

Research Article

Assessing Causes of Tuberculosis Infection: A Community Based Study

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A B S T R A C T

Background: Globally, Tuberculosis (TB) remains a major health challenge, especially among developing countries. Nigeria ranks third among the countries with a high TB burden worldwide and first in Africa. Annual TB incidence was estimated to be approximately 467,000, with 219 per 100,000 population incidence rate reported in 2021, and the pattern persist in subsequent years. Furthermore, an estimated 245,000 mortalities were reported annually for TB. This study investigates the factors associated with TB infection among residents of the Ikeja area in Lagos, Nigeria.

Methods: A random sample of 133 consenting patients was enrolled for the study after completing informed consent forms to participate. Data was collected in a cross-sectional design using structured questionnaires covering sociodemographic characteristics and other risk factors of TB. Bivariate Logistic regression analysis method was used to identify factors associated with TB and analysis was conducted using SPSS version 23 for statistical analysis. The results were presented in terms of crude odds ratio (OR), 95% confidence interval, and p-value reported for each predictor.

Results: The study found that Female sex was associated with lower odds of TB compared with males (OR = 0.24; 95% CI: 0.11–0.51, $p < 0.01$), non-smoking status was associated with reduced odds ratio compared with smokers (OR = 0.21; 95% CI: 0.10–0.45, $p < 0.001$), absence of immunosuppressive conditions was associated with lower odds of TB (OR = 0.32; 95% CI: 0.15–0.68, $p = 0.003$), and individuals without contact with TB patients showed significant reduced odds of TB compared with those with known contact (OR = 0.14; 95% CI: 0.06–0.33, $p < 0.001$).

Conclusions: TB control strategies should be prioritized with interventions against smoking, strengthen care for immunosuppressed individuals, and intensify contact tracing to limit transmission.

Keywords: Risk Factors, Tuberculosis, Bivariate Logistic Regression, Crude Odds Ratio

Introduction

In 2023, TB ranked highest in mortality among all other infectious diseases, with global estimates of more than 10 million new infections and 1.25 million deaths, surpassing Covid-19 in terms of mortality.^{1,2} The highest burden lies in South East Asia (43%) and Africa (25%), concentrated in 30 high-burden countries.² Mycobacterium tuberculosis, the bacteria that causes TB, is spread by inhaling airborne droplets from infected people. These droplets can persist in the environment for hours.³ Approximately 1.7 billion people were infected with TB in 1990, predominantly in developing countries.⁴ Although global incidence peaked in the early 2000s, the disease progression has continued, although unevenly.⁵ For instance, Africa witnessed a 24% reduction in TB cases and a 42% decrease in TB-related deaths between 2015 and 2023, linked to improved detection and treatment, although challenges related to funding and multidrug-resistant TB (MDRTB) persist.⁶ The National Directly Observed Treatments Short Course (DOTS) program, recommended by the World Health Organization (WHO), has greatly increased treatment coverage (for instance, in some areas, treatment coverage rose from 55% to 74% between 2020 and 2023), and the percentage of pulmonary TB cases confirmed through bacteria has risen globally to nearly 63%.^{7,8} However, smear-positive TB detection is still below targets, and the global incidence of TB remains a concern.

In Nigeria, which ranks fifth globally and second in Africa for TB burden, an estimated 395,000 TB cases were reported in 2007, corresponding to an incidence rate of 283 per 100,000 population.⁹ Key contributing factors include overcrowded urban centers, inadequate healthcare infrastructure, poverty, malnutrition, and HIV co-infection.⁹ The progression of TB from latent infection to active disease involves exogenous risk factors (infection, close contact, smoking, alcohol use, indoor air pollution) and endogenous factors (immunosuppression due to HIV, diabetes, age, malnutrition).^{10,11} People living with HIV are estimated to have a 20–37-fold higher risk of developing active TB, with TB being a leading cause of AIDS-related deaths.^{12,13} A meta-analysis in China identified low CD4+ T-cell count, smoking, and intravenous drug use as significant HIV/TB co-risk factors, while BCG vaccination provided protective benefits.¹²

Other populations at risk include individuals with silicosis, Hodgkin's lymphoma, chronic lung disease, end-stage renal disease, malnutrition, alcohol dependency, and occupational exposure.¹⁴ In Nigeria, limited contact tracing between known TB patients and children resulted in significantly higher infection rates.¹⁵ Recent innovations in TB control include genome sequencing of drug-resistant TB in India¹⁶ and conditional cash transfer programs in

Brazil that reduced TB incidence by 41% and mortality by 31% among impoverished populations.¹⁷ The present study investigates the factors associated with the incidence of TB in Ikeja community areas in Lagos, Nigeria.

Materials and Methods

A cross-sectional study approach was employed. Adult patients aged 18 and over who were at risk of contracting tuberculosis in the Ikeja area of Lagos State, Nigeria, comprised the study population. Participants were recruited after giving their informed consent to participate in the study. A structured questionnaire was designed and administered to participants to collect information on possible risk factors for the disease. Data were gathered using a structured questionnaire that captured socio-demographic details, lifestyle practices, and exposure histories. Both TB cases and non-cases were included to allow for comparison. After data collection, a sampling frame was created, from which 133 participants were selected through simple random sampling without replacement. Data entry, cleaning, and analysis were conducted using SPSS (version 23). Bivariate logistic regression analysis was employed to examine associations between independent variables and the binary outcome of TB status (1 = presence of TB, 0 = absence of TB). Predictor variables included occupational exposure, smoking, alcohol use, family history of TB, immune status, and contact with TB patients. A statistically significant probability value was defined as $p < 0.05$. The risk of acquiring TB was assessed using the bivariate logistic regression method, and the results were reported using odds ratio, 95% CI, and p-value. The association between the selected explanatory variables and the outcome variable, the presence/absence of TB, was examined using logistic regression models.

The following potential risk factors were considered:

- Occupational exposure (OE)
- Smoking
- Alcohol
- Family history (FH)
- Weak immune system
- Contact with TB patients

Bivariate Logistic Regression: Theoretical Methodology

Let Y_i denote a binary outcome variable for the i -th individual, where $Y_i = 1$ if the event of interest occurs (e.g., TB positive) and $Y_i = 0$ otherwise. Let X_i denote a single explanatory variable. Bivariate logistic regression is used to model the relationship between a binary outcome and one predictor.

Model Specification

The probability that the event occurs given X_i is denoted by $\pi_i = P(Y_i = 1|X_i)$. The logistic regression model is defined as:

$$\pi_i = \frac{\exp(\beta_0 + \beta_1 X_i)}{1 + \exp(\beta_0 + \beta_1 X_i)}$$

Logit Transformation

Applying the logit link function, the model can be written as:

$$\log\left(\frac{\pi_i}{1 - \pi_i}\right) = \beta_0 + \beta_1 X_i$$

Interpretation of Parameters

Here, β_0 represents the intercept, and β_1 represents the effect of the predictor on the log-odds of the outcome. The exponentiated coefficient $\exp(\beta_1)$ gives the odds ratio associated with a one-unit increase in X_i , or relative to a reference category when X_i is categorical.

Parameter Estimation

Model parameters are estimated using maximum likelihood estimation (MLE). The likelihood function for a sample of size n is given by:

$$L(\beta) = \prod_{i=1}^n [\pi_i^{Y_i} (1 - \pi_i)^{1-Y_i}]$$

The log-likelihood function is maximized numerically to obtain parameter estimates.

Statistical Inference

Hypothesis testing is performed to assess the association between and the outcome using the null hypothesis $H_0: \beta_1 = 0$. Statistical significance may be evaluated using Wald, likelihood ratio, or score tests.

Results

Characteristics of study population

Table 1 presents the socio-demographic profiles of the respondent. Most respondents (63.2%) were male. More than half (54.1%) of the respondents had TB, of which 67% were male and 82% were younger than 65 years. Among those who had TB, 22% were between 55 and 64 years of age. Regarding education, half of the respondents had tertiary education. About 45.1% were married, two-thirds were employed, and 30.1% reported income between ₦20,000 and ₦49,999.

Table 1. Profile of respondents by socio-demographic and economic characteristics

Background Characteristics	Total (n)	Percentage (%)
Age Group	-	-
≤34	30	22.6
35–54	28	40.4
55–64	21	17.5
≥65	20	16.7
Sex	-	-

Male	84	63.2
Female	49	36.8
Marital Status	-	-
Unmarried	52	39.1
Married	60	45.1
Separated	4	3.0
Widow	13	9.8
Widower	4	3.0
Educational Level	-	-
Uneducated	17	12.8
Primary Education	26	19.5
Secondary Education	40	30.1
Higher Learning	50	37.6
Work Status	-	-
Working	65	48.9
Unemployed	22	16.5
Retiree	16	12.0
Monthly Earnings	-	-
No Income	15	11.3
≤ ₦19,999	15	11.3
₦20,000–₦49,999	40	30.1
₦50,000–₦99,999	34	25.6
₦150,000–₦199,999	7	5.3
≥ ₦200,000	7	5.3

Table 2 shows that 63.2% were smokers, of which 74.7% had TB. Among alcohol consumers (54.1%), 56% had TB. Family history of TB was present in 63.9% of participants; among those, 62.6% had TB. A compromised immune system was reported in 56.4% of respondents; 51.6% of them had TB. For those exposed occupationally, 72.5% had TB.

Table 2. Description of habit and exposure characteristics of respondents

Habit and Exposure Factors	Total (n)	Percentage (%)
Smoking (Yes)	84	63.2
Smoking (No)	49	36.8
Alcohol Consumption (Yes)	72	54.1
Alcohol Consumption (No)	61	45.9
TB Family History (Yes)	85	63.9
TB Family History (No)	48	36.1

Compromised Immune System (Yes)	75	56.4
Compromised Immune System (No)	58	43.6
Interaction with TB Cases (Yes)	60	45.1
No	59	44.4
Not sure	14	10.5
Workplace Exposure (Yes)	92	69.2
No	41	30.8

Factors Associated with Tuberculosis Infection

Table 3 presents the bivariate logistic regression output. Smoking, immunosuppression, and contact with TB-infected persons were significantly associated with TB.

The final significant predictors for the bivariate logistic regression

Table 4 presents the final model retained smoking, immunosuppression, and contact with TB-infected persons as significant predictors.

Table 3. Association of socio-demographic and clinical factors with TB infection

-	TB Status	-	-	-	-
Variable	Positive n (%)	Negative n (%)	OR	95CI	P-value
Age	-	-	-	-	-
≤ 34	18(33.96)	12(26.09)	1(Reference)	-	-
35-54	10(18.87)	18(39.13)	0.37	0.13–1.07	0.068 ^{ns}
≥55	25(47.17)	16(34.78)	1.04	0.40–2.73	0.934 ^{ns}
Sex	-	-	-	-	-
Male	56(77.78)	28(45.90)	1(Reference)	-	-
Female	16(22.22)	33(54.10)	0.24	0.11 – 0.51	<.001***
Smoking	-	-	-	-	-
Yes	63(76.83)	21(41.18)	1(Reference)	-	-
No	19(23.17)	30(58.82)	0.21	0.10 – 0.45	<.001***
Alcohol Use	-	-	-	-	-
Yes	40(56.34)	31(50.0)	1(Reference)	-	-
No	31(43.66)	31(50.0)	0.78	0.39 – 1.54	0.46 ^{ns}
Yes	41(62.12)	44(65.67)	1(Reference)	-	-
No	25(37.88)	23(34.33)	1.17	0.58 – 2.36	0.67 ^{ns}
Immuno suppressive status	-	-	-	-	-
Yes	39(72.22)	36(45.57)	1(Reference)	-	-
No	15(27.78)	43(54.43)	0.32	0.15 – 0.68	0.003**
Contact with TB patients	-	-	-	-	-
Yes	45(59.21)	15(24.59)	1(Reference)	-	-
No	17(22.37)	42(68.85)	0.14	0.06 – 0.33	<.001***
Don't know	14(18.42)	4(6.56)	1.17	0.34 – 4.05	0.8 ^{ns}
Occupational exposure	-	-	-	-	-
Yes	67(72.83)	25(60.98)	1(Reference)	-	-
No	25(27.17)	16(39.02)	0.58	0.27–1.27	0.18 ^{ns}

*p<.05, **p<.01, ***p<.001, ns = not significant

Table 4. The final significant predictors for the bivariate logistic regression

Factors	Odds Ratio	95% CI Lower	Upper	P-value
Sex (Female vs Male)	0.24	0.11	0.51	<0.001***
Smoking (No vs Yes)	0.21	0.10	0.45	<0.001***
Immunosuppressive status (No vs Yes)	0.32	0.15	0.68	0.003**
Contact with TB patients (No vs Yes)	0.14	0.06	0.33	<0.001***

*p < 0.05, **p < 0.01, ***p < 0.001, ns = not significant

Discussion

For this study, we used respondents' age category of ≤34 as the reference group for comparison with the other age categories in the study. Participants in the age group 35-54 years had lower odds of being infected with TB compared to the reference age group (OR = 0.37, 95% CI: 0.13–1.07, p = 0.068); this association, however, was not statistically significant. Respondents aged ≤55 years showed an odds ratio slightly higher than one, indicating that participants in the age group are 1.04 more likely to be infected with TB compared to the reference category (OR = 1.04, 95% CI: 0.40–2.73, p = 0.93), but the association was not statistically significant. In conclusion, the tendency for a respondent to be infected with TB had no significant association with the age of respondents according to the study. The findings in the study are consistent with evidence that age effects on TB risk may vary across populations and settings.^{18,19} The wide confidence interval indicates low precision that is attributed to a modest cell count, commonly encountered for a study with a small sample size that are stratified.²⁰ Female respondents had significantly lower odds of being infected with TB compared to male respondents (OR = 0.24, 95% CI: 0.11–0.51, p ≤ 0.001). The result shows that females were approximately 76% less likely to be TB positive than males. In addition, the association was statistically significant, indicating a strong relationship between sex and TB status in the study population. This statistically significant association supports previous studies that demonstrate a higher burden of TB among males, often attributed to biological differences, occupational exposure, and behavioral risk factors such as smoking.^{18,21}

Respondents who did not smoke had significantly lower odds of being infected with TB compared to smokers (OR = 0.21, 95% CI: 0.10–0.45, p ≤ 0.001). The result demonstrates that non-smokers were approximately 79% less likely to be TB positive than smokers. The association was statistically significant. The result in this study agrees with the evidence linking tobacco smoking with increased susceptibility to TB infection and disease progression.^{19,22}

Respondents who did not consume alcohol had slightly lower odds of being TB positive compared to alcohol users (OR =

0.78, 95% CI: 0.39–1.54, p = 0.46). However, this association does not indicate significant relationships between alcohol use and TB status in the study population. Although harmful alcohol use has been associated with TB risk in other studies as in²³, low statistical power or variability in alcohol consumption patterns within the study population may account for the lack of significant association between the two variables. Relationships between a family history of TB and TB status were examined. Respondents without a family history of TB showed an odds ratio of 1.17 compared to those respondents without family history of TB. The result indicates that respondents with a family history of TB were approximately 17% more likely to be infected with TB compared to respondents who reported no family history of TB (OR = 1.17, 95% CI: 0.58–2.36, p = 0.67). However, there is no indication of significant association between family history of TB and TB status in the study population. Although household or family exposure is a known risk factor for TB transmission, the absence of a significant association in this study may reflect underreporting or limited sample size.²⁴

Respondents without immunosuppressive conditions had significantly lower odds of being TB positive compared with immunosuppressed respondents (OR = 0.32, 95% CI: 0.15–0.68, p = 0.003). This shows that individuals who were not immunosuppressed were approximately 68% less likely to be TB positive than those with immunosuppressive conditions. The association was statistically significant, indicating a strong relationship between immunosuppression and TB status. The study further established that immune suppression increases susceptibility to TB infection.^{18,25} Respondents who reported no contact with TB patients had significantly lower odds of being infected with TB compared with those who reported contact (OR = 0.14, 95% CI: 0.06–0.33, p ≤ 0.001), indicating a strong protective association. This group of respondents was about 86% less likely to be infected with TB than those in contact. In contrast, respondents who were unsure ("don't know") about prior contact were 17% more likely to be infected with TB compared to those who reported contact (OR = 1.17, 95% CI: 0.34–4.05, p = 0.80). The association shows no statistically significant difference.

These results agree with the study in²⁴ that close contact with infectious TB cases enhances transmission of the disease.

The relationship between occupational exposure and TB infection was assessed among the study respondents. Using respondents with occupational exposure (“Yes”) as the reference category, those without occupational exposure (“No”) had lower odds of TB infection (OR = 0.58, 95% CI: 0.27–1.27, $p = 0.18$). Although the odds suggest a potentially protective effect of having no occupational exposure, the association was not statistically significant, indicating that TB infection did not differ substantially between respondents with and without occupational exposure in this sample. Occupational exposure has been linked with the risk of TB, particularly in healthcare according to²⁶. Larger studies primarily reveal the effect, often establishing a statistically significant relationship that suggests occupational exposure may contribute to TB risk. These findings highlight that while occupational exposure may contribute to TB risk, other factors may also play important roles, and larger studies are needed to clarify this relationship.

Conclusion

The study’s findings demonstrate that, when taken collectively, several factors are strongly linked to TB infection. In particular, the most important predictors were close contact with people who have tuberculosis, smoking, and immunosuppressive conditions. The magnitude of these effects is demonstrated by the adjusted odds ratios, which show the protective effect of a healthy immune system: smokers had nearly eight times higher odds of TB compared to non-smokers, while those without immunosuppressive conditions had significantly lower odds. In a similar vein, coming into contact with people who had tuberculosis significantly raised the risk of contracting the illness. These results highlight how tobacco use and weak immunity can alter the body defenses, increasing the risk of contracting tuberculosis.

Given the contagious nature of tuberculosis, it is critical to ensure prompt medical attention and ongoing monitoring for people who have been exposed to tuberculosis patients. Effective contact tracing and early diagnosis are essential strategies to prevent transmission within the community. In addition, proactive screening of people with immunosuppressive conditions can help detect TB earlier, allowing timely treatment and reducing overall disease burden. Together, the study highlights the importance of targeted public health interventions that focus on modifiable risk factors, raise awareness, and strengthen surveillance systems to control TB and ultimately reduce its incidence.

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Conflicts of Interest

The authors declare no conflict of interest.

Ethics Approval

Ethical clearance was obtained from the University of Fort Hare Inter-Faculty Human Research Ethics Committee (Reference: 270710-028-RA Level 01/QIN021SADE0).

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