

Prevalence and Risk Factors of Pulmonary Tuberculosis among Presumptive TB Patients at Akim Oda Government Hospital, Ghana: A Cross-Sectional Study

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Abstract:

Background: Pulmonary tuberculosis (PTB) remains a major public health concern globally and continues to cause substantial morbidity and mortality, particularly in resource-limited settings. Early detection among presumptive TB cases is critical for timely treatment initiation and reducing transmission.

Methods: A hospital-based cross-sectional study was conducted from April to August 2025 at Akim Oda Government Hospital. A total of 234 participants aged 10–40 years with symptoms suggestive of PTB (especially cough ≥ 2 weeks) were recruited using a purposive sampling technique. Sputum samples were collected and analyzed using Ziehl–Neelsen smear microscopy and GeneXpert MTB/RIF assay for detection of *Mycobacterium tuberculosis*. A structured questionnaire was administered to obtain socio-demographic characteristics and risk factor information. Data were analyzed using SPSS version 26, and associations between PTB status and selected variables were tested using Chi-square, with statistical significance set at $p < 0.05$.

Results: Out of the 234 participants, 50 tested positive, giving an overall PTB prevalence of 21.4% (50/234). GeneXpert detected PTB in 26.6% (24/90) of tested samples, while smear microscopy detected PTB in 18.1% (26/144). PTB positivity was significantly associated with age group ($p = 0.001$) and gender ($p = 0.019$), with the highest burden observed among participants aged 30–40 years and among males. Sputum appearance was significantly associated with PTB detection by both GeneXpert ($p = 0.014$) and microscopy ($p = 0.020$), with mucopurulent samples yielding the highest positivity. Among the risk factors assessed (smoking, alcoholism, family history, overcrowding, and malnutrition), none showed significant association with PTB positivity ($p > 0.05$); however, TB awareness demonstrated a borderline association ($p = 0.067$).

Conclusion: Pulmonary tuberculosis prevalence among presumptive TB patients at Akim Oda Government Hospital was high (21.4%). GeneXpert MTB/RIF demonstrated a higher detection yield than smear microscopy. Age, gender, and sputum quality were significant predictors of PTB positivity, emphasizing the need for strengthened facility-based screening, improved sputum collection practices, and expanded access to rapid molecular diagnostics.

Keywords: Pulmonary tuberculosis; GeneXpert MTB/RIF; Ziehl–Neelsen microscopy; prevalence; risk factors; Ghana; Akim Oda Government Hospital

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Introduction

Tuberculosis (TB) remains a significant public health challenge worldwide (Getahun et al., 2015; WHO, 2019). Tuberculosis is a bacterial disease caused by *Mycobacterium tuberculosis*, which primarily affects the lungs (Lienhardt et al., 2024; WHO, 2022). Tuberculosis spreads through the air when people with pulmonary TB cough, sneeze, speak, or spit, and uninfected persons inhale the bacteria through airborne droplets (WHO, 2022; CDC, 2020). Globally, an estimated ten million people develop tuberculosis each year, making it one of the most important infectious diseases affecting human populations (Melsew et al., 2020; WHO, 2023). Most cases of tuberculosis affect the lungs, a condition referred to as pulmonary tuberculosis (PTB) (WHO, 2022; Lienhardt et al., 2024). However, tuberculosis can also affect other parts of the body, including lymph nodes, the brain, bones, kidneys, and other organs, resulting in extrapulmonary tuberculosis (Osei et al., 2020; WHO, 2022).

Tuberculosis can lead to a wide range of complications, including lung tissue destruction, chronic respiratory impairment, infection of bones and the spinal cord, TB meningitis, lymphatic involvement, liver or kidney dysfunction, and inflammation of tissues around the heart (WHO, 2019; Osei et al., 2020). Untreated or poorly managed tuberculosis may result in permanent lung damage and long-term respiratory problems, contributing significantly to morbidity and mortality worldwide (WHO, 2019; Ghana Health Service, 2020). Many individuals suffering from TB experiences complicated treatment regimens due to challenges



such as multidrug resistance, HIV co-infection, and the need for prolonged combination therapy, often associated with adverse drug reactions and poor adherence (CDC, 2020; Lienhardt et al., 2024). Tuberculosis is also strongly associated with weakened immune systems, prolonged close contact with infected individuals, alcohol or substance abuse, and chronic medical conditions such as diabetes mellitus, which increase susceptibility and likelihood of progression from latent infection to active disease (Lienhardt et al., 2018; Girma et al., 2023). In 2023, tuberculosis caused approximately 1.25 million deaths globally, including around 161,000 deaths among people living with HIV, reinforcing its status as a major cause of death from a single infectious agent (WHO, 2023; Ghana Health Service, 2020).

The most common organism responsible for tuberculosis is *Mycobacterium tuberculosis sensu stricto* (Mtbss), although other members of the *Mycobacterium tuberculosis* complex such as *Mycobacterium africanum* (Maf) and *Mycobacterium bovis* have also been implicated in TB infections, particularly within parts of West Africa (Asante-Poku et al., 2015). Tuberculosis incidence and susceptibility patterns are more frequent in populations exposed to socio-economic risks such as poverty, overcrowding, poor ventilation, malnutrition, and limited access to healthcare services (Girma et al., 2023; Ghana Health Service, 2020). People with latent tuberculosis infection usually do not feel sick and are not contagious, but a proportion of infected individuals develop active tuberculosis disease, especially when immune function becomes compromised (WHO, 2025; Lienhardt et al., 2018). The common symptoms of active pulmonary TB include persistent cough lasting more than two weeks (sometimes with hemoptysis), chest pain, weakness, fatigue, fever, weight loss, and night sweats (WHO, 2025; CDC, 2020).

In Akim Oda, a town located in the Eastern Region of Ghana, regular screening for tuberculosis could play a crucial role in early detection, timely treatment initiation, and prevention of community spread (Ghana Health Service, 2020). By identifying and treating TB cases promptly, transmission within families and communities may be reduced, and public health outcomes improved through strengthened TB control interventions (WHO, 2022; Ghana Health Service, 2020). This study therefore aims to investigate the effectiveness of regular tuberculosis screening in Akim Oda, with a focus on early detection and prevention, while contributing to evidence-based tuberculosis control at Akim Oda Government Hospital.

Study Area

This study was conducted at Akim Oda Government Hospital, located in Akim Oda in the Birim Central Municipality of the Eastern Region of Ghana. The municipality serves an estimated population of approximately 76,302 people. Akim Oda Government Hospital is a major healthcare facility in the area, with a capacity of 135 beds, and provides healthcare services to residents of Akim Oda and surrounding communities.

The hospital was selected as the study site due to its accessibility, its role as a key referral and diagnostic center within the municipality, and its capacity to support tuberculosis investigations through routine clinical services. The geographic coordinates of the hospital are approximately 5°55'42"N (5.92846°N) latitude and 0°59'9"W (-0.98575°W) longitude. The location and service coverage of the facility make it suitable for

recruiting a diverse patient population for a hospital-based tuberculosis prevalence and risk-factor assessment.

Study Design

A hospital-based cross-sectional study was conducted at Akim Oda Government Hospital in the Eastern Region of Ghana. The study was carried out from April to August 2025. Participants were recruited using a purposive sampling technique, and individuals presenting to the hospital with symptoms suggestive of pulmonary tuberculosis were enrolled.

Sputum samples were collected from eligible participants and analyzed using Ziehl–Neelsen smear microscopy and the GeneXpert MTB/RIF assay for the detection of *Mycobacterium tuberculosis* and rifampicin resistance. In addition, a structured questionnaire was administered to obtain sociodemographic data and information on potential tuberculosis-related risk factors. Data were entered and analyzed using SPSS version 26, with statistical significance assessed at a defined threshold.

Study Participants

The study participants consisted of adolescents and young adults who attended Akim Oda Government Hospital during the study period (April to August 2025) and presented with symptoms suggestive of pulmonary tuberculosis. Eligible participants were those within the specified age range (10–40 years) and who reported a cough lasting two weeks or more, with or without other clinical features consistent with tuberculosis.

Participants were required to provide spontaneous sputum samples for laboratory testing and to complete a structured questionnaire on demographic characteristics and potential tuberculosis-associated risk factors. Written informed consent was obtained from all participants prior to enrolment. For participants below 18 years, consent was obtained from a parent or guardian.

Inclusion Criteria

Participants were eligible for enrolment if they:

1. Were adolescents or young adults aged 10–40 years.
2. Attended Akim Oda Government Hospital during the study period (April–August 2025).
3. Presented with symptoms suggestive of pulmonary tuberculosis, particularly a cough lasting ≥ 2 weeks.
4. Were able and willing to provide a spontaneous sputum sample for laboratory analysis.
5. Provided written informed consent (or assent with parental/guardian consent for participants <18 years).
6. Agreed to complete the structured questionnaire on demographic characteristics and potential TB risk factors.

Exclusion Criteria

Participants were excluded from the study if they:

1. Had a previously known tuberculosis status, including confirmed TB cases currently on treatment.
2. Had completed tuberculosis treatment within the past two years.

3. Were asymptomatic and did not present with signs or symptoms suggestive of pulmonary TB.
4. Were unable to produce an adequate sputum sample for laboratory testing.
5. Were critically ill and required urgent intensive care or were too unwell to participate fully in the study procedures.

Sample Size Determination

The sample size for this study was determined using the standard formula for cross-sectional studies:

$$n = \frac{Z^2 P(1 - P)}{E^2}$$

Where:

- n = required sample size
- Z = Z-score for 95% confidence level (1.96)
- P = estimated prevalence of tuberculosis (0.15)
- E = margin of error (0.05)

Since the prevalence of tuberculosis at the study site was not readily available, an estimated prevalence (P = 0.15) was used. The calculation was therefore performed as follows:

$$n = \frac{(1.96)^2 \times 0.15 \times (1 - 0.15)}{(0.05)^2}$$

$$n = \frac{3.8416 \times 0.15 \times 0.85}{0.0025}$$

$$n = \frac{3.8416 \times 0.1275}{0.0025}$$

$$n = \frac{0.4898}{0.0025} = 195.9 \approx 196$$

Thus, a minimum sample size of 196 participants was required. However, a total of 234 participants were recruited using a purposive sampling technique to improve representativeness and strengthen the reliability of the findings.

Sample Collection

Sputum samples were collected from eligible participants using a spontaneous sputum collection method. Participants were instructed to produce sputum in a well-ventilated, low-traffic area to minimize the risk of airborne transmission. Each participant was guided to expectorate deep sputum directly into a sterile, leak-proof sputum container.

All specimens were assigned unique identification codes, properly labeled, and placed in biohazard specimen bags for safe handling. The samples were then transported promptly to the Medical Laboratory for processing and analysis.

Laboratory Analysis

All sputum specimens were processed and analyzed at the Medical Laboratory of Akim Oda Government Hospital. Laboratory diagnosis of pulmonary tuberculosis was performed using Ziehl–Neelsen (ZN) smear microscopy and the GeneXpert MTB/RIF assay, in accordance with recommended tuberculosis diagnostic protocols (CDC, 2024; Stop TB Partnership, 2013).

Materials and Equipment

Major laboratory materials and equipment included sterile sputum containers, clean microscope slides, Ziehl–Neelsen staining reagents (carbol fuchsin, acid-alcohol, methylene blue), Bunsen burner, inoculating loop, immersion oil, light microscope, GeneXpert MTB/RIF cartridges, GeneXpert instrument system, sample reagent, sterile disposable pipettes, discard containers, and a computer interface for test execution and result reporting (CDC, 2000; WHO, 1998).

Ziehl–Neelsen Smear Microscopy

Ziehl–Neelsen staining was performed to detect acid-fast bacilli (AFB) in sputum specimens. Smear microscopy remains a widely used and important diagnostic approach for tuberculosis case detection, especially in resource-limited settings (CDC, 2000; Stop TB Partnership, 2013).

Procedure

A clean labeled glass slide was prepared for each specimen, and a thin smear was made by evenly spreading sputum material. The smear was air-dried and heat-fixed. The fixed smear was flooded with carbol fuchsin and heated gently until vapour appeared without boiling. The stain was retained on the smear for approximately 5 minutes, then rinsed with water.

The smear was then decolorized using acid-alcohol until adequate decolorization occurred, followed by rinsing with water. A counterstain of methylene blue was applied for approximately 2 minutes and rinsed. The slide was allowed to dry and was examined under oil immersion using the ×100 objective lens to identify acid-fast bacilli (CDC, 2000; WHO, 1998).

GeneXpert MTB/RIF Assay

The GeneXpert MTB/RIF assay was used as a rapid molecular diagnostic method for the detection of Mycobacterium tuberculosis complex (MTBC) and rifampicin resistance (RIF resistance) directly from sputum specimens. The assay provides results within approximately 2 hours, making it valuable for early TB diagnosis and prompt treatment initiation (CDC, 2024; Cepheid, 2020).

Specimen Processing

Sputum specimens were processed using the manufacturer-recommended method. A sample reagent (SR) was added to sputum at the appropriate ratio (2:1 SR:sputum), and the mixture was vortexed or shaken thoroughly to ensure homogenization (Cepheid, 2020; WHO, 2014).

The mixture was incubated at room temperature for 15 minutes, with additional mixing performed during the incubation to improve processing efficiency (Cepheid, 2020; WHO, 2014).

Cartridge Loading

After incubation, approximately 2 mL of the processed specimen was transferred into the GeneXpert MTB/RIF cartridge using a sterile pipette, ensuring that bubbles were avoided. The cartridge lid was closed securely and inserted into the GeneXpert instrument system within the recommended timeframe to preserve specimen integrity and test performance (Cepheid, 2020).

Test Execution and Interpretation

Cartridge barcodes were scanned, and participant information was entered into the GeneXpert software system. The Xpert MTB/RIF protocol was selected and the test initiated. The assay runs automatically, producing output that reports MTB detected/not detected and rifampicin resistance detected/not detected/indeterminate, where applicable (CDC, 2024; Cepheid, 2020).

Data Analysis

Data obtained from the structured questionnaires and laboratory results were checked for completeness, coded, and entered into Microsoft Excel before being exported into the Statistical Package for Social Sciences (SPSS) version 26 for analysis. Descriptive statistics were computed and presented using frequencies, percentages, and graphical summaries to describe participants’ socio-demographic characteristics, level of knowledge on tuberculosis, and other relevant risk factors.

The prevalence of pulmonary tuberculosis was determined by calculating the proportion of laboratory-confirmed positive cases out of the total number of participants tested, and results were reported as percentages. The distribution of tuberculosis positivity across key variables such as age group, gender, educational level, and sputum characteristics was summarized using tables and charts.

To assess associations between pulmonary tuberculosis status and potential risk factors, Chi-square (χ^2) tests were applied for categorical variables. Variables assessed included age category, sex, smoking status, alcohol intake, family history of tuberculosis, overcrowding, and nutritional status. Statistical significance was determined using a p-value threshold, and results were interpreted accordingly. All statistical outputs were presented in appropriate tables and figures, and interpretations were made in relation to the study objectives and existing literature.

Results

Socio-demographic Characteristics of Study Participants

A total of 234 participants were enrolled in this study. With respect to age distribution, the highest proportion of respondents were within the 30–40 years age group (n = 104; 44.4%), followed by participants aged 20–29 years (n = 65; 27.8%) and 10–19 years (n = 65; 27.8%) as shown in Figure.1

In Figure 2, in terms of gender, the study population consisted of 132 males (56.4%) and 102 females (43.6%), yielding a female-to-male ratio of approximately 1:1.3.

Regarding educational status, 44 participants (18.8%) reported having no formal education, while 76 (32.5%) had attained basic education. Additionally, 55 participants (23.5%) had

secondary education, and 59 (25.2%) had completed tertiary education as shown in Figure3

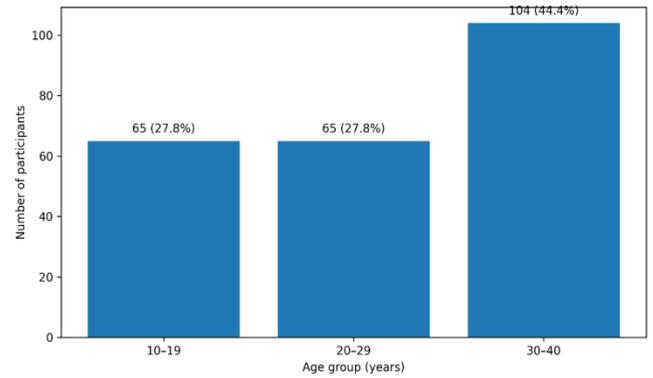


Figure 1: Age Distribution of Study Participants (N=234)

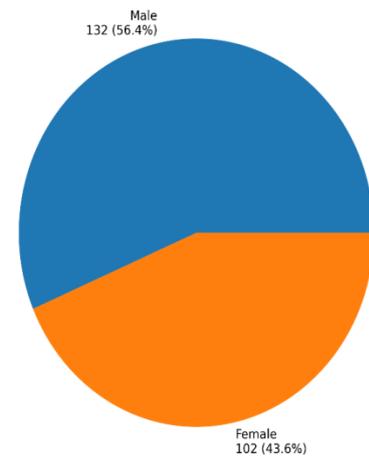


Figure 2: Gender Distribution of Study Participants (N=234)

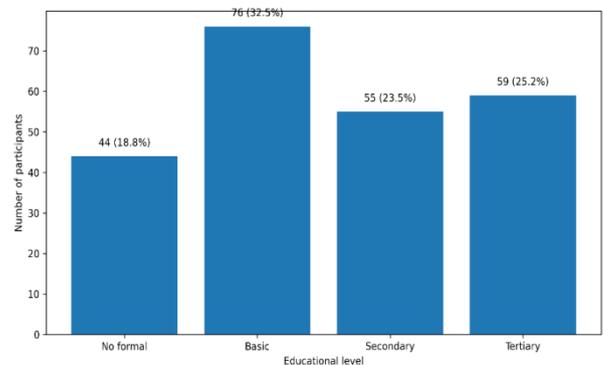


Figure 3: Educational Level of Study Participants (N=234)

Table.1 summarizes the distribution of pulmonary tuberculosis (PTB) status (positive vs negative) across selected participant characteristics, including age group, sex, and sputum macroscopic appearance, with statistical significance assessed using Chi-square tests (p < 0.05).

These variables are widely recognized as key determinants influencing TB infection risk and detection outcomes in facility-based populations (WHO, 2014).

Age Group and PTB Positivity

The table shows clear variation in PTB positivity across age categories. Among the TB-negative group (n = 184; 78.7%), most participants were within the 30–40 years category (76;

32.5%), followed by 20–29 years (62; 26.5%) and 10–19 years (46; 19.7%).

Similarly, among the TB-positive participants (n = 50; 21.4%), the largest proportion of confirmed cases occurred in the 30–40 years group (28; 12.0%), followed by the 10–19 years group (19; 8.1%), while the 20–29 years group had the lowest number of positives (3; 1.3%).

Importantly, there was a statistically significant association between age group and PTB status (p = 0.001).

This finding is epidemiologically plausible because TB risk is influenced by age-related differences in exposure intensity, immune status, living conditions, and household/community contact dynamics, which often affect older adolescents and adults more strongly (WHO, 2014).

Sex and PTB Positivity

Sex-based differences were also evident. Among females (n = 102; 43.6%), 14 (6.0%) were TB-positive and 88 (37.6%) were TB-negative. In contrast, males (n = 132; 56.4%) recorded 36 (15.4%) positive cases and 96 (41.0%) negative cases. The relationship between sex and PTB status was statistically significant (p = 0.019).

This pattern aligns with global TB epidemiology, where males frequently contribute a higher share of diagnosed cases, often linked to increased occupational exposure, delayed healthcare seeking, and higher prevalence of certain behavioral or environmental risk factors (WHO, 2014).

Sputum Macroscopy and PTB Detection

The table further evaluates TB positivity according to sputum appearance (macroscopy), categorized as mucopurulent, muco-bloody, and muco-salivary, using results from both GeneXpert MTB/RIF and Ziehl–Neelsen microscopy. Sputum quality is a recognized operational factor affecting diagnostic yield, as good-quality sputum (often mucopurulent) is more likely to contain detectable organisms than salivary specimens (Stop TB Partnership, 2013).

GeneXpert Findings

For samples tested using GeneXpert MTB/RIF, mucopurulent sputum recorded 19 positives (8.1%) compared to muco-bloody (3 positives; 1.3%) and muco-salivary (2 positives; 0.9%) specimens. The association between sputum appearance and GeneXpert result was statistically significant (p = 0.014).

This is consistent with WHO guidance indicating that Xpert MTB/RIF improves detection in presumptive pulmonary TB and supports rapid diagnosis due to its nucleic acid amplification mechanism, which identifies TB DNA directly from sputum (WHO, 2014).

Microscopy Findings

Similarly, microscopy results demonstrated that mucopurulent sputum accounted for most positive detections (23 positives; 9.8%), while muco-salivary sputum produced fewer positives (3 positives; 1.3%) and muco-bloody sputum had no detected positives (0; 0.0%). The association between sputum appearance and microscopy result was also statistically significant (p = 0.020).

These findings are supported by international laboratory guidance emphasizing that smear microscopy positivity is influenced by bacillary load and sample quality, meaning poor-quality specimens may contribute to false-negative microscopy outcomes (CDC, 2000; Stop TB Partnership, 2013).

Comparative Interpretation (GeneXpert vs Microscopy)

Table 1 also indirectly shows a higher positivity yield for GeneXpert compared with microscopy. Evidence from a major Cochrane systematic review indicates that Xpert MTB/RIF substantially increases TB detection compared with smear microscopy among culture-confirmed cases, with particularly strong benefits in smear-negative disease (Steingart et al., 2014).

Therefore, the diagnostic pattern shown in Table.1 supports the importance of expanding access to molecular testing as part of routine TB screening services to improve case detection, reduce diagnostic delay, and support early treatment initiation (WHO, 2014; WHO, 2014 Implementation Manual).

Table.1 demonstrates that pulmonary tuberculosis positivity among symptomatic patients was significantly associated with age group (p = 0.001) and sex (p = 0.019), with the highest burden observed among individuals aged 30–40 years and among males.

In addition, sputum appearance was significantly associated with TB detection under both GeneXpert (p = 0.014) and microscopy (p = 0.020), with mucopurulent sputum producing the highest proportion of positive results across methods. These patterns align with established TB diagnostic evidence showing that specimen quality influences bacillary detection and that GeneXpert generally improves diagnostic yield compared with smear microscopy (Stop TB Partnership, 2013; WHO, 2014; Steingart et al., 2014).

Table 1. Distribution of pulmonary tuberculosis status by age, sex, and sputum characteristics among study participants (N = 234)

Variable	Tuberculosis			P- value
	Negative (%)	Positive (%)	Total (%)	
Age Group				0.001
10 – 19	46 (19.7)	19 (8.1)	65 (27.8)	
20 – 29	62 (26.5)	3(1.3)	65(27.8)	

30 – 40	76(32.5)	28(12.0)	104(44.4)	
Gender				0.019
Female	88(37.6)	14(6.0)	102(43.6)	
Male	96(41.0)	36(15.4)	132(56.4)	
GeneXpert				0.014
Mucopurulent	40 (17.1)	19 (8.1)	59 (25.2)	
Muco-bloody	2 (0.9)	3 (1.3)	5 (2.1)	
Muco-salivary	24 (10.3)	2 (0.9)	26 (11.1)	
Microscopy				0.020
Mucopurulent	71 (30.3)	23 (9.8)	94 (40.2)	
Muco-bloody	9 (3.8)	0(0.00)	10(4.3)	
Muco-salivary	38(16.2)	3(1.3)	40(17.1)	

Knowledge of Pulmonary Tuberculosis and Associated Risk Factors

Table. 2 presents the distribution of selected behavioral, household, and awareness-related factors among participants and examines their relationship with pulmonary tuberculosis (PTB) status (TB-positive vs TB-negative) using p-values. These factors—including smoking, alcohol use, household exposure, overcrowding, malnutrition, and TB awareness—are commonly explored in TB epidemiology because they influence either the risk of infection, progression to active disease, or health-seeking behavior (Lin et al., 2007; Imtiaz et al., 2017).

Smoking and PTB status

Only 26 (11.25%) of participants reported smoking, compared to 208 (88.75%) non-smokers. Among smokers, 6 were TB-positive and 20 were TB-negative, whereas among non-smokers, 44 were TB-positive and 164 were TB-negative. However, the association between smoking status and PTB positivity was not statistically significant (p = 0.690).

Although this study did not find a significant association between smoking and PTB positivity, smoking remains a well-established risk factor for TB disease in broader literature. Smoking increases the risk of TB infection and active disease and contributes to worse TB outcomes, as supported by systematic reviews and epidemiological studies (Lin et al., 2007; Dogar et al., 2015; Feldman & Anderson, 2024). The lack of statistical significance in this dataset may reflect sample size limitations, underreporting, or confounding by other risk variables (Lin et al., 2007).

Alcohol use and PTB status

In Table 2, 58 (24.80%) participants reported alcohol use, while 176 (75.20%) did not. Among alcohol users, 12 were TB-positive and 46 were TB-negative, compared with 38 TB-positive and 138 TB-negative among non-alcohol users. The association between alcohol use and PTB positivity was not statistically significant (p = 0.978).

Even though this relationship was not significant in your results, alcohol consumption is strongly supported in global evidence as a risk factor for TB, contributing substantially to TB burden in multiple settings. Meta-analyses show that alcohol use increases the risk of active tuberculosis and may influence treatment outcomes through immune suppression, risky exposures, and reduced care engagement (Imtiaz et al., 2017; Chung et al., 2024).

Family history (household exposure) and PTB status

A total of 29 (12.5%) participants reported a family history of TB and 205 (87.5%) reported none. Among those with family history, 6 were TB-positive and 23 were TB-negative. Among those without family history, 44 were TB-positive and 161 were TB-negative. The relationship between family history and TB positivity was not statistically significant (p = 0.690).

Despite the non-significant association in this study, household exposure remains one of the most important and consistently supported TB risk factors. Systematic reviews show household contacts are at substantially higher risk of TB infection and disease compared with the general population, and contact investigation is widely recommended as a control strategy (Fox et al., 2012; Seid et al., 2022).

Overcrowding and PTB status

Overcrowding was reported by 35 (15%) participants, while 199 (85%) reported no overcrowding. TB positivity among those reporting overcrowding was 8, compared with 42 among those not overcrowded. The relationship between overcrowding and TB positivity was not statistically significant ($p = 0.787$).

From an epidemiological standpoint, overcrowding increases TB transmission potential because TB is airborne and spreads more efficiently in poorly ventilated indoor environments with prolonged close contact, although the strength of association often depends on intensity and duration of exposure and other confounders (Lin et al., 2007; WHO contact investigation guidance).

Malnutrition and PTB status

Only 15 (6.25%) participants reported malnutrition, whereas 219 (93.75%) did not. Among malnourished participants, 3 were TB-positive and 12 were TB-negative. Among those without malnutrition, 47 were TB-positive and 172 were TB-negative. There was no statistically significant association ($p = 0.935$).

Although your results did not show significance, malnutrition is widely recognized as a biological risk factor for TB progression because it compromises immune function and increases vulnerability to infection and disease activation. However, the small proportion of malnourished participants in this dataset may have limited the ability to detect statistical differences (Lin et al., 2007).

TB awareness and PTB status

TB awareness levels were categorized as Yes, No, and Not Sure (NS). In the table, 73 (31.25%) participants reported awareness, 140 (60.00%) reported no awareness, and 21 (8.75%) were not sure. Among those aware, 18 were TB-positive and 55 were TB-negative. Among those not aware, 28 were TB-positive and 112 were TB-negative, while among those not sure, 4 were TB-positive and 17 were TB-negative. The association between TB awareness and PTB positivity was borderline but not statistically significant ($p = 0.067$).

Although awareness was not statistically significant at the 0.05 level, the near-significant p-value suggests that TB knowledge and awareness may still play an important role in shaping risk patterns in this setting. This aligns with evidence that low TB knowledge and high stigma contribute to delayed diagnosis and ongoing community transmission, mainly by affecting symptom recognition and healthcare-seeking behaviour (Abebe et al., 2010; Makgopa et al., 2021; Kılıç et al., 2025).

Overall, Table 2 indicates that smoking, alcohol use, family history, overcrowding, and malnutrition were not statistically associated with PTB positivity in this study population ($p > 0.05$). However, TB awareness demonstrated a borderline association with PTB status ($p = 0.067$), implying that knowledge-related factors could still influence risk and detection patterns. These findings should be interpreted alongside strong evidence from global TB literature showing that smoking, alcohol use, and household exposure remain important TB risk factors and that inadequate knowledge and stigma are major barriers to early

diagnosis and treatment uptake (Lin et al., 2007; Imtiaz et al., 2017; Fox et al., 2012; Abebe et al., 2010).

Discussion

This study assessed the prevalence and selected risk factors of pulmonary tuberculosis (PTB) among presumptive TB patients attending Akim Oda Government Hospital in the Eastern Region of Ghana. The overall prevalence of laboratory-confirmed PTB in this study was 21.4% (50/234), indicating that approximately one in five symptomatic participants had active PTB.

This finding confirms that tuberculosis remains a major public health problem within symptomatic hospital-attending populations in Ghana, and it supports the importance of strengthening early diagnosis and prompt treatment initiation in line with global TB control priorities (WHO, 2023; Lienhardt et al., 2018).

Prevalence of Pulmonary Tuberculosis and Public Health Implications

The observed PTB prevalence of 21.4% among presumptive cases suggests a considerable burden of transmission or undetected infection in the catchment population of the hospital.

In many high-burden settings, facility-based prevalence among symptomatic patients is usually higher than community prevalence because symptomatic screening selects individuals with greater likelihood of disease (WHO, 2023). Importantly, undiagnosed or late-diagnosed TB contributes significantly to ongoing community transmission, especially where cough is prolonged before healthcare presentation (WHO, 2023). Therefore, the prevalence reported in this study supports the continued need for TB case finding and diagnostic strengthening at the hospital and district level.

Diagnostic Yield: GeneXpert MTB/RIF Compared with Smear Microscopy

A major strength of this study is the use of both Ziehl–Neelsen microscopy and GeneXpert MTB/RIF for TB detection. In this study, GeneXpert detected TB positivity in 26.6% (24/90) of samples tested, whereas microscopy detected TB in 18.1% (26/144) of samples examined.

This pattern is consistent with strong evidence that molecular tests such as Xpert MTB/RIF detect more TB cases than smear microscopy, especially among individuals with lower bacillary load or early disease. A Cochrane systematic review by Steingart and colleagues demonstrated that Xpert MTB/RIF has substantially higher sensitivity than smear microscopy while maintaining high specificity and enabling rapid detection of rifampicin resistance (Steingart et al., 2014). Similarly, WHO recommends Xpert MTB/RIF as an initial diagnostic tool in many presumptive TB cases because it enhances case detection and reduces diagnostic delay (WHO, 2014).

The higher proportion of positives with GeneXpert in this study reinforces the importance of scaling up rapid molecular testing to improve early diagnosis and reduce missed cases. This is relevant because smear microscopy alone—although widely used due to affordability—may fail to identify smear-negative but clinically infectious cases, which can prolong transmission chains (Steingart et al., 2014; WHO, 2014). In addition, early detection

through GeneXpert can facilitate timely initiation of appropriate treatment, including drug-resistant TB regimens where rifampicin resistance is detected (WHO, 2014).

Age as a Significant Factor Associated with PTB Positivity

Age group was significantly associated with tuberculosis positivity ($p = 0.001$). The highest proportion of PTB-positive cases was observed among participants aged 30–40 years, while the lowest positivity occurred among those aged 20–29 years.

The significant age association observed may reflect differences in cumulative exposure risk, workplace and social interactions, and household contact patterns. Adults in the productive age range often experience increased exposure due to mobility, occupational activity, and frequent social contact, which can raise TB transmission risk (WHO, 2023). Age-related disparities in TB patterns have also been linked to socioeconomic vulnerability and health-seeking behavior, where adults may delay hospital presentation until symptoms become severe, thereby increasing the probability of confirmed disease in facility-based samples (Lienhardt et al., 2018).

Notably, the burden observed among younger participants (10–19 years) also warrants attention. Adolescents may be exposed through household or close-contact transmission, and the finding supports the need for effective contact tracing and screening strategies, which have shown measurable yield for TB detection among household contacts of infectious cases (Fox et al., 2012). Evidence consistently indicates that household contact investigations improve early case detection and contribute to TB control by identifying cases earlier than passive facility presentation (Fox et al., 2012).

Sex Differences in Tuberculosis Positivity

Gender was significantly associated with PTB positivity ($p = 0.019$). In this study, males had a higher number of PTB-positive results compared with females. This male predominance aligns with global TB epidemiology, where men often represent a larger proportion of notified TB cases. Several explanations have been proposed in the literature, including differences in occupational exposure, smoking and alcohol-related behaviors, stigma-related delays, and reduced healthcare utilization among men (WHO, 2023). Sex differences may also reflect structural barriers or gender norms that influence early symptom reporting and health facility attendance, which in turn affects observed disease detection patterns (WHO, 2023).

Given this consistent pattern, targeted screening and awareness interventions focused on male populations may contribute to improved early detection and reduced transmission. In TB control programming, gender-responsive strategies are increasingly considered important for improving uptake of testing and reducing missed diagnosis among men (WHO, 2023).

Sputum Appearance and TB Detection

Sputum macroscopic appearance was significantly associated with TB detection by both GeneXpert ($p = 0.014$) and microscopy ($p = 0.020$). Mucopurulent sputum accounted for the highest number of TB-positive detections compared with mucosalivary and muco-bloody samples.

This finding is biologically and operationally plausible because mucopurulent sputum typically represents deeper

respiratory secretions and may contain higher bacillary load, improving the probability of detection, especially in smear microscopy where bacillary concentration strongly affects sensitivity (Stop TB Partnership, 2013). In practice, sputum quality is widely recognized as one determinant of smear positivity, and poor-quality samples may contribute to false-negative microscopy outcomes (Stop TB Partnership, 2013).

Nevertheless, sputum appearance alone should not be used to diagnose TB, as non-mucopurulent samples may still yield positive results, particularly when molecular tests are used. Molecular testing can detect MTB DNA in specimens with lower bacillary burden than required for smear positivity, reinforcing the value of GeneXpert for improving detection across specimen qualities (Steingart et al., 2014; WHO, 2014). This supports strengthening patient education on proper sputum production and ensuring that diagnostic protocols include sensitive methods where feasible.

Knowledge of Pulmonary Tuberculosis and Associated Risk Factors

Table.2 below assessed behavioral and exposure-related risk factors (smoking, alcoholism, family history, overcrowding, malnutrition) and TB awareness in relation to PTB status. Most variables were not statistically significant in this dataset: smoking ($p = 0.690$), alcoholism ($p = 0.978$), family history ($p = 0.690$), overcrowding ($p = 0.787$), and malnutrition ($p = 0.935$).

The absence of significant associations in these variables should be interpreted carefully, because lack of significance does not necessarily imply no true relationship. In cross-sectional facility-based studies, statistical associations may be weakened by limited sample size within subgroups (e.g., smokers, malnourished participants), reliance on self-reported exposures, and confounding effects. Additionally, because participants were already symptomatic, the population may have reduced variability in risk exposures, making it harder to detect significant differences.

Smoking

Although smoking was not statistically significant in this study, tobacco smoking is strongly supported as a major TB risk factor in global evidence. A systematic review and meta-analysis by Lin and colleagues reported that smoking increases the risk of TB infection and disease through impaired lung immunity and altered respiratory defenses (Lin et al., 2007). Similarly, smoking has been linked to worse clinical outcomes and delayed sputum conversion in TB patients, increasing the risk of poor treatment outcomes (Dogar et al., 2015). Therefore, even where significance is not observed, smoking remains an important public health factor for TB prevention and control.

Alcohol Use

Alcohol use was also not statistically significant in relation to PTB positivity. However, substantial evidence from meta-analyses indicates that alcohol consumption increases TB risk, possibly through immunosuppression, increased social exposure, and delayed healthcare-seeking behavior (Imtiaz et al., 2017). Alcohol use may also compromise treatment adherence and increase the likelihood of unfavorable outcomes once TB treatment begins (Imtiaz et al., 2017). For this reason, alcohol risk screening and counseling can complement TB prevention strategies.

Family History and Household Exposure

Family history was not significant in this analysis, but household contact remains one of the strongest predictors of TB infection and disease development. A systematic review by Fox et al. found that household contact investigation identifies a meaningful proportion of active TB cases and supports early diagnosis (Fox et al., 2012). Therefore, household screening remains essential, particularly in settings where TB awareness is low and delays in case detection persist.

Overcrowding

Overcrowding also showed no statistical association with PTB positivity in this study. Nonetheless, TB is transmitted through airborne particles, and crowded poorly ventilated spaces increase the probability of exposure and transmission, as emphasized by WHO TB transmission guidance (WHO, 2023). The non-significance here may reflect measurement limitations because overcrowding was assessed as a binary “yes/no” rather than measured using objective indicators such as persons per room, ventilation status, and duration of contact.

Malnutrition

Malnutrition was not statistically associated with PTB positivity. However, undernutrition is a biologically plausible and well-established risk factor for TB progression because it weakens immune function and increases susceptibility to active disease (WHO, 2023). The low prevalence of malnutrition among participants in this study may have reduced statistical power to detect associations.

TB Awareness

TB awareness approached borderline significance (p = 0.067). This is important because knowledge and awareness influence health-seeking behavior and early case detection. Studies

in multiple settings have shown that low TB knowledge, stigma, and misconceptions contribute to delayed diagnosis and poor engagement with TB services (Abebe et al., 2010; Makgopa et al., 2021). In this study, a high proportion of participants were not aware of TB, suggesting an opportunity for strengthened health education interventions.

Improving TB education within hospital settings and communities can enhance early symptom recognition and encourage testing. In addition, stigma-reduction interventions may increase willingness to seek care earlier, especially in populations where TB is associated with social discrimination (Abebe et al., 2010; Makgopa et al., 2021).

Implications for TB Control

The findings of this study provide evidence supporting enhanced TB screening strategies at Akim Oda Government Hospital. The higher TB detection yield from GeneXpert compared with microscopy supports WHO recommendations for expanded molecular testing where available (WHO, 2014; Steingart et al., 2014). Additionally, the significant associations with age and sex suggest that targeted screening interventions for high-risk groups—particularly adult males—may improve case detection and reduce transmission (WHO, 2023).

Moreover, although several risk factors did not show statistical significance, the established global evidence linking smoking, alcohol use, household exposure, malnutrition, and overcrowding to TB risk supports continued integration of these factors into TB risk assessment and prevention strategies (Lin et al., 2007; Imtiaz et al., 2017; Fox et al., 2012). Finally, the observed low awareness levels highlight the urgent need for improved TB health education and stigma reduction to strengthen early detection and care engagement (Abebe et al., 2010; Makgopa et al., 2021).

Table 2. Knowledge of Pulmonary Tuberculosis and Associated Risk Factors

Variable	Responses		Percentages (%)	TB-Positives (N)	TB-Negatives (N)	P- value
Smoking						0.690
	Yes	26	11.25	6	20	
	No	208	88.75	44	164	
Alcoholism						0.978
	Yes	58	24.80	12	46	
	No	176	75.20	38	138	
Family history						0.690
	Yes	29	12.5	6	23	
	No	205	87.5	44	161	
Overcrowding						0.787
	Yes	35	15	8	27	
	No	199	85	42	157	
Malnutrition						0.935
	Yes	15	6.25	3	12	
	No	219	93.75	47	172	

Tuberculosis					
Awareness					0.067
	Yes	73	31.25	18	55
	No	140	60.00	28	112
	NS	21	8.75	4	17

Key: NS: not sure

Conclusion

This study assessed the prevalence and associated risk factors of pulmonary tuberculosis (PTB) among presumptive tuberculosis patients attending Akim Oda Government Hospital in the Eastern Region of Ghana using a hospital-based cross-sectional design. The findings provide important facility-level evidence on the burden of PTB and determinants influencing tuberculosis positivity in this population.

The study recorded a relatively high prevalence of laboratory-confirmed pulmonary tuberculosis of 21.4% (50/234) among symptomatic participants, indicating that approximately one out of every five presumptive TB patients who presented to the hospital during the study period had active pulmonary disease.

This highlights the continuing public health relevance of tuberculosis in the study setting and emphasizes the importance of strengthening early detection and routine screening strategies in healthcare facilities located within TB-endemic communities (WHO, 2023).

The study further demonstrated differences in diagnostic yield between the two laboratory methods used. GeneXpert MTB/RIF detected tuberculosis positivity in 26.6% of tested samples compared with 18.1% detected by smear microscopy.

This confirms the improved case detection capacity of molecular diagnostic methods over smear microscopy, particularly in presumptive TB patients where bacillary load may be low, and supports WHO recommendations that encourage the increased use of rapid molecular assays such as GeneXpert for early diagnosis and prompt initiation of effective treatment (WHO, 2014; Steingart et al., 2014).

Analysis of factors associated with tuberculosis positivity revealed that age group and sex were significant predictors of PTB status. Participants aged 30–40 years recorded the highest proportion of TB-positive cases and the association between age and PTB status was statistically significant ($p = 0.001$).

Similarly, male participants accounted for a higher proportion of tuberculosis positivity than females, with sex showing a statistically significant association with TB status ($p = 0.019$).

These findings suggest that adult populations—particularly males within the productive age group—may represent an important target group for intensified TB screening and public health education aimed at reducing transmission and improving early case detection (WHO, 2023).

In addition, sputum macroscopic quality was significantly associated with PTB detection for both GeneXpert ($p = 0.014$) and smear microscopy ($p = 0.020$), with mucopurulent sputum producing the highest positivity yield.

This finding underscores the value of proper sputum collection techniques and patient instruction during specimen submission, as sputum quality influences bacillary detection and laboratory yield, particularly for smear microscopy. These results support the need for strengthening pre-analytical procedures, including specimen collection education and quality monitoring, to minimize false-negative outcomes and improve diagnostic performance (Stop TB Partnership, 2013).

Furthermore, the assessment of knowledge of pulmonary tuberculosis and selected risk factors showed that smoking, alcohol consumption, family history of TB, overcrowding, and malnutrition were not statistically associated with PTB positivity in this study ($p > 0.05$).

However, TB awareness showed a borderline association with PTB status ($p = 0.067$), suggesting that limited knowledge and uncertainty regarding tuberculosis could still contribute to delayed healthcare seeking and reduced access to early testing, which may sustain transmission within communities (Abebe et al., 2010).

In conclusion, this study confirms that pulmonary tuberculosis remains a significant health burden among presumptive TB patients at Akim Oda Government Hospital. The findings highlight the importance of using sensitive diagnostic tools such as GeneXpert MTB/RIF to improve case detection, strengthening sputum quality practices, and implementing targeted screening and education strategies among high-risk groups—particularly adult males.

Strengthened TB awareness interventions and improved diagnostic access may enhance early diagnosis, reduce transmission, and support tuberculosis control efforts within the Birim Central Municipality and similar settings across Ghana (WHO, 2023).

Recommendations

Based on the findings of this study, the following recommendations are proposed to strengthen pulmonary tuberculosis prevention, diagnosis, and control at Akim Oda Government Hospital and similar healthcare settings:

1. The hospital should intensify routine screening of presumptive TB patients, especially individuals presenting with prolonged cough and other TB-related symptoms. Given the relatively high prevalence of PTB recorded in this study (21.4%), systematic symptom screening at outpatient and emergency units should be prioritized to promote early detection and reduce community transmission.
2. Since GeneXpert detected a higher proportion of positive cases compared to smear microscopy (26.6% vs 18.1%), the hospital and municipal TB programme should prioritize increased access to GeneXpert MTB/RIF

testing for all presumptive TB patients, where feasible. This will improve diagnostic accuracy, reduce missed TB cases, and support early treatment initiation.

3. Targeted TB awareness and screening interventions should be directed toward groups with significantly higher positivity, particularly:
 - Adults aged 30–40 years (highest TB positivity; $p = 0.001$)
 - Male patients (higher TB positivity; $p = 0.019$)

Community sensitization and facility-based education sessions should be tailored to these priority groups to improve early presentation and reduce delay in diagnosis.

4. Because sputum appearance was significantly associated with TB detection for both GeneXpert ($p = 0.014$) and microscopy ($p = 0.020$), the hospital should strengthen sputum collection procedures through:
 - Patient education on producing deep sputum (not saliva)
 - Supervised sputum collection in appropriate settings
 - Training of staff on proper labeling and handling of specimens
 - Quality monitoring systems to reduce rejected or poor-quality samples
5. Since a large number of participants had low TB awareness and awareness showed a borderline association with PTB status ($p = 0.067$), continuous health education should be intensified at both facility and community levels. Education should focus on:
 - Signs and symptoms of TB
 - Modes of transmission
 - Prevention strategies
 - Importance of early testing and treatment compliance
 - Reduction of stigma associated with TB
6. The Municipal Health Directorate should strengthen community-level TB control through:
 - Outreach education in schools, markets, churches/mosques
 - Community screening and referral systems
 - Active contact tracing and follow-up for household contacts of confirmed cases
 - Collaboration with local leaders to improve public cooperation

These interventions can reduce transmission and improve early detection beyond hospital-based screening.

Limitations of the Study

This study provides important evidence on the prevalence of pulmonary tuberculosis and associated factors among presumptive TB patients at Akim Oda Government Hospital. However, the findings should be interpreted in light of the following limitations:

1. The study was conducted using a hospital-based cross-sectional design, which captures data at a single point in time. As a result, the study cannot establish causal relationships between the identified factors and pulmonary tuberculosis positivity, but only associations.

2. Participants were recruited from a single health facility (Akim Oda Government Hospital) and consisted mainly of symptomatic individuals who sought care. Therefore, the prevalence reported may not represent the true TB prevalence in the general community, and the findings may have limited generalizability to other settings.
3. The use of purposive sampling may have introduced selection bias, as participants were not randomly selected. This may affect the representativeness of the study population and could influence the strength of associations observed.
4. Some variables assessed in the study, including smoking status, alcohol use, overcrowding, malnutrition, and tuberculosis awareness, were self-reported. This could lead to recall bias or social desirability bias, particularly for sensitive behaviours such as smoking and alcohol consumption.
5. Not all samples were tested using both GeneXpert MTB/RIF and Ziehl–Neelsen microscopy. The use of different diagnostic methods across subsets of participants could have influenced the overall detection rates and made direct comparison between diagnostic approaches less precise.
6. The study did not include key medical factors such as HIV status, diabetes mellitus, previous TB history, or radiological findings, which are known to affect TB risk and disease progression. The absence of these variables may have limited the ability to fully explain PTB positivity patterns.
7. Some categories (e.g., smokers and malnourished participants) had relatively small numbers. This may have reduced the statistical power to detect significant associations between these risk factors and PTB positivity.

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Conflict of Interest

The authors declare no conflict of interest regarding the publication of this manuscript.

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