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Full Length Research Article

EPIDEMIOLOGY OF TUBERCULOSIS IN RESOURCE-LIMITED SETTINGS OF BAUCHI STATE, NORTHEASTERN NIGERIA

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ABSTRACT
Tuberculosis (TB) remains a major public health challenge in Nigeria, particularly in resource-limited settings. Understanding local disease burden and associated risk factors is essential for targeted control strategies. This study determined the prevalence of tuberculosis and identified associated socio-demographic, environmental, and clinical risk factors among patients attending selected health facilities in Bauchi North, Northeastern Nigeria. A facility-based cross-sectional study was conducted among 385 symptomatic patients. Early morning sputum samples were collected and analyzed using the TB-LAMP (Loop-Mediated Isothermal Amplification) assay for rapid detection of *Mycobacterium tuberculosis* DNA. A structured questionnaire was administered to obtain data on socio-demographic characteristics and potential risk factors. Data were analyzed using SPSS version 25. Chi-square tests were used to determine associations between TB infection and independent variables, with statistical significance set at $p < 0.05$. The overall prevalence of TB was 25.73%. Significant geographical variation was observed across Local Government Areas ($p < 0.001$). Age was significantly associated with TB infection, with the highest prevalence among individuals aged 70–79 years ($p < 0.001$). Low socioeconomic status, history of contact with TB patients, diabetes, HIV infection, and rural residence were significantly associated with TB ($p < 0.05$). Gender, smoking, and organ transplant history were not significantly associated with infection. Tuberculosis remains highly prevalent in Bauchi North. The findings highlight the need for strengthened case detection, targeted interventions for high-risk groups, integration of TB screening with HIV and diabetes services, and improved healthcare access in rural communities to reduce disease burden.

Keywords: Tuberculosis, Epidemiology, Bauchi North, Northeastern Nigeria, TB-LAMP.

INTRODUCTION

Tuberculosis (TB) remains one of the most significant infectious diseases globally and a leading cause of morbidity and mortality, particularly in low- and middle-income countries. The disease is caused by *Mycobacterium tuberculosis*, an obligate intracellular pathogen that primarily affects the lungs but may also involve other organs, resulting in extra-pulmonary tuberculosis (WHO, 2024). Despite being both preventable and curable, TB continues to constitute a major public health concern worldwide.

According to the World Health Organization (WHO, 2024), an estimated 10.6 million people developed tuberculosis in 2023, with approximately 1.25 million deaths recorded among HIV-negative individuals and an additional 167,000 deaths among people living with HIV (WHO, 2024). The global burden of tuberculosis is disproportionately concentrated in developing countries where poverty, overcrowding, malnutrition, and weak health systems facilitate transmission and disease progression (WHO, 2024; Chakaya *et al*., 2021).

Nigeria remains among the 30 high-burden TB countries globally, contributing substantially to incident cases and TB-related deaths. Recent national reports indicate persistent gaps in case detection, delayed diagnosis, and treatment interruptions, which continue to undermine TB control efforts (WHO, 2025). Socio-economic inequalities, stigma, and limited access to quality healthcare services further compound the challenge. Transmission of tuberculosis occurs mainly through inhalation of aerosolized droplet nuclei expelled by individuals with active pulmonary TB during coughing, sneezing, or speaking (Houben & Dodd, 2016; Drain *et al*., 2018). Following infection, individuals may develop latent tuberculosis infection (LTBI), with approximately 5–10% progressing to active disease during their lifetime. The risk of progression is significantly higher among immunocompromised individuals, including those living with HIV/AIDS, diabetics, smokers, and the malnourished (Houben & Dodd, 2016; Drain *et al*., 2018).

Environmental and behavioral factors such as poor ventilation, overcrowded housing, indoor air pollution, and occupational exposure have also been implicated in TB transmission. Studies across sub-Saharan Africa highlight strong associations between TB prevalence and poverty, low educational status, and rural residence (Chakaya *et al*., 2021; Moyo *et al*., 2022).

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Early and accurate diagnosis remains central to TB control. While smear microscopy is widely used in resource-limited settings, molecular diagnostic tools such as Loop-Mediated Isothermal Amplification (TB-LAMP) and GeneXpert MTB/RIF assays have significantly improved case detection rates due to higher sensitivity and rapid turnaround time (WHO, 2023; Nicol *et al*., 2022).

Understanding local epidemiology is essential for targeted interventions. Facility-based prevalence studies provide insights into disease burden, high-risk groups, and modifiable risk factors. However, limited data exist on tuberculosis prevalence and its determinants within Bauchi North, Bauchi State, North-Eastern Nigeria. Therefore, this study aimed to determine the prevalence of tuberculosis and identify associated socio-demographic, environmental, and lifestyle risk factors among patients attending selected health facilities in Bauchi North. Findings from this study could guide public health planning, strengthen TB control programs, and contribute to the existing body of knowledge on tuberculosis epidemiology in Nigeria.

MATERIALS AND METHODS

Study Area

The study was conducted in resource-limited areas of Bauchi North Senatorial District, North-Eastern Nigeria. The zone comprises semi-urban and rural communities characterized by varying socio-economic conditions, population density, and healthcare access levels. It consists of seven local government areas: Itas/ Gadau, Gamawa, Giade, Jama'are, Katagum, Shira/Yana, and Zaki.

Study Design

A facility-based cross-sectional study design was employed to determine the prevalence of tuberculosis and associated risk factors among patients attending selected health facilities in the resource-limited areas of Bauchi North Senatorial District.

Study Population

i. **Inclusion criteria:** The study consisted of patients of all ages and gender presenting with symptoms suggestive of pulmonary tuberculosis such as persistent cough, haemoptysis, fever, weight loss, and night sweats.
ii. **Exclusion criteria:** All patients without TB symptoms or who were unwilling to participate in the study were excluded.

Sample Size

A total of 385 participants were recruited for the study based on the previous hospital-based prevalence of 49.17% reported by Mahmud *et al*. (2025). This was calculated using formula (Equation 1):

$$n = \frac{\left(\frac{Z\alpha}{2}\right)^2 XP(1-P)}{d^2} \quad (1)$$

Where:
P = previous prevalence (49.17%)
d = precision (5%)
(Zα/2) = 1.96 for 95% confidence level
n = sample size
Therefore,

$$n = \frac{(1.96)^2 X\ 0.4917(1-0.4917)}{0.05^2}$$

$$n = 384.58$$

Therefore, 385 patients were enrolled in the study

Ethical Considerations

Ethical approval was obtained from the research and ethics committees of the facilities involved in the study prior to the sample collection. Informed consent was secured from all participants, and confidentiality of information was maintained.

Sample Collection and Questionnaire Administration

Early morning sputum samples were collected using sterile, leak-proof containers following standard biosafety procedures. Participants were educated on proper sputum expectoration techniques to avoid saliva contamination. The samples were processed for the TB-LAMP assay. At the time of sample collection, a structured and pre-tested questionnaire was administered to obtain information on socio-demographic characteristics, environmental exposures, and TB contact history.

Laboratory Analysis

Samples were analyzed using the TB-LAMP (Loop-Mediated Isothermal Amplification) technique for rapid detection of *Mycobacterium tuberculosis* DNA. The assay was conducted according to manufacturer guidelines with appropriate positive and negative controls.

Data Analysis

Data were analyzed using SPSS version 25. Descriptive statistics were used to compute prevalence, while Chi-square tests assessed associations between TB and risk factors. Statistical significance was set at $p < 0.05$.

RESULTS

The current study revealed that the overall prevalence of tuberculosis (TB) in Bauchi North was 25.73%. The prevalence varied across the different Local Government Areas (LGAs). The highest prevalence was recorded in Katagum (6.75%), followed by Gamawa (4.68%), Shira/Yana (3.90%), and Zaki (3.90%). The lowest prevalence was observed in Giade (1.82%) and Jama'are (1.82%), while Itas/Gadau (2.86%) had a relatively low prevalence (Table 1).

There was a statistically significant difference in TB prevalence across the LGAs ($\chi^2 = 25.591$, df = 6, $p < 0.001$) (Table 1).

Table 1: Prevalence of TB based on the local government area of the patients

LGAs	Negative	Positive	Prevalence (%)	χ^2	df	*p* value
Itas/ Gadau	44	11	2.86	25.591	6	0.000 *
Gamawa	37	18	4.68			
Giade	48	7	1.82			
Jama'are	48	7	1.82			
Katagum	29	26	6.75			
Shira/Yana	40	15	3.90			
Zaki	40	15	3.90			
Total	286	99	25.73			

χ^2 = Chi square
df = Degree of freedom
* = Significant at $p < 0.05$

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The current study also revealed that TB prevalence differed significantly across age groups (χ^2 = 100.583, df = 4, p < 0.001). The highest prevalence was found among individuals aged 70–79 years (6.49%), followed by those aged 30–39 years (5.45%) and 60–69 years (4.42%). The lowest prevalence was observed among participants aged 20–29 years (2.86%) and 50–59 years (2.86%). None of the participants was below 20 years or above 80 years (Table 2).

Similarly, the study showed that Males had a higher prevalence of TB (15.32%) compared to females (10.39%). However, the difference was not statistically significant (χ^2 = 3.55, df = 1, p = 0.059).

Table 2: Prevalence of TB based on age and gender of the patients

Categories	Negative	Positive	Prevalence (%)	χ^2	df	p value
Age						
20-29	37	11	2.86	100.583	4	0.000*
30-39	73	21	5.45			
40-49	73	14	3.64			
50-59	48	11	2.86			
60-69	40	17	4.42			
70-79	15	25	6.49			
Gender						
Male	139	59	15.32	3.55	1	0.059
Female	147	40	10.39			

χ^2 = Chi square
df = Degree of freedom
* = Significant at p < 0.05

The study also revealed that Socioeconomic status showed a strong and statistically significant association with TB infection (χ^2 = 158.042, df = 3, p < 0.001). Participants from the low socioeconomic class had the highest proportion of TB cases (57.58% within the group). In contrast, those from the middle (7.41%) and high (12.09%) classes had a much lower proportion of infection (7.41% and 12.09%, respectively).

Similarly, there was a significant association between history of contact with a TB patient and infection status (χ^2 = 169.858, df = 1, p < 0.001). Among participants who had contact with TB patients, 68.60% were positive. In comparison, only 6.06% of those without a history of contact tested positive.

Interestingly, smoking was not significantly associated with TB infection (χ^2 = 1.031, df = 1, p = 0.310). Although smokers had TB cases (15.79%), the difference between smokers and non-smokers was not statistically meaningful. Likewise, there was no significant association between a history of organ transplant and TB infection (χ^2 = 0.099, df = 1, p = 0.753).

On the other hand, diabetes showed a statistically significant association with TB infection (χ^2 = 5.291, df = 1, p = 0.021). Participants with diabetes had a higher proportion of TB infection (41.67%) compared to non-diabetic participants (24.07%).

Furthermore, place of residence was strongly associated with TB infection (χ^2 = 195.863, df = 1, p < 0.001). Participants living in rural areas had a much higher prevalence (74.77%) compared to those living in urban areas (5.86%).

HIV status was also significantly associated with TB infection (χ^2 = 86.140, df = 1, p < 0.001). Among HIV-positive participants, 57.39% were TB positive, compared to only 12.22% among HIV-negative participants (Table 3).

Table 3: Assessment of the risk factors of TB

Variables		Infection status			χ^2	df	*p* value
		Positive (%)	Negative (%)	Total			
Socioeconomic status	Low class	76(57.58)	56(42.42)	132	158.042	3	0.000*
	Middle class	12(7.41)	150(92.59)	162			
	High class	11(12.09)	80(87.91)	91			
Contact history	Yes	83(68.60)	38(31.40)	121	169.858	1	0.000*
	No	16(6.06)	248(93.94)	264			
Smoking practice	Smoker	3(15.79)	16(84.21)	19	1.031	1	0.310
	Non-smoker	96(26.23)	270(73.77)	366			
Organ transplant	Received	3(30.00)	7(70.00)	10	0.099	1	0.753
	Not received	96(25.60)	279(74.40)	375			
Diabetes status	Positive	15(41.67)	21(58.33)	36	5.291	1	0.021*
	Negative	84(24.07)	265(75.93)	349			
Residence	Rural	83(74.77)	28(25.23)	111	195.863	1	0.000*
	Urban	16(5.86)	257(94.14)	273			
HIV status	Positive	66(57.39)	49(42.61)	115	86.140	1	0.000*
	Negative	33(12.22)	237(87.78)	270			

χ^2 = Chi square
df = Degree of freedom
* = Significant at p < 0.05

DISCUSSION

This study found an overall tuberculosis (TB) prevalence of 25.73% in Bauchi North. This indicates that TB remains a serious public health problem in the study area. Although this prevalence is lower than the 49.17% hospital-based prevalence previously reported in Bauchi North by Mahmud *et al*. (2025), it remains high compared with some other studies conducted in Northern Nigeria. For example, Olalere *et al*. (2022) reported a prevalence of 19.14% in Jigawa State. The difference in prevalence may be due to variation in study design, sampled population, diagnostic methods, and the level of TB control services across areas.

The prevalence of TB differed significantly across the Local Government Areas (LGAs), with Katagum recording the highest and Giade and Jama'are the lowest. This uneven distribution suggests that TB transmission is influenced by local factors such as population density, poverty level, access to healthcare, and awareness. Similar geographical variation has been reported in Northern Nigeria, where certain states, such as Kano and Bauchi, have been described as TB hotspots due to high population and limited access to diagnostics (Lawson *et al*., 2020; Magaji *et al*., 2025). These findings highlight the need for LGA-specific interventions rather than a uniform control approach.

Age was strongly associated with TB infection in this study, with the highest prevalence observed among individuals aged 70–79 years, followed by those aged 30–39 years. The high prevalence among older adults may be explained by weakened immunity and reactivation of latent TB infection. This agrees with previous findings that TB burden increases with age due to declining immune function (Magaji *et al*., 2025). The high prevalence among individuals aged 30–39 years is also consistent with earlier studies in Northern Nigeria, which reported that TB commonly affects economically active age groups (Minion *et al*., 2013; Komolafe *et al*., 2021). This is important because infection in this age group may increase community transmission due to their high level of social interaction.

Although males had a higher TB prevalence (15.32%) than females (10.39%), the difference was not statistically significant. Globally, TB is often reported to be more common among males. The World Health Organization has consistently reported higher TB notification rates among men than women. Similarly, previous studies in Northern Nigeria documented higher TB prevalence among males (Asfaw *et al*., 2010; Komolafe *et al*., 2021). The absence of statistical significance in this study suggests that gender alone may not be a strong predictor of TB infection in Bauchi North, and both men and women are at considerable risk.
Socioeconomic status showed a strong and statistically significant association with TB infection. Participants from low socioeconomic backgrounds had the highest proportion of infections. This finding agrees with earlier reports that poverty is a major driver of TB transmission (Farouq *et al*., 2022). Poverty contributes to overcrowding, poor nutrition, and limited access to healthcare services, all of which increase vulnerability to TB. The link between TB and poverty has also been emphasized in studies on drug-resistant TB in Northern Nigeria, where weak health systems and socioeconomic challenges were identified as major contributors to disease persistence (Magaji *et al.,* 2025).

A history of contact with a TB patient was significantly associated with infection in this study. Individuals who had contact with TB patients were far more likely to be infected. This is expected because TB is transmitted through inhalation of infected droplets. Similar findings were reported in previous studies in Bauchi and other parts of Northern Nigeria, where close contact with infected persons significantly increased the risk of TB (Mahmud *et al*., 2025). This emphasizes the importance of effective contact tracing and early screening of household members.

Diabetes was significantly associated with TB infection in this study. Participants with diabetes had a higher proportion of TB compared to non-diabetic individuals. This is consistent with established evidence that diabetes weakens immune function and increases susceptibility to TB (Mahmud *et al*., 2025; Farouq *et al*., 2022; Tang *et al*., 2015; Ahuja *et al*., 2012). Although diabetes was not significantly associated with TB in some earlier hospital-based studies in Bauchi (e.g., Mahmud et al., 2025), the present finding suggests that the growing burden of non-communicable diseases may be contributing to TB risk in the region.

HIV infection showed a strong and statistically significant association with TB. A much higher proportion of HIV-positive participants were TB positive compared to HIV-negative individuals. This finding is in agreement with numerous studies in Northern Nigeria that have reported TB/HIV co-infection as a major public health challenge (Mahmud *et al*., 2025; Farouq *et al*., 2022; Tang *et al*., 2015; Ahuja *et al*., 2012). HIV weakens the immune system, making individuals more likely to progress from latent TB infection to active disease. The synergy between TB and HIV remains one of the biggest obstacles to TB control in sub-Saharan Africa.

Residence was also significantly associated with TB, with rural residents having a much higher prevalence than urban residents. This may reflect limited access to healthcare, delayed diagnosis, lower awareness, and poor living conditions in rural areas. Similar concerns have been raised in Northern Nigeria, where rural and conflict-affected communities face barriers to timely TB diagnosis and treatment (Mahmud *et al*., 2025; Farouq *et al*., 2022; Magaji *et al*., 2025). Improving rural health infrastructure is therefore essential for reducing TB transmission.
Smoking and a history of organ transplant were not significantly associated with TB infection in this study. While some studies have identified smoking as a risk factor for TB (Farouq *et al*., 2022), the lack of association in this study may be due to the small number of smokers or possible underreporting.

Conclusion

This study revealed that tuberculosis remains highly prevalent in Bauchi North, with significant differences across Local Government Areas. Older age, low socioeconomic status, history of contact with TB patients, diabetes, HIV infection, and rural residence were significant risk factors for TB. Although males had a higher prevalence than females, gender was not a statistically significant determinant.
The findings show that TB control in Bauchi North requires an integrated approach that addresses both biomedical and social risk factors. Strengthening early diagnosis, improving rural healthcare services, integrating TB screening with HIV and diabetes programs, and addressing poverty-related conditions are essential steps toward reducing the TB burden in the region.

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