

Research Article

Evaluation of Clinical, Demographic, Microbiological and Radiological Characteristics of Patients Suspected of Pulmonary Tuberculosis

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ABSTRACT

Background: Tuberculosis (TB) remains an important public health problem in India. Early diagnosis requires appropriate integration of clinical, demographic, microbiological, molecular, and radiological findings. The present study was undertaken to evaluate these characteristics among patients suspected of pulmonary tuberculosis.

Methods: A hospital-based cross-sectional observational study was conducted in the Department of Respiratory Medicine, Index Medical College, Indore. A total of 146 patients suspected of pulmonary tuberculosis were evaluated. Demographic and clinical details, risk factors, nutritional status, laboratory findings, sputum AFB smear microscopy, culture, molecular testing, chest X-ray, and HRCT findings were recorded and analyzed.

Results: Of the 146 participants, 85 (58.2%) were males and 61 (41.8%) were females. The most common age group was 31-40 years (21.2%). Underweight was observed in 32.9% of participants. Smoking was the most common risk factor (34.9%), followed by alcohol use (24.0%), TB contact (21.2%), and diabetes mellitus (18.5%). Cough was the predominant symptom (87.7%), followed by fever (62.3%) and weight loss (53.4%). AFB smear microscopy was negative in 69.2% of patients. Sputum culture detected MTB in 26.7%, while molecular testing detected MTB in 29.5%. Overall, 47 (32.2%) patients had microbiologically confirmed pulmonary tuberculosis. On chest X-ray, upper-zone infiltrates were the most common finding (26.7%), followed by consolidation (18.5%) and cavitation (17.1%). Among 82 patients undergoing HRCT, tree-in-bud pattern was the commonest finding (41.5%), followed by centrilobular nodules (35.4%) and cavitation (29.3%).

Conclusion: Pulmonary tuberculosis was predominantly observed among males and economically productive age groups. Persistent cough, fever, weight loss, smoking, undernutrition, TB contact, and diabetes were important clinical and epidemiological characteristics. The findings emphasize the importance of combining clinical assessment with microbiological, molecular, and radiological investigations for timely and accurate diagnosis of pulmonary tuberculosis.

Keywords: Pulmonary tuberculosis, AFB smear, GeneXpert, CBNAAT, sputum culture, chest X-ray, HRCT, risk factors.

Introduction: Tuberculosis (TB) remains a major infectious disease and an important public health problem, particularly in developing countries including India.¹ Early diagnosis and appropriate treatment are essential to reduce morbidity, mortality, and transmission of the disease. Despite advances in diagnostic techniques, delayed diagnosis

and missed cases continue to be important challenges in TB control.²

Pulmonary tuberculosis (PTB) is the most common form of TB and usually presents with symptoms such as prolonged cough, fever, weight loss, night sweats, chest pain, and haemoptysis. However, these manifestations are often nonspecific, making clinical diagnosis

alone insufficient. Demographic and associated risk factors may further influence the likelihood of TB and should therefore be considered during evaluation.³ Microbiological examination remains the basis for confirmation of pulmonary TB. Sputum smear microscopy for acid-fast bacilli (AFB) is widely used, while culture provides greater sensitivity. Molecular techniques such as GeneXpert/CBNAAT have improved the rapid detection of *Mycobacterium tuberculosis* and rifampicin resistance and have become an important component of modern TB diagnosis.⁴

Radiological investigations, especially chest X-ray, provide supportive evidence in suspected pulmonary tuberculosis. Findings such as consolidation, cavitation, nodules, and upper-lobe involvement may suggest active disease, while HRCT can provide additional details when X-ray findings are inconclusive. However, radiological findings should be interpreted along with clinical and microbiological results.^{5,6} Several demographic and epidemiological factors, including age, sex, smoking, alcohol consumption, previous TB, contact history, diabetes, and other comorbidities, may influence the risk and presentation of pulmonary tuberculosis.⁷ Identifying these factors helps clinicians recognize high-risk patients and plan appropriate diagnostic evaluation.⁸ The diagnosis of pulmonary tuberculosis has evolved with the introduction of rapid molecular diagnostic techniques. Although AFB smear microscopy remains widely available and useful for identifying infectious cases, its sensitivity may be limited, particularly in patients with paucibacillary disease. Sputum culture has higher sensitivity but requires longer time for confirmation. Molecular tests such as GeneXpert MTB/RIF and Xpert MTB/RIF Ultra provide rapid detection of *M. tuberculosis* and can simultaneously identify rifampicin resistance, thereby facilitating early initiation of appropriate treatment.^{3,9}

Radiological assessment is an important supportive tool in suspected pulmonary tuberculosis. Chest X-ray is commonly used as the initial investigation and may show consolidation, cavitation, nodules, fibrosis, and upper-lobe involvement. HRCT provides more detailed evaluation and can demonstrate findings such as tree-in-bud and centrilobular nodules, cavitation, bronchiectasis, and consolidation.^{5,6,10} The epidemiology and clinical profile of pulmonary tuberculosis may vary according to geographical region, age group, sex, socioeconomic conditions, and associated risk factors. In India, tuberculosis

continues to affect economically productive age groups and is frequently associated with factors such as undernutrition, smoking, diabetes mellitus, and other comorbidities.¹¹ Understanding these demographic and clinical characteristics is important for identifying individuals at increased risk and improving the efficiency of diagnostic services.¹²

Sex-related differences have also been observed in the occurrence and presentation of tuberculosis. Several studies have reported a higher proportion of tuberculosis among males compared with females. Differences in occupational exposure, smoking and alcohol use, healthcare-seeking behaviour, and biological factors may contribute to this variation. Evaluation of sex distribution among patients suspected of pulmonary tuberculosis can therefore provide useful epidemiological information.¹³

Molecular diagnostic techniques have consequently become an important part of tuberculosis diagnostic algorithms. GeneXpert MTB/RIF and related nucleic acid amplification tests can detect *M. tuberculosis* rapidly and provide information regarding rifampicin resistance. The availability of such tests has improved the possibility of early diagnosis, particularly among patients in whom conventional smear microscopy is negative but clinical suspicion remains high.^{9,14}

Materials And Methods

Study Design:

This will be a hospital-based, cross-sectional observational study designed to evaluate the clinicodemographic profile of patients suspected of pulmonary tuberculosis attending the Chest Outpatient Department (Chest OPD) at Index Medical College, Indore. The study aims to assess demographic characteristics, clinical presentation, associated risk factors, comorbidities, and laboratory findings among patients presenting with symptoms suggestive of pulmonary tuberculosis.

Study Setting

The study will be conducted in the Department of Respiratory Medicine (Chest OPD) Index Medical College, Indore. Patients attending the outpatient department with symptoms suggestive of pulmonary tuberculosis will be screened according to the National Tuberculosis Elimination Programme (NTEP) guidelines.

The Chest OPD receives patients referred from primary health centers, community health

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centers, private practitioners, and other hospital departments, thereby representing a wide spectrum of suspected pulmonary tuberculosis cases.

Study Duration

The study will be conducted over a period of 12 months after obtaining approval from the Institutional Ethics Committee.

Sample Size Calculation: 146 Subjects

Inclusion Criteria

Patients fulfilling all of the following criteria will be included in the study:

- Patients Aged >18 years
- Patients attending the Chest OPD with symptoms suggestive of pulmonary tuberculosis.
- Patients presenting with cough for two weeks or more with or without sputum production.
- Patients presenting with constitutional symptoms such as fever, weight loss, night sweats, or loss of appetite suggestive of tuberculosis.
- Patients willing to undergo sputum examination and other investigations.
- Patients providing written informed consent.

Exclusion Criteria

The following patients will be excluded from the study:

- Patients already diagnosed with pulmonary tuberculosis and currently receiving anti-tubercular treatment.
- Patients diagnosed exclusively with extrapulmonary tuberculosis without pulmonary involvement.
- Patients unwilling to participate in the study.
- Patients with incomplete clinical information or laboratory reports.
- Critically ill patients unable to provide history or undergo evaluation.
- Patients with known lung malignancy or other confirmed pulmonary diseases explaining the symptoms

Study Procedure

Following approval from the Institutional Ethics Committee, eligible patients attending the Chest OPD will be informed regarding the purpose of the study.

Written informed consent will be obtained before enrollment.

Each participant will undergo a detailed evaluation consisting of:

- Detailed history taking
- General physical examination
- Systemic examination
- Laboratory investigations
- Radiological evaluation
- Microbiological confirmation wherever indicated

All information will be recorded in a pre-designed structured Case Record Form (CRF).

Study Parameters

A. Demographic Profile

The demographic variables to be recorded include age, gender, religion, residence (urban/rural), marital status, educational status, occupation, monthly family income, socioeconomic status (according to the Modified Kuppuswamy Scale), and family size.

B. Clinical Profile

A detailed clinical history will include:

Presenting Symptoms

Presenting symptoms included cough, duration of cough, type of cough (productive/non-productive), fever, weight loss, loss of appetite, night sweats, hemoptysis, chest pain, breathlessness, and fatigue.

History

- Previous history of tuberculosis
- History of anti-tubercular treatment
- Contact with known TB patient
- Family history of tuberculosis
- History of hospitalization
- History of recurrent respiratory infections

C. Risk Factors

Risk factors evaluated included cigarette smoking, bidi smoking, tobacco chewing, alcohol consumption, substance abuse, biomass fuel exposure, occupational dust exposure, overcrowding, poor ventilation, malnutrition, HIV infection, diabetes mellitus, chronic kidney disease, chronic liver disease, chronic obstructive pulmonary disease (COPD), silicosis, long-term corticosteroid therapy, and immunosuppressive therapy.

D. Physical Examination

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General examination included height, weight, body mass index (BMI), temperature, pulse rate, blood pressure, respiratory rate, and oxygen saturation.

Systemic examination will include:

- Respiratory system
- Cardiovascular system
- Abdomen
- Central nervous system

Laboratory Investigations

The following investigations will be performed.

Hematological Investigations

- Complete Blood Count (CBC)
- Hemoglobin
- Total Leukocyte Count
- Differential Leukocyte Count
- Platelet Count
- Erythrocyte Sedimentation Rate (ESR)

Biochemical Investigations

- Random Blood Sugar/Fasting Blood Sugar
- HbA1c (where indicated)
- Liver Function Test
- Renal Function Test
- Serum Electrolytes

Microbiological Investigations

1. Sputum Examination

Patients will be instructed regarding proper sputum collection according to NTEP guidelines.

AFB Smear Microscopy

Two sputum samples (spot/early morning as per institutional protocol) will be examined using Ziehl–Neelsen staining for detection of acid-fast bacilli.

Results will be graded according to NTEP recommendations.

Sputum Culture

Where indicated, sputum specimens will be processed for mycobacterial culture using:

- Lowenstein–Jensen (LJ) medium
- MGIT liquid culture system

Culture remains the gold standard for microbiological confirmation.

2. Molecular Diagnostic Tests

CBNAAT (GeneXpert MTB/RIF)

Sputum samples will be subjected to Cartridge-Based Nucleic Acid Amplification Test (CBNAAT).

The test provides:

- Detection of Mycobacterium tuberculosis
- Rifampicin resistance
- Results within approximately two hours

Line Probe Assay (LPA)

Patients diagnosed with rifampicin-resistant tuberculosis or clinically indicated cases will undergo Line Probe Assay for detection of resistance to first-line and second-line anti-tubercular drugs.

Interferon-Gamma release Assays

- Blood test such as QuantiFERON-TB; useful for latent TB infections

Radiological Evaluation

Every patient will undergo:

Chest X-ray (PA View)

Radiological findings will include:

- Radiological findings included upper lobe infiltrates, cavitary lesions, fibrosis, nodular opacities, consolidation, pleural effusion, miliary shadows, and bilateral disease.

HRCT Chest

- Performed when clinically indicated for inconclusive chest radiographs or suspected complications.
- Mantoux Test (Tuberculin Skin Test)
- Outcome Measures
- Primary Outcome
- To determine the clinicodemographic profile of patients suspected of pulmonary tuberculosis.

Secondary Outcomes

- Distribution according to age and gender.
- Clinical presentation.
- Risk factors.
- Comorbidities.
- Microbiological positivity.
- Radiological findings.
- Association of clinicodemographic variables with confirmed pulmonary tuberculosis.

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Statistical Analysis

- Data will be entered into Microsoft Excel and analyzed using SPSS version 26.0
- Continuous variables will be expressed as mean $\pm$ standard deviation (SD) or median with interquartile range (IQR) depending on data distribution.
- Categorical variables will be expressed as frequency and percentage.
- The Chi-square test or Fisher's exact test will be used to compare categorical variables.
- The student's t-test or Mann-Whitney U test will be used for comparison of continuous variables.
- Multivariate logistic regression analysis

may be performed to identify independent predictors of pulmonary tuberculosis among suspected patients.

- A p-value <0.05 will be considered statistically significant.

Ethical Considerations:

The study protocol will be submitted to the Institutional Ethics Committee (IEC) for approval before commencement. Written informed consent will be obtained from all participants prior to enrollment. Confidentiality and anonymity of patient information will be strictly maintained throughout the study. Participation will be entirely voluntary, and patients will be free to withdraw from the study at any stage without affecting their treatment.

Table 1. Gender-wise distribution of study participants (n=146)

Gender	Number (n)	Percentage (%)
Male	85	58.2
Female	61	41.8
Total	146	100.0

Among the 146 study participants, 85 (58.2%) were males and 61 (41.8%) were females, indicating a male predominance in the study population.

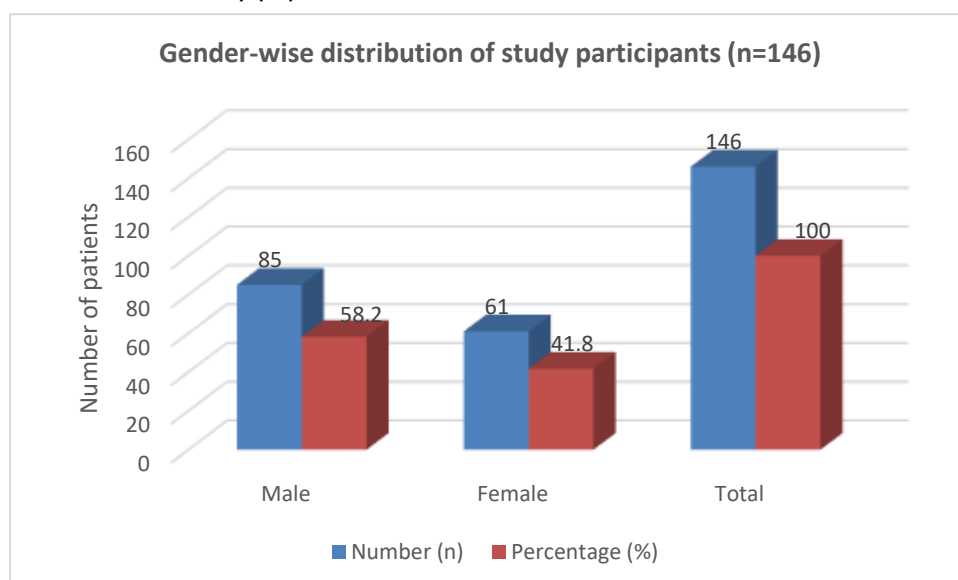


Fig: 1 Graphical represents Gender-wise distribution of study participants

Table 2. Age-wise distribution of study participants (n=146)

Age group (years)	Number (n)	Percentage (%)
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19–30	29	19.9
31–40	31	21.2
41–50	28	19.2
51–60	25	17.1
61–70	20	13.7
>70	13	8.9
Total	146	100.0

The majority of participants were in the 31–40 years age group (21.2%), followed by 19–30 years (19.9%) and 41–50 years (19.2%). Patients aged >70 years constituted the smallest proportion (8.9%) of the study population.

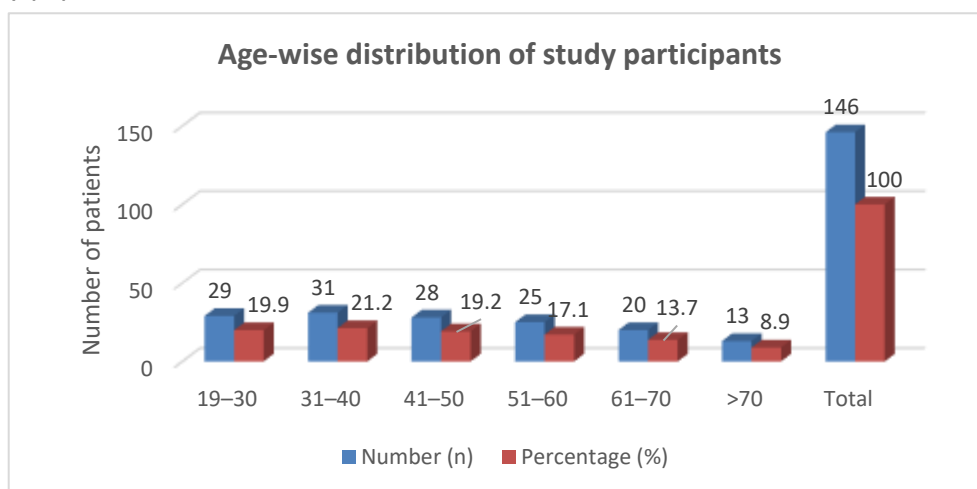


Fig: 2 Graphical represents Age-wise distribution of study participants

Table 3. BMI-wise distribution of study participants (n=146)

BMI category	BMI range (kg/m ²)	Number (n)	Percentage (%)
Underweight	<18.5	48	32.9
Normal weight	18.5–24.9	69	47.3
Overweight	25.0–29.9	23	15.8
Obese	≥30.0	6	4.1
Total		146	100.0

The majority of participants had normal BMI (47.3%), followed by underweight (32.9%). Overweight and obese participants constituted 15.8% and 4.1%, respectively.

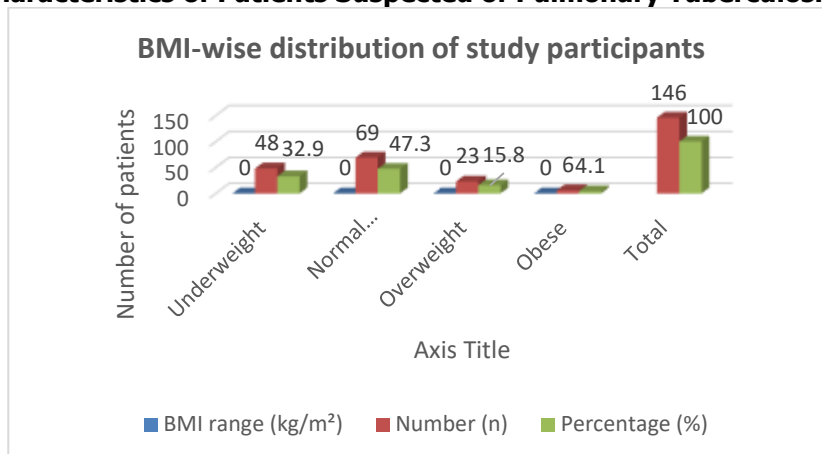


Fig: 3 Graphical represents BMI-wise distribution of study participants

Table 4. Distribution according to presenting symptoms (n=146)

Clinical symptom	Number (n)	Percentage (%)
Cough	128	87.7
Fever	91	62.3
Weight loss	78	53.4
Loss of appetite	69	47.3
Night sweats	54	37.0
Breathlessness	47	32.2
Chest pain	39	26.7
Hemoptysis	27	18.5

Cough was the most common presenting symptom, reported in 87.7% of patients, followed by fever (62.3%) and weight loss (53.4%). Hemoptysis was the least frequently reported symptom (18.5%).

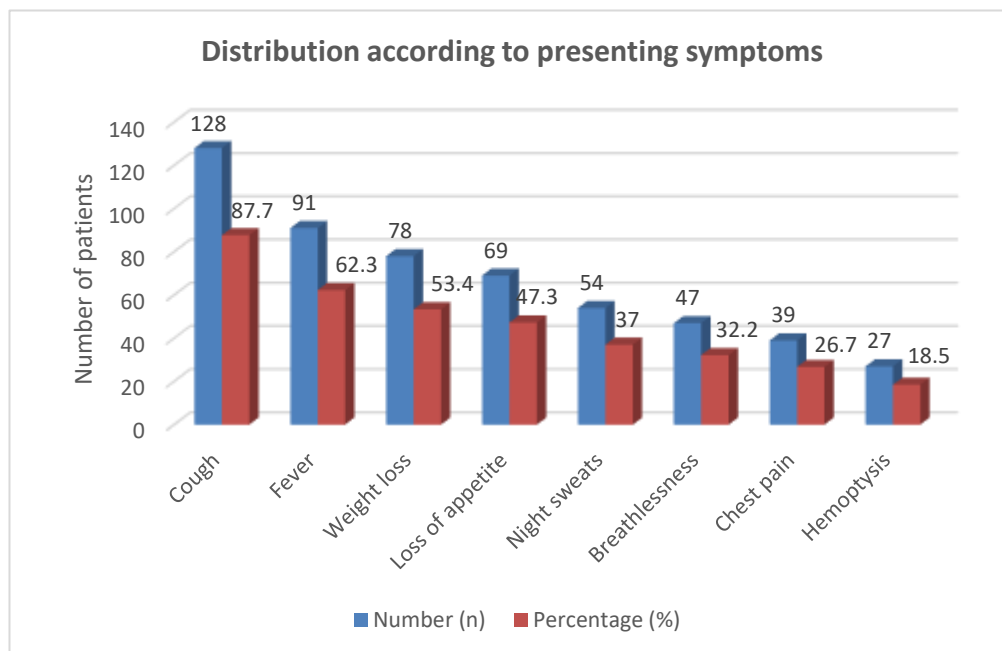


Fig: 4 Distribution according to presenting symptoms

Table 5. Duration of symptoms (n=146)

Duration	Number (n)	Percentage (%)
<2 weeks	21	14.4
2–4 weeks	49	33.6
1–3 months	52	35.6
>3 months	24	16.4
Total	146	100.0

Most patients had symptoms for 1–3 months (35.6%), followed by 2–4 weeks (33.6%). Patients with symptoms for less than 2 weeks constituted 14.4%, while 16.4% had symptoms for more than 3 months.

Table 6. Distribution according to risk factors (n=146)

Risk factor	Number (n)	Percentage (%)
Smoking	51	34.9
Diabetes mellitus	27	18.5
Previous TB	22	15.1
TB contact	31	21.2
Alcohol use	35	24.0
Immunosuppression	11	7.5
HIV infection	5	3.4

Among the 146 study participants, smoking was the most common risk factor (34.9%), followed by alcohol use (24.0%), TB contact (21.2%), and diabetes mellitus (18.5%). Previous history of TB was reported in 15.1% of patients, while immunosuppression (7.5%) and HIV infection (3.4%) were less frequently observed.

Table 7. Sputum AFB smear microscopy findings (n=146)

AFB result	Number (n)	Percentage (%)	p-value
Negative	101	69.2	<0.001
Scanty	8	5.5	
1+	14	9.6	
2+	11	7.5	
3+	12	8.2	
Total	146	100.0	

AFB smear microscopy was negative in the majority of patients (69.2%). Among the smear-positive patients, 1+ grading was most common (9.6%), followed by 3+ (8.2%), 2+ (7.5%), and scanty bacilli (5.5%). The overall distribution of AFB smear results was statistically significant ($p<0.001$).

Table 8. Sputum culture findings (n=146)

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Culture result	Number (n)	Percentage (%)	p-value
MTB positive	39	26.7	<0.001
Negative	92	63.0	
Contaminated/inconclusive	5	3.4	
Not performed	10	6.8	
Total	146	100.0	

Sputum culture was negative in 63.0% of patients, while MTB was isolated in 26.7%. Culture was contaminated or inconclusive in 3.4% of patients, and culture was not performed in 6.8%. The distribution of culture results was statistically significant ($p < 0.001$).

Table 9. Molecular testing/NAAT findings (n=146)

Result	Number (n)	Percentage (%)	p-value
MTB detected	43	29.5	<0.001
MTB not detected	87	59.6	
Not performed	16	11.0	
Total	146	100.0	

Molecular testing detected MTB in 29.5% of patients, while 59.6% had no MTB detected. The test was not performed in 11.0% of patients. The overall distribution of molecular test results was statistically significant ($p < 0.001$).

Table 10. Chest X-ray findings (n=146)

Radiological finding	Number (n)	Percentage (%)	p-value
Upper-zone infiltrates	39	26.7	<0.001
Cavitary lesion	25	17.1	<0.001
Consolidation	27	18.5	<0.001
Nodular/reticulonodular shadows	18	12.3	<0.001
Fibrotic changes	12	8.2	<0.001
Pleural effusion	9	6.2	<0.001
Miliary pattern	5	3.4	<0.001
Normal X-ray	11	7.5	<0.001
Total	146	100.0	<0.001

On chest X-ray, upper-zone infiltrates were the most common radiological finding (26.7%), followed by consolidation (18.5%) and cavitary lesions (17.1%). Nodular/reticulonodular shadows were observed in 12.3% of patients, while miliary pattern was the least common finding (3.4%). The overall distribution of radiological findings was statistically significant ($p < 0.001$).

Table 11. HRCT findings (n=82)

HRCT finding	Number (n)	Percentage (%)	p-value
Tree-in-bud pattern	34	41.5	
Centrilobular nodules	29	35.4	
Cavitation	24	29.3	
Consolidation	21	25.6	
Lymphadenopathy	18	22.0	
Fibrotic changes	15	18.3	

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Pleural involvement	11	13.4	
Ground-glass opacity	9	11.0	

Among the 82 patients who underwent HRCT, the most common finding was a tree-in-bud pattern (41.5%), followed by centrilobular nodules (35.4%) and cavitation (29.3%). Consolidation was observed in 25.6%, while ground-glass opacity was the least common finding (11.0%). Multiple radiological findings could be present in the same patient.

Table 12. Overall microbiological evidence of pulmonary tuberculosis (n=146)

Microbiological status	Number (n)	Percentage (%)	p-value
Microbiologically confirmed TB	47	32.2	<0.001
Microbiologically negative	99	67.8	
Total	146	100.0	

Out of the 146 patients evaluated, 47 (32.2%) were microbiologically confirmed to have pulmonary tuberculosis, while 99 (67.8%) were microbiologically negative. The overall distribution was statistically significant ($p < 0.001$).

Discussion

The present study evaluated 146 patients suspected of pulmonary tuberculosis and found a male predominance (58.2%), with the majority belonging to the economically productive age group of 31–40 years. Underweight was observed in 32.9% of participants. Smoking was the most common risk factor (34.9%), followed by alcohol use, TB contact, and diabetes mellitus.

Cough was the most common symptom (87.7%), followed by fever (62.3%) and weight loss (53.4%). AFB smear was negative in 69.2% of patients, while MTB was detected by culture in 26.7% and molecular testing in 29.5%. Overall, 32.2% had microbiologically confirmed pulmonary tuberculosis, on chest X-ray, upper-zone infiltrates were the commonest finding (26.7%), while tree-in-bud pattern was the most frequent HRCT finding (41.5%). These findings highlight the importance of combining clinical, microbiological, molecular, and radiological evaluation for timely diagnosis of pulmonary tuberculosis, particularly in patients with persistent respiratory symptoms and associated risk factors.

Conclusion

The present study concluded that pulmonary tuberculosis was more commonly suspected among males and individuals in the economically productive age group. Cough, fever, and weight loss were the predominant clinical symptoms, while smoking, alcohol use, TB contact, diabetes, and undernutrition were important associated factors. Microbiological confirmation was obtained in 32.2% of participants, emphasizing the importance of sputum examination and rapid molecular

testing. Radiological findings such as upper-zone infiltrates, cavitation, and tree-in-bud patterns supported the diagnosis. Overall, an integrated approach combining clinical, microbiological, molecular, and radiological evaluation is essential for early and accurate diagnosis of pulmonary tuberculosis.

Conflict of Interest

The authors declare that there is no conflict of interest related to this study.

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