confounding the clinical picture and

delaying diagnosis (Sharma *et al*., 2024). Furthermore, standard diagnostic procedures, such as sputum smear microscopy, frequently produce low sensitivity in this population, and immunological testing may be erroneous due to the impaired immune response (Liqin *et al*., 2023). The lack of systematic approaches in medical institutions further exacerbates these diagnostic difficulties, as many healthcare providers may not be adequately alert to the possibility of TB in HIV patients (Chan *et al*., 2024). The burden of TB among people living with HIV is exacerbated by socio-economic factors, low CD4 counts, and gender disparities, with females showing a higher risk (Olowookere *et al*., 2023). So, it is important to study impact of CD4 counts and development of tuberculosis in People living with HIV (PLHIV). This study addresses the lack of understanding of how CD4 counts influence the development of tuberculosis in people living with HIV. While existing studies show a link between low CD4 counts and higher TB risk, they frequently lack complete longitudinal data and do not investigate the intricacies of this connection across diverse populations. A study indicated that a baseline CD4 count below 200 cells/mm³ greatly increased the chance of tuberculosis, with 42.1% of patients developing the disease despite ART (Nikhil *et al*., 2024). Another study found that PLHIV with a history of tuberculosis have a bigger HIV reservoir, limiting treatment outcomes (Juste *et al.,* 2024). Another study indicated that PLHIV with a history of TB had a larger HIV reservoir, complicating treatment outcomes. Furthermore, the variability in clinical presentations of TB as CD4 counts decrease suggests a need for tailored diagnostic approaches (Sourabh *et al.,* 2023). The aim of this study is to fill these gaps by investigating the relationship between tuberculosis and CD4 T-Cells in HIV-infected patients attending specialist hospital in Sokoto, North West Nigeria.

Materials and Method

Study Design

This study determined the association between Tuberculosis (TB) with CD4 T-cells in HIV infected patients attending Specialist Hospital Sokoto.

Study Area

This study focusses on the Sokoto metropolis in Sokoto State, northwest Nigeria. It has boundaries with Niger Republic to the north, Kebbi State to the south-west, and Zamfara State to the east (SSBD, 2007). The city is located between longitude 05o 42" to 22" East and latitude 12o 15" to 29" North, covering an area of 60.33 km² (SSBD, 2007). The study area's indigenous population is predominantly Hausa and Fulani. Other ethnic groups living in the area include Igbo, Yoruba, Nupe, Ibira, and Igala.

Study Population

This study recruited HIV patients attending Specialist Hospital in Sokoto, North Western Nigeria for the purpose of study.

Sample Size Determination

The sample size was calculated using the formula below;

$n = Z^2pq/d^2$

Where,

n = Minimum required sample size
z = Standard Normal deviation (1.96)
p = Population of success or prevalence (10.5%) (Iliyasu Z *et al.,* 2009
q = 1 – p
d = Precision tolerance margin of error (0.05)

Therefore:

$n = \underline{(1.96)^2 \times 0.105 \times (1-0.105)} / (0.05)^2 = 154$

Therefore, minimum of 154 subjects was required for the study.

Ethical Approval

Ethical approval was obtained from the ethics committee of Specialist hospital Sokoto. Informed consent was secured from all participants, ensuring confidentiality and anonymity. The study followed the ethical guidelines outlined in the 1964 Helsinki Declaration for medical research with humans.

Questionnaire

Questionnaires were used in this study to collect data from each participant. All the patients who fulfilled the inclusion criteria were interviewed in details and the data was recorded on a prescribed questionnaire.

Inclusion and Exclusion Criteria
HIV infected individuals, between the age bracket of 15 to 65 years and that have given their consent to participate in the study. HIV negative individuals, those below 15 and those above the age 65 years with addition to those that did not give their consent to participate in the study were excluded.

Sample Collection
A venous blood specimen was collected from each subject using a sterile vacutainer blood specimen bottle, holder, and needle. Two millilitres of the blood were collected into a sterile ethylene diamine tetra acetic acid (EDTA) vacutainer blood specimen bottle and used to determine the enumeration of CD4+ T cell counts within 3 hours of collection.

CD4+ T Cell Count
The procedure for the detection of CD4 T-cells less than or equal to 200 cells/uL using the patient blood sample was carried out according to the manufacturer's manual.

Determination of TB LAM
The procedure for the qualitative detection of lipoarabinomannan (LAM) antigen of mycobacterium in human urine was carried out in accordance to the manufacturers manual.

Statistical Analysis
Variables were expressed as Mean and Standard deviation (SD). Statistical analysis was performed using statistical package for social sciences IBM SPSS Statistics (Version 25). ANOVA was used to find the association between two or more variable. *P*-values of less than or equal to 0.05 was considered statistically significant.

Results
The results are obtained through statistical data analysis obtained through a designated questionnaire distributed to participants diagnosed with Human Immunodeficiency Virus (HIV) patients attending Specialist Hospital Sokoto, Sokoto State, Nigeria as depicted in tables below. A total of 154 patients were enrolled in the research with their consents properly documented.

Distribution of CD4 Count Among Newly Diagnosed HIV Positive Patients
Table 1 shows the distribution of CD4 counts among the 154 newly diagnosed HIV-positive individuals who participated in the study. Of these, 99 patients (64.3%) had CD4 levels greater than 200 cells/μL, while 55 patients (35.7%) had CD4 counts below this level. The study found that 35.7% of newly diagnosed HIV patients had CD4 counts below 200 cells/μL, indicating severe immunosuppression. This emphasises the critical necessity for early diagnosis and beginning of antiretroviral medication (ART) to prevent further deterioration in immune function and lower the risk of opportunistic infections such as tuberculosis.

Table 1: Distribution of CD4 count among Newly diagnosed patients with HIV infection

CD4 Count (μL)	Frequency (N)	Percentage (%)
< 200	55	35.7
> 200	99	64.3
Total	**154**	**100**

Tuberculosis Infection Among Newly Diagnosed HIV Infected Patients With CD4 Count <200 cells / ul
Among the 55 participants with CD4 counts <200 cells/μL, 3 patients (5.4%) tested positive for tuberculosis, while 52 patients (94.5%) tested negative. The association between CD4 counts <200 cells/μL and tuberculosis had a chi-square value of 154 and a *p*-value of 1.0, indicating no statistically significant association as shown in **table 2.** The low prevalence (5.4%) of tuberculosis among HIV-positive patients with CD4 counts below 200 cells/μL suggests that while these patients are at higher risk due to their immunocompromised status, other factors such as access to prophylactic treatments, or the quality of healthcare services may be influencing the TB infection rates. Further research would be required to clarify these findings.

Table 2: Prevalence of Tuberculosis infection among newly diagnosed HIV infected patients attending Specialist Hospital Sokoto

Tuberculosis	Frequency	Percentage	*X*2	p-value
Positive	3	5.4	154	1.0
Negative	52	94.5		
Total	55	100		

Key: X^2 = Chi-square value, p = Statistically significant ($p < 0.05$)

Distribution of HIV and Tuberculosis Among Participants Based on Age and Marital Status

Table 3 shows the distribution of age and marital status among tuberculosis-positive participants. All TB-positive patients were between the ages of 31 and 60, with an equal prevalence (33.3%) among the 31-40, 41-50, and 51-60 age groups. Furthermore, tuberculosis infection was found solely among married people (100%). The age distribution indicates that those in their middle to late years (31-60) may be more vulnerable to TB-HIV co-infection, possibly due to extended periods of untreated or poorly controlled HIV. The concentration of tuberculosis cases among married people may reflect socioeconomic or behavioural characteristics unique to this group, such as limited access to healthcare or increased exposure to tuberculosis through household contacts.

Table 3: Distribution of HIV patients tested for Tuberculosis among the different age group and marital status attending specialist hospital Sokoto

Characteristics Age Range	Frequency	Percentage %	*X*2	P-value
15-20	0	0.0	13.29	0.29
21-30	0	0.0		
31-40	1	33.3		
41-50	1	33.3		
51-60	1	33.3		
61-70	0	0.0		
Total	3	100		
Marital Status				
Co-habiting	0	0.0	9.49	0.24
Engaged	0	0.0		
Married	3	100		
Single	0	0.0		
Total	3	100		

Key: X^2 = Chi-square value, p = Statistically significant ($p < 0.05$)

Socioeconomic Risk Factors Associated with Low CD4 And Tuberculosis Infection Among Newly Diagnosed HIV Infected Patient

Table 4 shows the socioeconomic risk factors related with HIV and tuberculosis co-infection among the study participants. The Hausa/Fulani group accounted for the bulk of participants with low CD4 levels (93.5 percent). Most of them (62.3%) had only informal education, with the highest rates among businessmen (40.3%) and housewives (29.9%). The significant prevalence of low CD4 counts and tuberculosis co-infection among the Hausa/Fulani tribe is likely due to the demographic structure of Sokoto State, where this study was done. The substantial link with lower educational achievement implies that limited access to health education may contribute to poorer health outcomes. The high incidence among businesses and housewives may imply socioeconomic situations that predispose these groups to increased risks, such as frequent social interaction or restricted access to healthcare services.

Table 4: Socioeconomic risk factors associated with HIV and Tuberculosis coinfection among participating patients

Characteristics	Frequency	Percentage %
Education Status		
No formal	4	2.6
Informal Education	96	62.3
Primary	9	5.8
Secondary	30	19.5
Tertiary	15	9.7
Total	154	100.0
Occupation		
Students	4	2.6
Civil Servant	24	15.6
Housewife	46	29.9
Business	62	40.3
Unemployed	8	5.2
Others	10	6.5
Total	154	100.0
Tribe		
Hausa/Fulani	144	93.5
Yoruba	2	1.3
Igbo	4	2.6
Others	4	2.6

Discussion

The findings from this study showed the distribution of CD-4 count among newly infected HIV patients attending specialist Hospital Sokoto. Among 154 participants in this study 55 patients (35.7%) are having a CD-4 count below 200/μL. This is in agreement with a similar study carried out at AKTH with incidence occurring in 30.7% (Musa *et al.,* 2015) and another study that showed 50% of the patients with CD-4 count below 200/μL (Akinbami *et al.,* 2012). In contrary, another study shows a prevalence of 17.43% in 1000 patients with HIV (Iliyasu *et al.,* 2009). However, our finding disagrees with similar study carried out in Jos, Plateau State in Nigeria with a prevalence of 8.7% (Musa *et al*., 2015). Also, in disagreement with another research that showed a prevalence of 13% (Kranzer *et al.,* 2010). This finding is concerning because it implies that a large proportion of the HIV positive patients are not detected until their immune systems have been severely damaged. Low CD4 counts (less than 200 cells/μL) increase the risk of opportunistic infections like TB and indicate advanced HIV. This highlights the need for more extensive and early HIV testing campaigns, especially in areas like Sokoto State where healthcare access may be limited. Early detection and commencement of antiretroviral medication (ART) are crucial for preventing the progression to severe immunosuppression and lowering the risk of opportunistic infection.

This study indicated that only 5.4% of patients with CD4 counts below 200 cells/μL tested positive for tuberculosis, which is lower than predicted given the reported higher susceptibility to tuberculosis among immunocompromised individuals. Several factors could contribute to this reduced prevalence. To begin, it is probable that Sokoto State's healthcare system has been effective in providing prophylactic medicines or early interventions to prevent latent tuberculosis from progressing to active tuberculosis in HIV-positive patients. Alternatively, the lower-than-expected TB prevalence may reflect diagnostic constraints, notably in finding TB in patients with atypical presentations, which are common in those with late HIV illness. Using more sensitive diagnostic methods, such as GeneXpert, may indicate a higher prevalence of tuberculosis in this population. Moreover, this finding is consistent with a similar study conducted at Usmanu Danfodiyo University Teaching Hospital with a prevalence of 5.6% (Isaac *et al*., 2016). Another study in Nigeria shows a median prevalence of 17.0% of HIV-TB coinfection and 12.7% in Ife, 19% in Maiduguri (Erhabor *et al*., 2010). However, this is in disagreement with another study that shows high prevalence of 44.2% recorded in Nasarawa state in the North central region of Nigeria and 25% recorded in Port Harcourt in the south-south region of Nigeria and 28.1% in Ibadan (Erhabor *at al*., 2010). Contrary to the findings in this study, research in Abeokuta, Ogun State, Nigeria recorded no TB/HIV coinfection among the study participants (Okonko *et al.,* 2012). Furthermore, the study methodology catches only a snapshot in time, potentially missing cases of tuberculosis that emerge after the study period. The age distribution of TB cases among the study participants, concentrated in the 31-60 age group, aligns with other studies that have found middle-aged individuals to be at higher risk for TB, particularly in the context of HIV. This age group is often still economically active, potentially increasing their exposure to TB in the workplace or community. Moreover, as individuals in this age range are likely to have been living with HIV for longer, their cumulative risk of developing TB is higher. This in consistent with another study carried out by (Iliyasu *et al.,* 2009) that shows the distribution among ages group 31-40 years (39%) and 41-50 years (15.5%). Another study carried out by Musa *et al*. (2015) at Aminu Kano Teaching Hospital shows distribution among age group 30-39 years (37.39%), 40-49 years (37.39) and 50 years and above (15.36%). The finding that all TB-positive people in the study were married could reflect distinct social and behavioural dynamics. Married people may have a higher household exposure to tuberculosis if a spouse or other family member is afflicted. This study disagrees with another research by Musa *et al*. (2015) that shows prevalence among married patients at (66.9%), divorced (6.96%), widowed (15.65%) and single (10.43%). Another finding by Iliyasu *et al*. (2009) shows prevalence among marital status, married (67%), widowed (7.0%), divorced (8.7%) and single (17.3%). Furthermore, societal norms and economic pressures within marriages may hinder individuals, particularly women, from seeking timely treatment, increasing the likelihood of advanced disease manifestation. This finding highlights the need of taking family dynamics and gender roles into account when developing interventions to reduce the burden of tuberculosis in HIV-infected populations. The high prevalence of low

CD4 counts and tuberculosis co-infection among the Hausa/Fulani tribe, as well as persons with only informal education, demonstrates the importance of socioeconomic variables in health outcomes. Limited access to school is likely to contribute to lower health literacy, reducing people's comprehension of HIV and tuberculosis prevention and treatment. This, in turn, may postpone seeking medical attention and limit adherence to ART, increasing the risk of disease development. This finding is consistent with similar study conducted by Iliyasu *et al. (2009)* where the prevalence of 66.8% was obtained. However, this outcome of high prevalence among Hausa/Fulani might be due to the specific geographical location in which study was conducted. Based on education status the result from this finding shows high prevalence among people with no-formal education (Informal) having a prevalence. This agrees with Iliyasu *et al.* whose reported a prevalence among those with no-formal education. However, this disagrees with another study that shows high prevalence of (93.4%) among patients with formal education (Aliyu *et al.,* 2019). Occupational data showing greater prevalence among business people and housewives highlight the importance of socioeconomic determinants of health. Business people may be more exposed to tuberculosis due to frequent social interactions, but housewives, who are generally reliant on their spouses for healthcare access, may encounter barriers to obtaining care. The findings show that public health programs should address not only medical interventions, but also the larger social and economic situations that predispose particular groups to poor health outcomes. Mitigating these hazards requires tailored educational programmes, community outreach, and increased access to healthcare services. A similar study by Iliyasu *et al. (2009*) shows high prevalence among unemployed patients with prevalence of 43.1%. In contrast, 39.7% unemployed and 62.9% employed (Musa *et al*., 2015).

Conclusion

This study's findings underline the vital relevance of early HIV diagnosis, as well as the need for integrated healthcare services that address both HIV and tuberculosis. The relationships between CD4 counts, socioeconomic characteristics, and tuberculosis prevalence highlight the importance of a comprehensive strategy to public health that involves both medical and social treatments. Addressing the broader determinants of health, notably education and access to care, will be critical in lowering the TB burden among HIV-positive persons in Sokoto State and Nigeria.

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