

# Pattern and Clinical Profile of Tuberculosis Cases Attending a Tertiary Care Centre in Central Kerala, India

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**Keywords:** Tuberculosis, Extrapulmonary tuberculosis, Clinical profile, Comorbidities, CBNAAT, Rifampicin resistance, Kerala, India

**Posted Date:** October 14th, 2026

**DOI:** <https://doi.org/10.21203/rs.3.rs-11060448/v1>

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**Additional Declarations:** No competing interests reported.

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# Abstract

## Background

Tuberculosis (TB) remains a major global public health challenge despite the availability of effective preventive and therapeutic measures. India bears the highest burden of TB worldwide, and regional variations in clinical presentation and disease patterns highlight the need for institution-specific evidence. This study aimed to analyse the pattern and clinical profile of tuberculosis cases attending a tertiary care centre in central Kerala, India.

## Methods

A hospital-based cross-sectional study was conducted at a tertiary care centre in Kerala. All patients diagnosed with tuberculosis between January 2024 and December 2025 were included. Data were collected from the Medical Records Department using a semi-structured data extraction tool capturing sociodemographic characteristics, clinical presentation, diagnostic investigations, comorbidities, and treatment status. Statistical analysis was performed using Jamovi 2.6.2 and SPSS 21.0. Continuous variables were summarized as mean  $\pm$  standard deviation or median with interquartile range, while categorical variables were expressed as frequencies and percentages. Associations between selected variables and type of tuberculosis were assessed using Chi-square or Fisher's exact tests.

## Results

A total of 319 tuberculosis cases were analysed. The median age of participants was 51 years, and males constituted 61.4% of cases. Extrapulmonary tuberculosis accounted for 65.8% of cases, while pulmonary tuberculosis constituted 34.2%. The most common presenting symptoms were cough (44.5%), fever (41.4%), and weight loss (34.2%). CBNAAT was the most frequently used diagnostic modality (57.7%). Rifampicin resistance was observed in 2.8% of cases. Diabetes mellitus (31.7%) and hypertension (30.1%) were the most common comorbidities. Univariate analysis showed that age  $< 49$  years (OR = 1.66; 95% CI: 1.03–2.65) and female sex (OR = 2.39; 95% CI: 1.44–3.97) were significantly associated with extrapulmonary tuberculosis.

## Conclusion

Extrapulmonary tuberculosis constituted the majority of cases in this tertiary care setting, with younger age and female sex showing significant association. A high prevalence of comorbid conditions such as diabetes and hypertension was observed. Strengthening early diagnostic strategies, integrating TB care with non-communicable disease screening, and improving patient follow-up may help enhance treatment outcomes and support tuberculosis elimination efforts.

# INTRODUCTION

Tuberculosis (TB) continues to be a major global public health concern despite the availability of effective preventive and therapeutic interventions for several decades. Caused by *Mycobacterium tuberculosis*, the disease predominantly affects the lungs, although extrapulmonary involvement is also common [1]. According to the World Health Organization (WHO), an estimated 10.8 million people developed TB worldwide in 2023, with approximately 1.25 million deaths reported, including among people living with HIV. TB remains the leading cause of death from a single infectious agent globally and continues to rank among the top ten causes of mortality worldwide [1].

In recent years, the global response to TB has been increasingly challenged by the emergence of drug-resistant forms of the disease. Multidrug-resistant tuberculosis (MDR-TB), defined as resistance to at least isoniazid and rifampicin, along with pre-extensively drug-resistant and extensively drug-resistant TB, has significantly complicated treatment regimens and adversely affected patient outcomes [2]. The true burden of drug-resistant TB remains difficult to ascertain due to underdiagnosis, delayed detection, and gaps in surveillance, particularly in low- and middle-income countries [3].

India bears the highest burden of tuberculosis globally, accounting for nearly one-quarter of all reported cases [1]. Despite sustained public health efforts through the National Tuberculosis Elimination Programme (NTEP), TB continues to pose a major challenge in the country. Factors such as delayed diagnosis, treatment interruptions, social stigma, and the presence of comorbid conditions including HIV infection and diabetes mellitus have been shown to influence disease presentation and outcomes [4]. Hospital-based studies from India have demonstrated higher proportions of extrapulmonary TB among people living with HIV and increased vulnerability to TB among individuals with diabetes [5].

Recognizing the magnitude of the problem, the Government of India has set an ambitious target to eliminate tuberculosis by 2025, five years ahead of the global Sustainable Development Goal timeline of 2030. Achieving this goal requires not only robust national strategies but also high-quality evidence generated from local and regional settings to inform programmatic and clinical decision-making [6]. Regional variations in disease patterns, clinical presentation, and drug-resistance profiles underscore the need for institution-specific data to guide effective TB control strategies [1, 6].

Kerala, despite its comparatively strong health indicators and well-developed healthcare infrastructure, continues to report a substantial burden of tuberculosis, including drug-resistant forms. Studies from different regions of the state have highlighted variability in clinical profiles, comorbidities, and treatment outcomes among TB patients, emphasizing the importance of continuous surveillance and context-specific evidence generation [7]. However, data on the clinical characteristics and drug-resistance patterns of tuberculosis patients from tertiary care settings in central Kerala remain limited.

Against this background, the present study aims to analyse the clinical profile and disease patterns of tuberculosis patients attending a tertiary care hospital in central Kerala, with particular emphasis on

drug-resistant TB. The findings are expected to contribute to improved clinical management at the institutional level and support ongoing national efforts toward tuberculosis elimination.

## METHODS

A cross-sectional, record based study was conducted over a period of one month at a tertiary care institute in Kerala, India. The study population comprised all patients diagnosed with tuberculosis between January 2024 and December 2025 at the study institution. All diagnosed TB cases during this period were included in the study.

The sample size was calculated based on a study by Bilagi RB et al. [5], which reported a prevalence of 30.08% for pulmonary tuberculosis among tuberculosis cases. Using the formula for estimation of a single proportion, with a Z-score of 1.96 corresponding to a 95% confidence level, an assumed proportion of 0.3008, and an absolute precision of 6%, the minimum required sample size was calculated to be 225. However, a total of 319 participants were included in the final analysis.

Data were collected using a semi-structured questionnaire designed to capture sociodemographic variables including age, sex, occupation, and place of residence, along with clinical details such as presenting symptoms, investigation findings, comorbidities, substance use, drug-susceptibility status, and treatment completion status. Following administrative approval, patient information was retrieved from the Medical Records Department, and relevant variables were systematically extracted and entered into an electronic database for analysis.

Data entry was performed using Microsoft Excel (Microsoft, Redmond, WA, USA), and statistical analysis was carried out using Jamovi 2.6.2 software (<https://www.jamovi.org>) and SPSS Statistics for Windows, Version 21.0 (IBM Corp., Armonk, NY, USA). Variables with  $p < 0.2$  were entered into multivariable logistic regression models to identify independent predictors. Adjusted odds ratios (AOR) with 95% confidence intervals were reported, and statistical significance was set at  $p < 0.05$ .

### Ethical approval

for the study was obtained from the Institutional Ethics Committee (ECASM-AIMS-2025-145) prior to commencement of data collection. The requirement for informed consent was waived by the Institutional Ethics Committee due to the retrospective, record-based nature of the study.

## RESULTS

A total of 319 tuberculosis cases were included in the study. More than half of the participants were aged  $\geq 49$  years (53.3%) and a majority were male (61.4%). With regard to area of residence, 52% of participants were from urban areas and 48% were from rural areas. Among participants with available occupation data, professionals formed the largest group (30.8%), followed by skilled workers (24.1%), unemployed individuals (18.8%), unskilled workers (14.3%), and retired individuals (12%).

Most cases were adult tuberculosis (94.4% [95% CI: 91.8–96.9]), while paediatric tuberculosis accounted for 5.6% (95% CI: 3.1–8.2) cases. Regarding presenting symptoms, cough was the most frequently reported symptom (44.5%), followed by fever (41.4%), weight loss (34.2%), and breathlessness (26.3%). Other reported symptoms included gastrointestinal complaints (9.7%), back pain (7.2%), CNS symptoms (6.0%), and localized swelling (6.0%). Haemoptysis was reported by 4.7% participants, while chest pain was reported by 1.9% participants. (Table 1)

Table 1  
Distribution of TB cases by type and presenting symptoms (n = 319)

| Variable           | Category      | n (%)      |
|--------------------|---------------|------------|
| TB cases           | Paediatric TB | 18 (5.6)   |
|                    | Adult TB      | 301 (94.4) |
| Cough              | Yes           | 142 (44.5) |
|                    | No            | 177 (55.5) |
| Fever              | Yes           | 132 (41.4) |
|                    | No            | 187 (58.6) |
| Breathlessness     | Yes           | 84 (26.3)  |
|                    | No            | 235 (73.7) |
| Weight loss        | Yes           | 109 (34.2) |
|                    | No            | 210 (65.8) |
| Haemoptysis        | Yes           | 15 (4.7)   |
|                    | No            | 304 (95.3) |
| CNS symptoms       | Yes           | 19 (6.0)   |
|                    | No            | 300 (94.0) |
| Back pain          | Yes           | 23 (7.2)   |
|                    | No            | 296 (92.8) |
| Chest pain         | Yes           | 6 (1.9)    |
|                    | No            | 313 (98.1) |
| GI issues          | Yes           | 31 (9.7)   |
|                    | No            | 288 (90.3) |
| Localized swelling | Yes           | 19 (6.0)   |
|                    | No            | 300 (94.0) |

Information on alcohol consumption was available for 195 participants, among whom 16.4% reported alcohol use and 83.6% reported no alcohol consumption. Smoking status was available for 200 participants, of whom 9.0% were smokers and 91.0% were non-smokers.

Regarding diagnostic investigations, chest X-ray findings were available for 230 cases, of which 46.9% showed abnormal findings while 53.0% were reported as normal. Smear microscopy results were

available for 300 cases, among whom 13.3% were smear-positive and 86.7% were smear-negative. CBNAAT results were available for 299 participants, with Mycobacterium tuberculosis detected in 61.9% of cases and not detected in 38.1%. In terms of the diagnostic method used for confirmation, CBNAAT was the most commonly used modality (57.7%), followed by histology (14.4%) and cytology (13.7%). Other diagnostic methods included culture (3.4%), radiology (2.8%), smear microscopy (0.6%), and other ancillary diagnostic methods or combinations of investigations (7.2%) (Table 2).

Table 2

Distribution of investigation findings and diagnostic methods used among tuberculosis cases

| Variable                                                                                                                                                        | Category     | n (%)      |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|------------|
| Chest X-ray findings (n = 230)                                                                                                                                  | Present      | 108 (46.9) |
|                                                                                                                                                                 | Absent       | 122 (53.0) |
|                                                                                                                                                                 | Missing      | 89         |
| Smear AFB (n = 300)                                                                                                                                             | Positive     | 40 (13.3)  |
|                                                                                                                                                                 | Negative     | 260 (86.7) |
|                                                                                                                                                                 | Missing      | 19         |
| CBNAAT (n = 299)                                                                                                                                                | Detected     | 185 (61.9) |
|                                                                                                                                                                 | Not Detected | 114 (38.1) |
|                                                                                                                                                                 | Missing      | 20         |
| Diagnostic method used for confirmation (n = 319)                                                                                                               | CBNAAT       | 184 (57.7) |
|                                                                                                                                                                 | Histology    | 46 (14.4)  |
|                                                                                                                                                                 | Cytology     | 44 (13.7)  |
|                                                                                                                                                                 | Radiology    | 9 (2.8)    |
|                                                                                                                                                                 | Smear        | 2 (0.6)    |
|                                                                                                                                                                 | Culture      | 11 (3.4)   |
|                                                                                                                                                                 | Others*      | 23 (7.2)   |
| *Others include combinations such as cytopathology/FNAC, histopathology, BAL GeneXpert, EBUS-TBNA, CECT, MRI, CT brain, ELISA, ADA, and culture of body fluids. |              |            |

Based on the site of disease, extrapulmonary tuberculosis accounted for the majority of cases (65.8%; 95% CI: 60.6–71.0), while pulmonary tuberculosis constituted 34.2% of the cases; (95% CI: 29.0–39.4). (Fig. 1)

Rifampicin sensitivity was observed in 175 (54.9%) cases, while 9 (2.8%) cases were rifampicin-resistant. In 135 cases (42.3%), rifampicin susceptibility status could not be determined. (Table 3)

Table 3  
Rifampicin susceptibility pattern among tuberculosis cases (n = 319)

| Variable                                                                                                                                                                                                                        | Category    | Frequency n (%) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------|-----------------|
| Rifampicin susceptibility                                                                                                                                                                                                       | Sensitive   | 175 (54.9)      |
|                                                                                                                                                                                                                                 | Resistant   | 9 (2.8)         |
|                                                                                                                                                                                                                                 | Don't Know* | 135 (42.3)      |
| *Category comprised patients who were CBNAAT-negative, those in whom CBNAAT was not performed, and cases where CBNAAT was positive but rifampicin resistance could not be determined due to inadequate sample quality/quantity. |             |                 |

Regarding treatment status, 45.5% participants were currently on treatment and 40.1% had completed treatment. Lost to follow-up was reported in 13.8% cases, while 0.6% participants had discontinued treatment. A total of 9.7% participants expired while on treatment, whereas 90.3% did not report mortality during treatment. (Table 4)

Table 4  
Treatment status of tuberculosis cases (n = 319)

| Variable                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Category               | Frequency n(%) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|----------------|
| Treatment status                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Currently on treatment | 145 (45.5)     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Completed              | 128 (40.1)     |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Lost to follow up      | 44 (13.8)      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Discontinued           | 2 (0.6)        |
| Expired while on treatment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Yes                    | 31(9.7)        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | No                     | 288 (90.3)     |
| *Others included endocrine disorders (hypothyroidism,), cardiovascular conditions (pericardial effusion), renal and hepatic disorders (AKI, nephrotic syndrome, hepatitis C), respiratory diseases (COPD, asthma, PAH), neurological and psychiatric conditions (seizure disorders, schizophrenia, stroke), autoimmune/rheumatologic diseases (SLE, Behçet's disease, rheumatoid arthritis, spondyloarthritis, myositis), gastrointestinal disorders (ulcerative colitis, Crohn's disease, chronic pancreatitis), and malignancies (hepatocellular carcinoma, bladder, colon, thyroid, and esophageal cancers). |                        |                |

Various comorbid conditions were observed among the study participants. Diabetes mellitus was present in 31.7% participants, hypertension in 30.1%, chronic kidney disease in 9.7%, chronic liver disease in 4.4%, coronary artery disease in 7.5%, and dyslipidaemia in 3.8%. Other comorbid conditions were reported in 63.3% participants. (Fig. 2)

Univariate analysis was performed to assess factors associated with extrapulmonary tuberculosis (EPTB) compared with pulmonary tuberculosis (PTB). Participants aged < 49 years had 1.66 times higher odds of EPTB compared to those aged ≥ 49 years (95% CI: 1.03–2.65; p = 0.035). Female participants

also showed significantly higher odds of EPTB than males (OR = 2.39; 95% CI: 1.44–3.97;  $p < 0.001$ ). With respect to occupation, unemployed or retired individuals had higher odds of EPTB compared to skilled workers (OR = 5.70; 95% CI: 1.42–22.99), although it was not statistically significant ( $p = 0.306$ ). Among comorbid conditions, the presence of chronic liver disease was significantly associated with PTB (OR = 0.27; 95% CI: 0.09–0.83;  $p = 0.015$ ), while dyslipidaemia was also more frequent among PTB cases (OR = 0.25; 95% CI: 0.07–0.83;  $p = 0.016$ ). In contrast, the presence of other coexisting diseases was significantly associated with higher odds of EPTB (OR = 2.74; 95% CI: 1.70–4.43;  $p < 0.001$ ). No statistically significant associations were observed between the type of tuberculosis and area of residence, diabetes mellitus, hypertension, chronic kidney disease, coronary artery disease, overall comorbidity status, alcohol use, smoking status, or rifampicin susceptibility ( $p > 0.05$ ). (Table 5)

Table 5  
Univariate Analysis of Factors Associated with Extrapulmonary Tuberculosis (EPTB) (n = 319)

| Variable                   | Category           | EPTB n (%) | PTB n (%)  | p-value           | Crude OR (95% CI) |
|----------------------------|--------------------|------------|------------|-------------------|-------------------|
| Age category               | ≥ 49 years         | 103 (60.6) | 67 (39.4)  | <b>0.035</b>      | 1 (Reference)     |
|                            | < 49 years         | 107 (71.8) | 42 (28.2)  |                   | 1.66 (1.03–2.65)  |
| Sex                        | Male               | 115 (58.7) | 81 (41.3)  | <b>&lt; 0.001</b> | 1 (Reference)     |
|                            | Female             | 95 (77.2)  | 28 (22.8)  |                   | 2.39 (1.44–3.97)  |
| Area                       | Urban              | 107 (64.5) | 59 (35.5)  | 0.59              | 1 (Reference)     |
|                            | Rural              | 103 (67.3) | 50 (32.7)  |                   | 1.14 (0.71–1.81)  |
| Occupation                 | Skilled            | 18 (56.3)  | 14 (43.8)  | 0.306             | 1 (Reference)     |
|                            | Professional       | 30 (73.2)  | 11 (26.8)  |                   | 2.12 (0.79–5.67)  |
|                            | Unemployed/Retired | 31 (75.6)  | 10 (24.4)  |                   | 5.70 (1.42–22.99) |
|                            | Unskilled          | 13 (68.4)  | 6 (31.6)   |                   | 1.69 (0.51–5.56)  |
| Diabetes Mellitus          | Absent             | 144 (66.1) | 74 (33.9)  | 0.901             | 1 (Reference)     |
|                            | Present            | 66 (65.3)  | 35 (34.7)  |                   | 0.97 (0.59–1.59)  |
| Hypertension               | Absent             | 148 (66.4) | 75 (33.6)  | 0.758             | 1 (Reference)     |
|                            | Present            | 62 (64.6)  | 34 (35.4)  |                   | 0.92 (0.56–1.53)  |
| Chronic Lung Disease (CLD) | Absent             | 205 (67.2) | 100 (32.8) | <b>0.015</b>      | 1 (Reference)     |
|                            | Present            | 5 (35.7)   | 9 (64.3)   |                   | 0.27 (0.09–0.83)  |
| Chronic Kidney Disease     | Absent             | 189 (65.6) | 99 (34.4)  | 0.813             | 1 (Reference)     |

| Variable                  | Category  | EPTB n (%) | PTB n (%)  | p-value           | Crude OR (95% CI)  |
|---------------------------|-----------|------------|------------|-------------------|--------------------|
| Other Diseases            | Present   | 21 (67.7)  | 10 (32.3)  | <b>&lt; 0.001</b> | 1.10 (0.50–2.43)   |
|                           | No        | 60 (51.3)  | 57 (48.7)  |                   | 1 (Reference)      |
| Dyslipidemia              | Yes       | 150 (74.3) | 52 (25.7)  | 0.016             | 2.74 (1.70–4.43)   |
|                           | Absent    | 206 (67.1) | 101 (32.9) |                   | 1 (Reference)      |
| Coronary Artery Disease   | Present   | 4 (33.3)   | 8 (66.7)   | 0.928             | 0.25 (0.07–0.83)   |
|                           | Absent    | 194 (65.8) | 101 (34.2) |                   | 1 (Reference)      |
| Comorbidities (overall)   | Present   | 125 (62.2) | 76 (37.8)  | 0.073             | 1.04 (0.43–2.52)   |
|                           | Absent    | 85 (72.0)  | 33 (28.0)  |                   | 1 (Reference)      |
| Alcohol use               | Yes       | 19 (59.4)  | 13 (40.6)  | 0.455             | 0.64 (0.39–1.05)   |
|                           | No        | 108 (66.3) | 55 (33.7)  |                   | 1 (Reference)      |
| Smoking                   | Yes       | 11 (61.1)  | 7 (38.9)   | 0.789             | 0.74 (0.34–1.62)   |
|                           | No        | 117 (64.3) | 65 (35.7)  |                   | 1 (Reference)      |
| Rifampicin Susceptibility | Resistant | 5 (55.6)   | 4 (44.4)   | 0.584             | 0.87 (0.32–2.36)   |
|                           | Sensitive | 81 (46.3)  | 94 (53.7)  |                   | 1 (Reference)      |
|                           |           |            |            |                   | 0.689 (0.179–2.65) |

On multivariable logistic regression, female sex remained independently associated with extrapulmonary tuberculosis (AOR = 2.21; 95% CI: 1.12–4.36; p = 0.022). Additionally, the presence of other coexisting diseases was independently associated with increased odds of EPTB (AOR = 3.37; 95% CI: 1.46–7.77; p = 0.004). Age < 49 years, chronic liver disease, dyslipidaemia, rifampicin resistance, and overall comorbidity status were not significantly associated with EPTB. (Table 6)

Table 6  
Multivariable Logistic Regression Analysis for Factors Associated with  
Extrapulmonary Tuberculosis (EPTB) (n = 319)

| Predictor                                          | AOR (95% CI)     | p-value      |
|----------------------------------------------------|------------------|--------------|
| Age (< 49 vs ≥ 49)                                 | 1.14 (0.50–2.61) | 0.757        |
| Sex (Female vs Male)                               | 2.21 (1.12–4.36) | <b>0.022</b> |
| Chronic Liver Disease (Present vs No)              | 0.52 (0.12–2.23) | 0.381        |
| Other Diseases (Yes vs No)                         | 3.37 (1.46–7.77) | <b>0.004</b> |
| Dyslipidemia (Present vs No)                       | 0.53 (0.10–2.94) | 0.47         |
| Rifampicin Susceptibility (Resistant vs Sensitive) | 0.74 (0.17–3.14) | 0.682        |
| Comorbidities (Present vs Absent)                  | 1.65 (0.65–4.18) | 0.287        |

## DISCUSSION

In the present study of 319 tuberculosis patients, the median age was 51 years, with 53.3% of participants aged ≥ 49 years. This finding indicates that tuberculosis in our setting predominantly affects middle-aged and older adults. In contrast, Bilagi et al. reported a lower mean age of 41.17 years among hospitalized TB patients in Marathwada, Maharashtra [5]. Differences in the age distribution across studies may reflect variations in regional epidemiology, referral patterns in tertiary care hospitals, and differences in population demographics. Similar hospital-based studies from India have also reported a predominance of TB cases in the economically productive age group, highlighting the continued public health and socioeconomic burden of the disease [8].

Male predominance was observed in the present study (61.4%), which is consistent with the established epidemiological pattern of tuberculosis globally. Bilagi et al. also reported a higher proportion of male patients (74.3%) [5]. The higher burden among males has been attributed to several factors, including increased occupational exposure, higher prevalence of risk behaviours such as smoking and alcohol use, and differences in health-seeking behavior between men and women [9]. Biological differences in immune response and social determinants of health may also contribute to these observed disparities.

In our study, EPTB accounted for 65.8% of cases, whereas pulmonary tuberculosis constituted 34.2%. A similar predominance of EPTB was observed in the study by Bilagi et al., where 69.9% of hospitalized patients had extrapulmonary disease [5]. The higher proportion of EPTB in tertiary care settings may be explained by referral bias, as complicated and diagnostically challenging cases are often managed in such institutions. Previous studies from India have also reported a substantial burden of extrapulmonary TB, particularly involving lymph nodes, pleura, and the central nervous system [10].

The present study demonstrated that younger age (< 49 years) and female sex were significantly associated with extrapulmonary tuberculosis. These findings are supported by previous epidemiological

studies which suggest that EPTB tends to occur more frequently in younger individuals and females, possibly due to immunological and hormonal factors, as well as differences in disease manifestation and healthcare utilization [10].

Comorbid conditions were common among the study participants. Diabetes mellitus was present in 31.7% of cases, while hypertension was reported in 30.1%. Chronic kidney disease, coronary artery disease, chronic liver disease, and dyslipidemia were also observed in a smaller proportion of patients. These findings are consistent with the growing recognition of the interaction between tuberculosis and NCDs. Chauhan et al., in a cross-sectional study on TB multimorbidity in India, reported that approximately 52% of TB patients had at least one comorbid condition, commonly including diabetes, hypertension, depression, and lifestyle-related disorders [11]. The coexistence of TB with metabolic and cardiovascular conditions may complicate disease management and adversely affect treatment outcomes.

With respect to diagnostic modalities, CBNAAT was the most frequently used diagnostic method in our study, accounting for 57.7% of confirmed diagnoses. Cytology and histopathology were also commonly used, particularly in extrapulmonary cases. The increasing use of CBNAAT reflects the emphasis on rapid molecular diagnostics in TB control programs. VidyaRaj et al. reported that GeneXpert demonstrated a high diagnostic yield in extrapulmonary samples, particularly in lymph node aspirates and abscess material, reinforcing its importance as a frontline diagnostic tool [12]. The widespread implementation of molecular diagnostics has significantly improved early detection of TB and identification of rifampicin resistance.

In the present study, rifampicin resistance was identified in 2.8% of cases. This proportion is comparable to reported estimates among newly diagnosed tuberculosis cases and reflects the relatively low burden of drug-resistant tuberculosis in Kerala [13]. Early detection of rifampicin resistance using molecular diagnostic methods such as CBNAAT facilitates timely initiation of appropriate treatment and contributes to improved patient management [2]. However, rifampicin susceptibility could not be determined for a substantial proportion of patients because of negative or unavailable CBNAAT results, highlighting the need for wider diagnostic coverage.

Regarding treatment outcomes, 40.1% of patients had completed treatment, while 45.5% were still undergoing treatment at the time of assessment. Loss to follow-up was documented in 13.8% of cases according to hospital records. Since this was a record-based study, the specific reasons for treatment interruption or loss to follow-up could not be ascertained. Kerala has implemented the STEPS (System for TB Elimination in Private Sector) model to strengthen patient tracking, treatment adherence, and coordination between healthcare facilities and the National TB Elimination Programme [14]. Further strengthening and sustained implementation of such patient-centred approaches may help improve treatment outcomes and reduce loss to follow-up.

The study provides a comprehensive description of the clinical profile of tuberculosis patients in a tertiary care setting, including pulmonary, extrapulmonary, and paediatric TB cases. Rifampicin

resistance was assessed using CBNAAT, enabling early identification of drug-resistant disease. In addition, the study highlights the coexistence of tuberculosis with important comorbid conditions such as diabetes, hypertension, and other chronic illnesses, which are increasingly recognized as significant factors influencing TB outcomes. The findings also provide insight into the common presenting symptoms and diagnostic pathways of TB patients, which may assist clinicians in improving early detection and management.

The study was conducted in a tertiary care center, which may limit the generalizability of the findings to the broader community, as more severe or complicated cases are often referred to such institutions. A proportion of patients with drug-resistant tuberculosis were transferred to government hospitals for treatment, resulting in incomplete treatment and outcome data. Loss to follow-up further limited the availability of longitudinal information. Additionally, missing data for certain variables, particularly occupation and lifestyle factors such as alcohol and smoking status, restricted the depth of analysis for some risk factors.

## CONCLUSION

The present study highlights the predominance of extrapulmonary tuberculosis among patients presenting to a tertiary care center in central Kerala, with a higher likelihood observed among females and younger individuals. A substantial proportion of patients also had comorbid conditions such as diabetes mellitus and hypertension, underscoring the growing intersection between tuberculosis and non-communicable diseases. CBNAAT emerged as the most used diagnostic modality, reinforcing the importance of rapid molecular diagnostics in early detection and identification of drug resistance.

These findings emphasize the need for strengthening early diagnostic strategies, improving screening for comorbid conditions among TB patients, and ensuring systematic follow-up to reduce loss to follow-up and improve treatment outcomes. Integrating tuberculosis services with non-communicable disease screening programs, expanding access to molecular diagnostic tools, and enhancing coordination between tertiary care centers and national tuberculosis control programs may further support progress toward the goal of tuberculosis elimination.

## Declarations

### **Ethics approval and consent to participate**

The study was approved by the Institutional Ethics Committee of Amrita Institute of Medical Sciences, Kochi (ECASM-AIMS-2025-145). The requirement for informed consent was waived by the Institutional Ethics Committee due to the retrospective, record-based nature of the study. The study was conducted in accordance with the ethical standards of the Institutional Ethics Committee and the principles of the Declaration of Helsinki and its subsequent amendments or comparable ethical standards.

### **Consent for publication**

Not applicable.

## Competing interests

The authors declare that they have no competing interests or conflicts of interest related to this work.

## Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

## Author Contribution

G.N., E.A., C.P., B.A., I.E., D.B., D.U., and B.S.R. contributed to the conception and design of the study. G.N., E.A., C.P., B.A., I.E., D.B., D.U., B.S.R., and P.S. contributed to data collection and data extraction. G.N., E.A., C.P., B.A., I.E., D.B., D.U., B.S.R., P.S., and B.M.R. performed the statistical analysis. G.N., E.A., C.P., B.A., I.E., D.B., D.U., B.S.R., P.S., B.M.R., N.S., P.T.F., and A.K. drafted the manuscript. All authors contributed to the interpretation of the findings, critically reviewed and revised the manuscript, approved the final version, and agree to be accountable for all aspects of the work.

## Acknowledgements

The authors thank the Medical Records Department for their assistance in facilitating access to the relevant medical records and supporting the conduct of the study.

## Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available because they contain information that could compromise participant confidentiality and privacy.

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## Figures

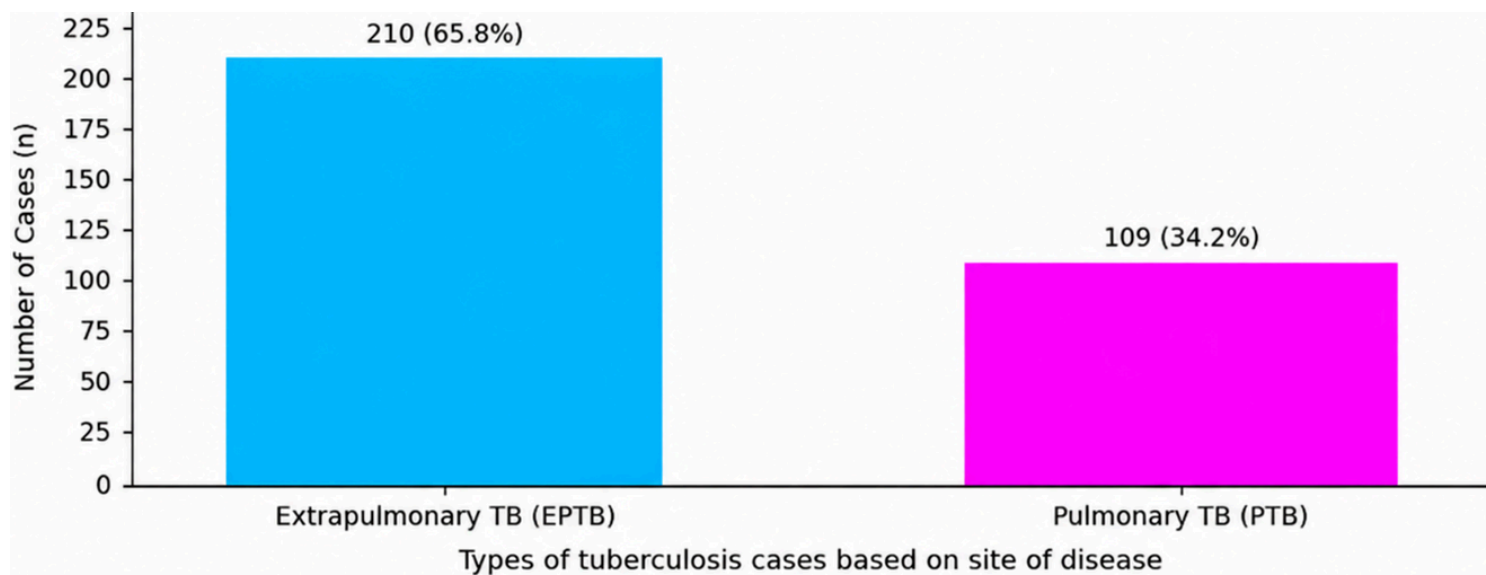


Figure 1

Legend not included with this version.

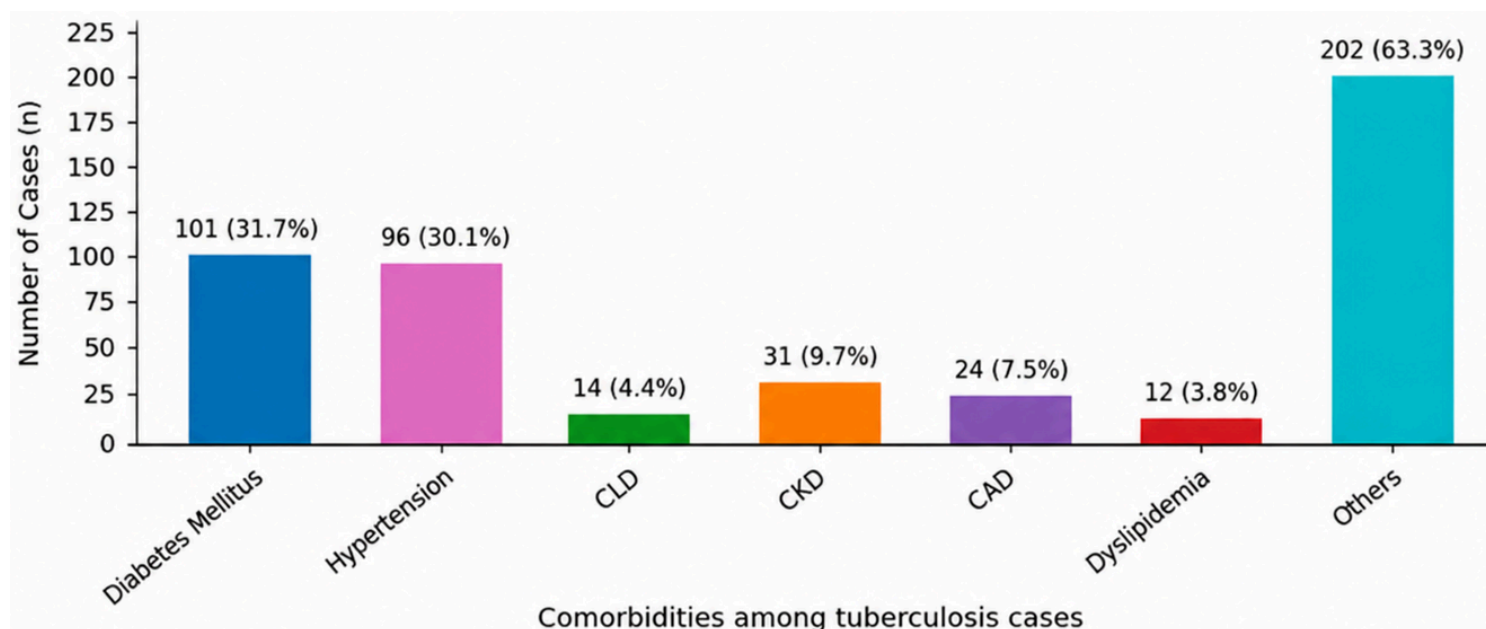


Figure 2

### Distribution of comorbidities among tuberculosis cases (n=319)

*\*Others included endocrine disorders (hypothyroidism), cardiovascular conditions (pericardial effusion), renal and hepatic disorders (AKI, nephrotic syndrome, hepatitis C), respiratory diseases (COPD, asthma, PAH), neurological and psychiatric conditions (seizure disorders, schizophrenia, stroke), autoimmune/rheumatologic diseases (SLE, Behçet's disease, rheumatoid arthritis, spondyloarthritis, myositis), gastrointestinal disorders (ulcerative colitis, Crohn's disease, chronic pancreatitis), and malignancies (hepatocellular carcinoma, bladder, colon, thyroid, and esophageal cancers).*

