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Co-morbidity of human immunodeficiency virus and *Mycobacterium tuberculosis* among asymptomatic individuals in southern Taraba State, Nigeria

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ABSTRACT

Background: Human Immunodeficiency Virus (HIV) and *Mycobacterium tuberculosis* (MTB) co-infection is a major health problem in many parts of the world. But the prevalence varies from one place to another. This study was designed to assess prevalence of HIV and MTB co-morbidity and to determine its risk factors. It was a cross-based study conducted in January 2024. The study included asymptomatic individuals between age 0-65years. **Method**: A total of hundreds (100) blood samples were collected from asymptomatic individuals, who filled structured questionnaires, gave consent and were selected by random sampling techniques. The samples were analysed using Accu-Tell® TB Rapid Test Cassette and Determine HIV-1/2 Ag/Ab Combo Rapid Test kit. **Results:** The prevalence of HIV was 2.0%. *Mycobacterium tuberculosis* infection had a prevalence of 4.0%. Males within age 16-25, with secondary education, single, untested for TB, and alcohol drinkers showed higher tuberculosis prevalence compared to others. This is possibly linked to shared local alcoholic beverage consumption. HIV showed equal prevalence across genders and certain age groups, with higher prevalence in rural areas, individuals untested for HIV, and those with one sexual partner, reflecting limited healthcare access and awareness challenges. **Conclusion:** Surprisingly, the study found that no co-infection existed between HIV and *Mycobacterium tuberculosis* among asymptomatic individuals with a prevalence of 0.0%. Despite limitations, such as a lack of universal sputum testing and a small sample size, this study has demonstrated that TB can be detected in blood and has contributed to knowledge and provided valuable documentation of co-morbidity patterns in Southern Taraba State.

Introduction

Human Immunodeficiency Virus (HIV) and *Mycobacterium tuberculosis* (MTB) are two major public health issue. Tuberculosis (TB) remains a common infection in young people, the elderly or immunocompromised individuals according to World Health Organization [1]. Despite the WHO labeling it a "global health emergency," TB remains a persistent challenge, as highlighted by [2]. This centuries-old disease resulted in 10.6 million active cases and 1.6 million deaths in 2021 alone, according to the WHO [1] A fraction of the global population, estimated by the WHO to be a quarter, consists of individuals with

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latent TB infection, where *Mycobacterium tuberculosis* (MTB), the causative bacterium, remains dormant within the body without displaying active TB symptoms. MTB spreads via respiratory secretions from infected individuals and incubates within exposed persons for 4 to 12 weeks before manifesting as latent TB infection, characterized by a persistent immune response to MTB stimuli, yet without active TB symptoms [3]. Approximately one-fourth of the global population is thought to carry the MTB infection, with 5-10% facing a lifelong risk of developing active TB disease [4].

The majority, around 90-95%, respond to this infection with a robust immune reaction characterized by the formation of granulomas. These granulomas consist of concentrated groups of infected and uninfected macrophages, lymphocytes, and neutrophils arranged in distinct layers, housing MTB without completely eliminating it [5][6][7]. Within these structures, infected macrophages regulate the pathogen's replication rates, and a small portion can enter a dormant state, leading to the establishment of latent tuberculosis infection (LTBI) [6][7]. Disruption in granuloma maintenance, often triggered by conditions like malnutrition or immune deficiencies, can disturb this balance, causing uncontrolled pathogen growth and tissue damage, ultimately resulting in tuberculosis [8]. Notably, TB stands as the leading cause of death among individuals infected with HIV [4].

Human immunodeficiency virus (HIV) types 1 and 2 (HIV-1 and HIV-2) are the underlying causes of acquired immunodeficiency syndrome (AIDS). As of the close of 2021, approximately 38.4 million individuals had contracted HIV (primarily HIV-1), resulting in the loss of 40.1 million lives since the onset of the AIDS pandemic [3]. Key characteristics of HIV infection in humans encompass: (i) the permanent reduction of CD4+ T lymphocytes in both peripheral blood and mucosa-associated lymphoid tissues, compromising the body's ability to control microbial threats; (ii) the formation of a reservoir of dormant infected cells (such as T-CD4+ lymphocytes and macrophages) carrying viral genetic material integrated into cellular DNA [9]; (iii) continual viral replication, persisting even in patients undergoing antiretroviral therapy [10].; and (iv) prolonged immune activation leading to immune exhaustion and deficiency, contributing to various opportunistic infections alongside the depletion of T-CD4+ lymphocytes [11].

The co-infection of HIV and *Mycobacterium tuberculosis* (MTB) poses a significant global health threat, contributing to a substantial number of deaths worldwide. The WHO estimates that approximately 187,000 co-infected individuals will succumb to tuberculosis in 2021 alone [4].This co-infection exhibits a synergistic effect, magnifying the adverse outcomes of both diseases, leading to a concept termed a "synergistic epidemic" or syndemic, wherein HIV and MTB exacerbate each pathogenic potential. Individuals co-infected with HIV and MTB face a significantly higher risk of developing active tuberculosis, estimated to be 20 to 37 times higher than the general population [12]. Furthermore, mortality rates are elevated in HIV-infected individuals with tuberculosis compared to those without HIV [13]. This research therefore seeks to ascertain the comorbidity of HIV and *Mycobacterium tuberculosis* among asymptomatic individuals in southern Taraba State Nigeria.

Materials and Methods

Study design

The study design for this project employed a cross-sectional design to collect data. This design allows for the collection of data from a well-defined population, at a specific point in time, to determine the comorbidity of HIV and *Mycobacterium tuberculosis* among asymptomatic individuals in Southern Taraba State. Ethical approval was sought for, and obtained from the Research Ethical Committe of Taraba State Ministry of health with an authorized number.

Study area/population

The study was carried out from January 3rd, 2024 to January 8th, 2024. in Southern Taraba State Nigeria. Semi urban areas with population approximately 1,071,500 people (made up of Wukari; 374,800, Ibi; 132,600, Takum; 211,700, Ussa; 143,000 and Donga; 209,400). And are characterized by a mix of Agricultural and commercial activities, with the following coordinates; Wukari: 7.9303ºN and 9.8125ºE, with 189m elevation above the sea level, Ibi: 8.3197ºN and 9.7679ºE, Takum: 7.2577ºN and 9.9745ºE, Ussa: 7.1128ºN and 10.0360ºE and Donga: 7.7500ºN and 10.1703ºE. The study population was comprised of asymptomatic individuals in Southern Taraba State. The inclusion criteria for the study

participation was asymptomatic individuals in Southern Taraba State within age 0-65 years, who gave consent to be enrolled.

Data collection

Prior to data collection, fully informed consent was gathered from the head of the household on behalf of all household members and for children, where applicable, for both questionnaire information and blood collection. Study information was provided in written and/or verbal form in a language understandable to the participant and written consent was provided by signature or thumb print. In each selected household, a standard questionnaire was administered to the head of the household. The questionnaire was designed to gather data related to socio-demographic profile, and risk factors predisposing to these infections. Data was analysed using Chi-square test to determine the association between the risk factors and co-infection, P-values less than 0.05 were considered statistical significance. About 5ml of venous blood samples was aseptically collected from hundred (100) asymptomatic individuals and wereimmediately transported to the laboratory in Wukari.

Laboratory analyses

To test for *Mycobacterium* tuberculosis: Serum was obtained from the EDTA bottle sample by centrifugation at 5000 rpm for 10 minutes, and used for the rapid detection of *Mycobacterium tuberculosis* immunoglobulin M (IgM) and/or immunoglobulin G (IgG) antibodies using qualitative lateral flow immuno-chromatographic cassettes according to the manufacturer's instructions (Accu-Tell® TB Rapid Test Cassette). the test device was allowed, specimen and buffer to equilibrate at room temperature before testing. The test device was then placed on a clean level surface and immediately, two drops of serum (approximately 30 micro litter) were added to the sample well of the test cassette). The results were then read after 15–20 minutes. The appearance of a single distinct red line, the control line (C), was recorded as negative MTB antibody test, while the appearance of two distinct red lines, the control line (C) and IgM line (M) or IgG line (G), was recorded as positive MTB IgM or IgG antibody test, respectively. The test was considered invalid when the control line did not appear regardless of the presence or absence of other lines. In such cases, the test was repeated. Serum samples which was not immediately tested was stored in cryovials at 2–8°C for not more than three days and thereafter the test for HIV was conducted by addition of 2 drops of the serum sample on the sample well according to the manufacturer's instruction (Determine HIV-1/2 Ag/Ab Combo Rapid Test kit) timer was used to track the testing time (15-20minutes). After the designated testing time pass, the kit was observed for the presence of specific lines or indicators. The appearance of specific lines or indicators on the test kit indicate whether the patient is Positive or Negative for HIV antibodies and antigens. The appearance of lines in the result window (one next to "C" for control and one next to "T" for test), was recorded reactive result, suggesting the presence of HIV antibodies and/or p24 antigen, the appearance of only one line next to "C" for control and no line appearing next to "T" for test, was recorded non-reactive result, meaning the individual is likely not infected with HIV. While no lines appear or only a line next to "T" for test and not next to "C" for control, the test was considered invalid, and the test was repeated with a new kit.

Results

The results of the seroprevalence of HIV and *Mycobacterium tuberculosis* is presented in figure 1 and 2 showing an overall prevalence of 2% and 4% for HIV and TB respectively.

Socio-Demographic Characteristic and Prevalence of HIV Infection: The study investigated the prevalence of HIV among asymptomatic individuals in Southern Taraba State. The overall HIV prevalence was 2.0%, with an equal distribution between males and females (50.0%). No significant differences were observed based on gender (χ^2=0.0131, d.f=1, *P*=0.9089). Age groups showed no statistically significant associations with HIV prevalence, and educational levels also did not exhibit significant differences. However, marital status revealed a significant association, with a higher prevalence among single and divorced individuals (χ^2=49.6599, d.f=3, *P*=0.0001). Occupational differences did not show statistical association.

Risk Factors Associated with HIV Infection: Regarding risk factors, family type, place of residence, knowledge of HIV, previous testing, and blood transfusion did not exhibit statistically significant associations with HIV prevalence. Notably, a higher prevalence was observed among participants with no sexual partners (100%) and those who had not been transfused (100%) (χ^2=3.6280, d.f=4, *P*=0.4587; χ^2=0.9170, d.f=1,

P=0.3383). Alcohol consumption showed statistical significance, with an equal prevalence among those who drink (50.0%) (χ^2=2.4703, d.f=1, *P*=0.1160). The findings highlight significant associations between HIV prevalence and marital status, as well as alcohol consumption, emphasizing the complexity of factors influencing HIV prevalence in the studied population as shown in **Table 2.**

Socio-Demographic Characteristics and Prevalence of *Mycobacterium tuberculosis* Infection:The overall prevalence was 4.0%, with 46.0% males and 54.0% females participating. Males exhibited a higher prevalence (75.0%) than females (25.0%), though not statistically significant (χ^2=1.4108, d.f=1, *P*=0.2349). Age groups, educational levels, marital status, and occupation did not show significant associations with Mycobacterium tuberculosis infection as shown in **Table 3.**

Risk factors associated with *Mycobacterium tuberculosis* infection among asymptomatic individuals: Regarding risk factors, urban areas had a higher prevalence (75.0%) compared to rural areas (25.0%) (χ^2=0.3907, d.f=1, *P*=0.539). Knowledge about TB did not significantly impact prevalence. Notably, participants without previous TB testing had a higher prevalence (100%) compared to those tested (χ^2=0.2659, d.f=1, *P*=0.6061). Living with TB patients, sexual partners, blood transfusion, and alcohol consumption did not show significant associations with *Mycobacteriumtuberculosis* infection. However, alcohol consumption exhibited statistical significance (χ^2=5.1034, d.f=1, *P*=0.0239) as shown in **Table 4.**

Table 1. Socio-demographic features of prevalence of HIV among asymptomatic individuals in Southern Taraba State.

Variables	Frequency (%)	NO: Positive (%)	NO: Negative (%)	χ^2 *P*-value
Sex				
Male	46 (46.0)	1 (50.0) 0.9089	45 (45.92)	0.013
Female	54 (54.0)	1 (50.0)	53 (54. 10)	
Age				
0-15	15 (15.0)	0 (0) 0.3704	15 (15.31)	6.4922
16-25	41 (41.0)	1 (50.0)	40 (40.82)	
26-35	20 (20.0)	0 (0)	20 (20.41)	
36-45	11 (11.0)	0(0)	11 (11.22)	
46-55	7 (7.0)	1 (50.0)	6 (6. 12)	
56-65	4 (4.0)	0 (0)	4 (4. 10)	
>65	2 (2.0)	0 (0)	2 (2.04)	
Educational level				
Primary	17 (17.0)	1 (50.0) 0.5425	16 (16.33)	2.1469
Secondary	33 (33.0)	0 (0)	33 (33.67)	
Tertiary	43 (43.0)	1 (50.0)	42 (42.86)	
None	7 (7.0)	0 (0)	7 (7. 14)	
Marital status				
Single	75 (75.0)	1 (50.0) 0.0001	74 (75.51)	49.6599
Married	22 (22.0)	0 (0)	22 (22.45)	
Divorced	1 (1.0)	1 (50.0)	0 (0.00)	
Widowed	2 (2.0)	0 (0)	2 (2.04)	
Occupation				
Farmer	20 (20.0)	1 (50.0) 0.6495	19 (19.39)	1.6440
Trader	27 (27.0)	0 (0)	27 (27.55)	
Civil	8 (8.0)	0 (0)	8 (8. 16)	
servant				
Others	45(45.0)	1 (50.0)	44 (44.90	

Table 2. Frequency of risk factors associated with HIV among asymptomatic individuals in Southern Taraba State.

Variables	Frequency (%)	NO: Positive (%)	NO: Negative (%)	χ^2	*P*-value
Type of family					
Monogamo	61 (61.0)	0 (0)	61(62.24)	3.1920	0.0740
us					
Polygamous	39 (39.0)	2 (100.0)	37 (37.75)		
Place of residence					
Urban	60 (60.0)	0 (0)	60 (61.22)	3.0612	0.0802
Rural	40 (40.0)	2 (100.0)	38 (38.78)		
Knowledge on HIV					
Yes	76 (76.0)	1 (50.0)	75 (76.53)	0.7563	0.3845
No	24 (24.0)	1 (50.0)	23 (23.47)		
Tested for HIV before					
Yes	31 (31.0)	0 (0)	31(3.63)	0.91563	0.3383
No	69 (69.0)	2 (100)			
Sexual partner					
1	49 (49.0)	0 (0)	49 (50.0)	3.6280	0.4587
2	6 (6.0)	0 (0)	6 (6.12)		
3	4 (4.0)	0 (0)	4 (4.08)		
Above	5 (5.0)	0 (0)	5 (5.10)		
None	36 (36.0)	2 (100)	34 (34.69)		
Been transfused					
Yes	12 (12.0)	0 (0)	12 (12.24)	0.2783	0.5978
No	88 (88.0)	2 (100)	86 (87.76)		
Drink alcoholic beverages					
Yes	13 (13.0)	1 (50.0)	12 (12.24)	2.4707	
0.1160	No	87 (87.0)	1 (50.0)	86 (87.76)	

Table 3. Socio-demographic features of prevalence of *Mycobacterium tuberculosis* (TB) among asymptomatic individuals in Southern Taraba State.

Variables	**Frequency (%)**	**NO: Positive (%)**	**NO: Negative (%)** χ^2 ***P*-value**	
Sex				
Male	46 (46.0)	3 (75.0)	43 (44.79) 0.2349	1.4108
Female	54 (54.0)	1 (25.0)	53 (55.21)	
Age				
0-15	15 (15.0)	0 (0) 0.6879	15 (15.63)	3.9172
16-25	41 (41.0)	3 (75.0)	38 (39.58)	
26-35	20 (20.0)	0 (0) 20 (20.83)		
36-45	11 (11.0)	1(25.0)	10 (10.41)	
46-55	7 (7.0)	0 (0)	7 (7.29)	
56-65	4 (4.0)	0 (0)	4 (4. 17)	
>65	2 (2.0)	0 (0)	2 (2. 10)	
Educational level				
Primary	17 (17.0)	0 (0) 0.3154	17 (17.71)	3.5413
Secondary	33 (33.0)	3 (75.0)	30 (31.25)	
Tertiary	43 (43.0)	1 (25.0)	42 (43.75)	
None	7 (7.0)	0 (0)	7 (7.27)	

Marital status				
Single	75 (75.0)	3 (75.0) 0.9885	72 (75.0)	0.1264
Married	22 (22.0)	1 (25.0)	21 (21.88)	
Divorced	1 (1.0)	0 (0)	1 (1.04)	
Widowed	2 (2.0)	0 (0)	2 (2. 10)	
Occupation				
Farmer	20 (20.0)	1 (25.0) 0.9372	19 (19.79)	0.4146
Trader	27 (27.0)	1 (25.0)	26 (27. 10)	
Civil	8 (8.0)	0 (0)	8 (8.33)	
servants				
Others	45 (45.0)	2 (50.0)	43 (44.79)	

Table 4. Frequency of risk factors associated with *Mycobacterium tuberculosis* among asymptomatic individuals in southern Taraba state.

Variables	Frequency (%)	NO: Positive (%)	NO: Negative (%)	χ^2	*P*-value
Type of family					
Monogamo 0.6453	61 (61.0)	2 (50.0)	59 (61.46)		0.2119
us					
Polygamous	39 (39.0)	2 50.0)	37 (38,54)		
Place of residence					
Urban 0.5319	60 (60.0)	3 (75.0)	57 (59.38)		0.3907
Rural	40 (40.0)	1 (25.0)	39(40.63)		
Knowledge on TB					
Yes	33 (33.0)	0 (0)	33 (34.38)	2.0522	0.1520
No	67 (67.0)	4 (100.0)	63 (65.63)		
Tested for TB before					
Yes	6 (6.0)	0 (0)	6 (6.25)	0.2659	0.6061
No	94 (94.0)	4 (100)	90 (93.75)		
Lived for TB Patient					
Yes	6 (6.0)	0 (0)	6 (6.25)	0.2659	0.6061
No	94 (94.0)	4 (100)	90 (93.75)		
Sexual partner					
1	49 (49.0)	3 (75.0)	47 (46.06)	4.9568	0.2918
2	6 (6.0)	1 (25.0)	5 (5.10)		
3	4 (4.0)	0 (0)	4 (4.08)		
Above	5 (5.0)	0 (0)	5 (5.10)		
None	36 (36.0)	2 (100)	37 (37.76)		
Been transfused					
Yes	12 (12.0)	0 (0)	12 (12.5)	0.5682	0.4510
No	88 (88.0)	4 (100)	84 (87.5)		
Drink alcoholic beverages					
Yes	13 (13.0)	2 (50.0)	11 (11.46)	5.1034	0.0239
No	87 (87.0)	2 (50.0)	85 (88.54)		

Figure 1. Prevalence of HIV among asymptomatic individuals.

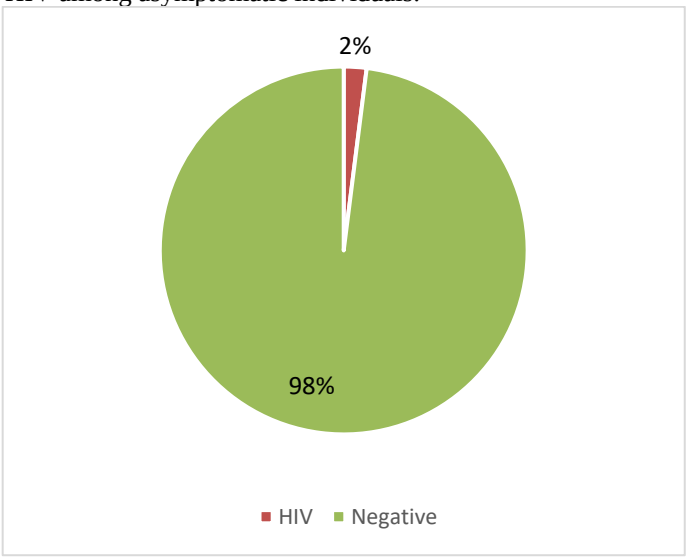
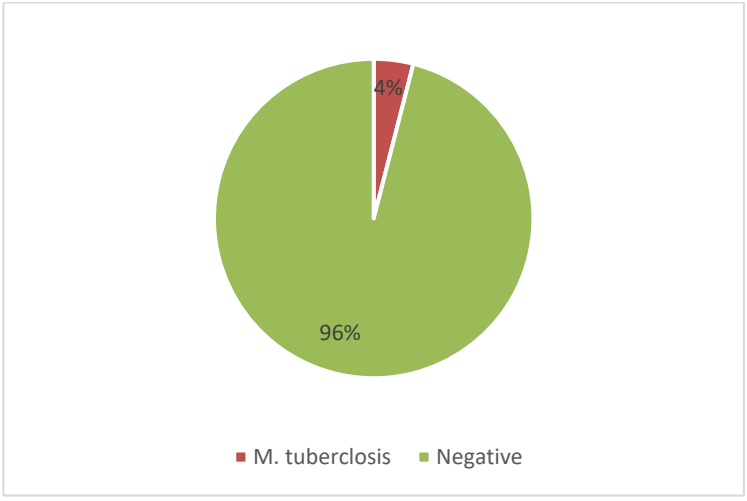


Figure 2. Prevalence of *M. tuberculosis* among asymptomatic individuals.



Discussion

Tuberculosis is an opportunistic infection in individual with HIV. The prevalence of HIV in this study was 2.0%. This study finding is in line with the findings of [14] in their study among university students in Port harcourt, Nigeria with the prevalence rate of 3.4%, [15] in their study in the universities [16], in their study among Cameroon undergraduates. However, the findings are slightly different from that of [17] in their study among college students in the United States of America, with the prevalence of 13.0%, and that of [18] in the Universities in Adamawa state, with prevalence of 13.7% and that of [19] among Niger Delta students with the prevalence of 13.7%.

The finding of *Mycobacterium tuberculosis* infection among asymptomatic individuals in this study shows a prevalence rate of 4.0%. This finding corresponds with the result of [14] in their study among university students in port Harcourt, Nigeria estimate prevalence rate of 2.1%, [20], with an estimate of 2.5% and with that of [21], with a rate of 2.1% students which were low prevalence rates. [22] in Ethiopia, [23] also in Ethiopia and [24]. in Uganda, reported in their various studies, pralence rates of 9.2%, 6.1% and 13.7% respectively. These results are higher possibly as a result of the difference in the sample size, age variation of the population used for the study

This study sampled asymptomatic individuals between age 0 to 65 years. *Mycobacterium tuberculosis* infection was higher in male than in female, individuals between 16-25years age group, individual with secondary level of education, single individuals, individuals that has not tested for TB before and individuals that drink

alcoholic beverages. Male have a higher prevalence of *Mycobacterium tuberculosis* infection, which may be attributed to their involvement in consumption of local alcoholic beverages like burkutu, where they often share or drink from the same calabash among themselves. This could also be attributed to increased in social interactions, limited awareness and delayed in healthcare seeking behavior in this demographic.

The finding shows that HIV has equal prevalence among male and female individuals, individuals within the age groups 16-25 and 45-55, individuals with primary and secondary levels of education, single and divorced, and higher prevalence among individuals in rural areas, individuals that has not tested for HIV, individuals with one sexual partner. This could be attributed to the fact there is limited access to healthcare resources in the rural areas, lower education levels, and potential challenges in awareness and preventive measures like consistent condom use and regular HIV testing. Additionally, changes in relationship status may contribute to shifts in risk behaviors, influencing the transmission of HIV across these gender and age groups.

As indicated in this study, the prevalence rate of HIV and *Mycobacterium tuberculosis* co-infection in this study was 0.0%. This means that none of the asymptomatic individuals was infected with HIV and *Mycobacterium tuberculosis* co-infection. This finding is similar to that reported by [14] in their study among university students in Port Harcourt, Nigeria. This could be due to their level of education as HIV infection would be kept at a controlled level that no opportunistic infections such as *Mycobacterium tuberculosis* would invade the body [25] However, studies like that of [26]. in the central Hospital of Benin City showed a high rate of co-infection of 19.8%. Also, that of [27] which was carried out in Lagos Hospitals reported 18.4% HIV and *Mycobacterium tuberculosis* co-infection and that of [28] in Port Harcourt City which revealed a prevalence rate of 18.8%. [29] had reported 14.0% among HIV-infected patients in Port Harcourt and 2020, reported 1.4% among HIV-infected patients in old Cross River State, Nigeria. This wide gap could be explained by the fact that these research works were done in hospitals and in communities where people with full-blown AIDS can be found. Also, the potential sources of variability between this study and others could be attributed in part to the analytical method or diagnostic kit used to generate the HIV and *Mycobacterium tuberculosis* data.

The limitation of this study was that sputum smear and culture was not attempted for all participants. The generalizability of this findings is also limited because participants were voluntary and self-selected. The power to observe statistically significant findings is limited because the study included only small numbers of asymptomatic individuals in Southern Taraba State. Despite these limitations, the study provides documentation of the *Mycobacterium tuberculosis* and HIV comorbidity among asymptomatic individuals in Southern Taraba State, Nigeria.

Conclusion

In conclusion, the study has revealed that the prevalence of HIV among asymptomatic individuals in Southern Taraba State, Nigeria (2.0%) is similar to that in other developing areas in the country, but the *Mycobacterium tuberculosis* rate was 4.0% and HIV/*Mycobacterium tuberculosis* co-infection was zero. This does not imply a need for relaxation in the fight against these two killer diseases. Individuals should be advised to stop behaviour that enhance the transmission of HIV such as pre-marital sex, sharing of sharp objects such as razor blades, needles, syringes clippers, etc. New and sustained efforts must be made to contain this infection, prevent HIV transmission and expand efforts to implement ways of delivering health care to developing countries. Further studies could be undertaken to investigate other epidemiological parameters. On the side of the authority, the Government could reduce the infection rate further down by embarking on health education campaigns and training on HIV and *Mycobacterium tuberculosis* prevention.

Conflict of interest

There are no conflicts of interests, nor are there any financial obligation owed anybody.

Financial disclosure

None declared

Data availability

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Authors' contribution

All authors have participated in the concept and design, analysis and interpretation of data, and

drafting or revising of the manuscript, and they have approved the manuscript as submitted.

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