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# DIVERSE RADIOLOGICAL PATTERNS IN ADULT TUBERCULOSIS

*Original Research*

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## ABSTRACT

**Background:** Tuberculosis remains a major public health challenge, particularly in low- and middle-income countries where delayed diagnosis contributes to ongoing transmission and poor outcomes. Chest radiography continues to serve as a frontline diagnostic tool for pulmonary tuberculosis due to its accessibility and ability to demonstrate a wide spectrum of disease manifestations. However, variability in radiographic appearances, especially in the presence of underlying risk factors such as smoking, diabetes, and substance abuse, may complicate accurate diagnosis and assessment of disease severity.

**Objective:** To identify and describe the radiological patterns of adult pulmonary tuberculosis in a defined population and to explore their association with underlying conditions, particularly those related to tobacco smoking.

**Methods:** A prospective study was conducted at Civil Hospital involving adult patients undergoing chest X-ray evaluation for suspected tuberculosis. A total of 103 patients with radiographically confirmed tuberculosis were enrolled using a convenient sampling technique. Imaging was performed using a Toshiba 500 mA X-ray machine with standardized posteroanterior positioning. Demographic data, clinical history, and comorbid conditions were recorded using a structured proforma. Data were analyzed using SPSS version 20, with descriptive statistics applied to summarize clinical and radiographic variables.

**Results:** All 103 patients demonstrated radiographic findings consistent with pulmonary tuberculosis. Females constituted 58.3% of the cohort, while males accounted for 41.7%. A family history of tuberculosis was present in 44.7% of patients. Smoking was reported by 34.0%, drug abuse by 29.1%, and diabetes mellitus by 6.8% of participants. Radiographic findings included lung infiltrations in 87.4% of patients, consolidation in 58.3%, pleural effusion in 33.0%, cavitary lesions in 19.4%, and small nodules in 2.9%, reflecting a heterogeneous spectrum of disease severity.

**Conclusion:** The study demonstrated that adult pulmonary tuberculosis presents with diverse radiographic patterns frequently accompanied by modifiable risk factors. These findings emphasize the importance of comprehensive radiological assessment combined with evaluation of underlying clinical and lifestyle factors to support timely diagnosis and effective tuberculosis management.

**Keywords:** Chest X-Ray, Diabetes Mellitus, Drug Abuse, Pulmonary Tuberculosis, Risk Factors, Smoking, Tuberculosis.

# Radiographic Patterns of Adult Tuberculosis

## A Prospective Study in Civil Hospital

### Background

Evaluating radiographic patterns and risk factors in adult TB.

### Methods

103 Patients

Chest X-Ray

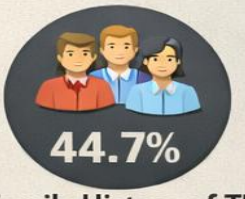
Data Analysis

### Key Findings

34% Smokers

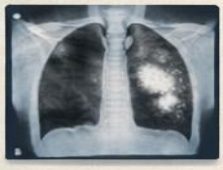
29% Drug Abuse

6.8% Diabetes

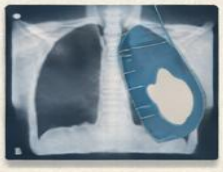


44.7% Family History of TB

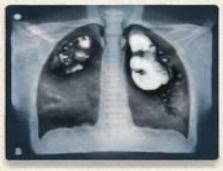
### Radiographic Results



Consolidation 58.3%

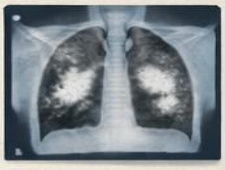


Pleural Effusion 33.0%



Cavities 19.4%

Infiltration 87.4%



Small Nodules 2.9%

### Conclusion

Diverse TB patterns linked with smoking, diabetes and drug abuse. Comprehensive evaluation needed for effective TB management.

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## INTRODUCTION

Tuberculosis (TB) remains one of the most formidable infectious diseases worldwide, with an estimated 10 million new cases and approximately 1.4 million deaths reported globally in 2019 (1). Caused by *Mycobacterium tuberculosis*, TB can involve multiple organ systems; however, pulmonary tuberculosis constitutes the most prevalent and clinically significant form in adults (2). The interaction between the virulence of the pathogen and the host immune response results in a wide spectrum of pathological changes, which are often reflected in diverse radiographic appearances on chest imaging (3). Understanding these radiographic manifestations is therefore fundamental to adult TB diagnosis, clinical decision-making, and disease monitoring. Chest radiography remains a cornerstone in the evaluation of suspected pulmonary TB, particularly in resource-limited settings where advanced imaging modalities may not be readily available (4). Chest X-rays assist clinicians in distinguishing between early, subtle infiltrative changes and advanced structural damage such as cavitation, fibrosis, or volume loss (5). Nevertheless, TB diagnosis based solely on imaging is challenging, as classical features—including consolidations, nodules, and cavities—may present as patchy or diffuse opacities that overlap with findings seen in other pulmonary conditions (6). Secondary radiographic signs such as lymphadenopathy and pleural effusion further complicate interpretation, while fibrotic changes highlight the long-term consequences of untreated or inadequately managed disease (7). A comprehensive understanding of this radiological spectrum is therefore essential for timely diagnosis, accurate assessment of disease severity, and appropriate evaluation of treatment response (8).

The variability in TB radiographic presentation becomes particularly pronounced in special populations. In immunocompromised individuals, including those with HIV/AIDS, TB often manifests with atypical or extensive pulmonary involvement and a higher likelihood of extrapulmonary disease (9). Miliary TB, characterized by hematogenous dissemination, poses a unique diagnostic challenge as early radiographic findings may be subtle, evolving over time into diffuse micronodular patterns that signify systemic involvement (10). Similarly, drug-resistant TB represents a growing global concern, and while its radiographic features may not differ markedly from drug-sensitive disease, imaging plays a vital role in identifying persistent or progressive abnormalities that necessitate re-evaluation of therapeutic strategies (11). These complexities underscore the need for nuanced radiographic interpretation to distinguish active disease from post-treatment sequelae and from conditions that mimic TB (12,13). Another major diagnostic challenge arises from the overlap between TB radiographic patterns and those associated with smoking-related lung diseases. Chronic tobacco exposure can produce radiological changes such as emphysematous alterations, chronic bronchitis, or mass-like opacities that obscure or mimic TB findings, thereby delaying diagnosis and appropriate management. This overlap contributes to increased morbidity and mortality, particularly in populations with high smoking prevalence and TB burden, highlighting a critical gap in current diagnostic frameworks (14). Despite extensive literature describing individual radiographic features of pulmonary TB, there remains a lack of systematic evaluation that integrates classical and atypical imaging patterns while accounting for temporal variation, immune status, and confounding conditions such as smoking-related lung disease (15,16). Addressing this gap is essential to improve diagnostic accuracy, risk stratification, and clinical outcomes. Therefore, the objective of the present research is to systematically identify and analyze the diverse radiological patterns of adult pulmonary tuberculosis, with particular emphasis on differentiating TB from smoking-related pulmonary conditions, in order to enhance diagnostic precision and inform more effective patient management strategies.

## METHODS

This prospective study was conducted over an approximate duration of six months following formal approval of the research synopsis. Adult patients with confirmed tuberculosis who consented to participate were consecutively enrolled during the study period. A total sample size of 103 participants was included, derived using a convenient sampling approach based on the average sample sizes reported in comparable published studies (9,10). Only adult patients with a confirmed diagnosis of tuberculosis were eligible for inclusion, while individuals with co-existing respiratory conditions that could confound radiographic interpretation, as well as those unwilling to share their information or provide consent, were excluded from participation. This selection strategy was intended to ensure a relatively homogeneous study population for accurate assessment of tuberculosis-related radiographic patterns. Chest radiography was performed using a Toshiba 500 mA X-ray system equipped with a high-frequency generator, a rotating anode tube, and a tube voltage range of 40–150 kVp. The system utilized a small focal spot and high-resolution digital detectors to enhance spatial resolution and image detail, particularly for subtle tuberculosis-related lesions. Automatic Exposure Control (AEC), precise collimation, and anti-scatter grids were employed to optimize radiation dose while maintaining diagnostic image quality. Advanced image processing software was used to reduce noise, enhance contrast, and suppress artifacts, ensuring reliable and reproducible imaging suitable for both diagnostic evaluation

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and disease monitoring. Images were acquired with patients positioned in the posteroanterior orientation, and participants were instructed to hold their breath during exposure to minimize motion artifacts and improve visualization of lung parenchyma.

Data were collected after obtaining written informed consent from each participant. A structured data collection proforma was used to record demographic variables such as age and gender, as well as clinical and radiographic parameters including upper and lower lobe infiltrations, radiographic appearance patterns, and the presence of underlying conditions such as diabetes mellitus or hypertension. Participants were informed about the non-invasive nature of the procedure and reassured that no additional risk was involved beyond routine diagnostic imaging. Radiographic images were reviewed and relevant findings were documented systematically to ensure consistency across observations. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 20. Descriptive statistics were applied to summarize demographic and clinical characteristics, while the chi-square test was used to assess associations between radiographic patterns and selected variables. Statistical significance was evaluated using appropriate confidence levels to explore relationships between categorical variables relevant to the radiological spectrum of tuberculosis. Ethical approval for the study was obtained from the Ethical Committee of the University of Lahore, Gujrat Campus, and all procedures were conducted in accordance with institutional ethical guidelines. Participant confidentiality and anonymity were strictly maintained throughout the study. Individuals were informed of their right to withdraw at any stage without any consequences, and privacy was ensured during imaging and data handling.

## RESULTS

A total of 103 adult patients with radiographic evidence of pulmonary tuberculosis were included in the analysis. The study population demonstrated a higher proportion of female patients, with 60 females (58.3%) compared to 43 males (41.7%). With regard to familial exposure, 46 patients (44.7%) reported a positive family history of tuberculosis, whereas 57 patients (55.3%) had no known family history of the disease. Assessment of comorbid conditions and behavioral risk factors showed that diabetes mellitus was present in 7 patients (6.8%), while the majority of participants, 96 patients (93.2%), were non-diabetic. Drug abuse was documented in 30 patients (29.1%), whereas 73 patients (70.9%) reported no history of substance abuse. Smoking history was identified in 35 patients (34.0%), while 68 patients (66.0%) were non-smokers. Radiographic evaluation revealed a wide range of pulmonary abnormalities consistent with tuberculosis. Lung infiltrations were the most prevalent finding, observed in 90 patients (87.4%). Consolidation was present in 60 patients (58.3%), reflecting a common manifestation of active pulmonary disease. Pleural effusion was identified in 34 patients (33.0%), indicating more extensive disease involvement in a substantial proportion of cases. Cavitary lesions, suggestive of advanced pulmonary tuberculosis, were detected in 20 patients (19.4%). Small nodular opacities were uncommon and were observed in only 3 patients (2.9%), while the remaining 100 patients (97.1%) showed no nodular involvement. Overall, the results demonstrated that adult pulmonary tuberculosis presented with heterogeneous radiographic patterns, with infiltrative changes and consolidations being the dominant features, followed by pleural effusions and cavitary disease. The coexistence of metabolic and behavioral risk factors, particularly smoking, substance abuse, and diabetes mellitus, was notable among the affected population and formed an important part of the clinical profile observed in this cohort.

**Table 1: Gender Distribution of Adult Tuberculosis Patients**

| Gender | | |
|---|---|---|
| | Frequency | Percent |
| female | 60 | 58.3 |
| male | 43 | 41.7 |
| Total | 103 | 100.0 |

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**Table 2: Distribution of Family History of Tuberculosis Among Adult Patients**

| Family history of TB | | | |
|---|---|---|---|
| | Frequency | Percent | Valid Percent |
| no | 57 | 55.3 | 55.3 |
| yes | 46 | 44.7 | 44.7 |
| Total | 103 | 100.0 | 100.0 |

**Table 3: Distribution of Clinical Risk Factors and Radiographic Findings Among Adult Tuberculosis Patients**

| **Variable** | **Category** | **Frequency** | **Percent** |
|---|---|---|---|
| Diabetes Mellitus | No | 96 | 93.2 |
| | Yes | 7 | 6.8 |
| Drug Abuse | No | 73 | 70.9 |
| | Yes | 30 | 29.1 |
| Smoking | No | 68 | 66.0 |
| | Yes | 35 | 34.0 |
| Small Nodules | Absent | 100 | 97.1 |
| | Present | 3 | 2.9 |
| Cavities | Absent | 83 | 80.6 |
| | Present | 20 | 19.4 |
| Consolidation | Absent | 43 | 41.7 |
| | Present | 60 | 58.3 |

**Table 4: Distribution of Pleural Effusion Among Adult Tuberculosis Patients**

| Pleural Effusion | | |
|---|---|---|
| | Frequency | Percent |
| absent | 69 | 67.0 |
| present | 34 | 33.0 |
| Total | 103 | 100.0 |

**Table 5: Distribution of Pulmonary Infiltration Among Adult Tuberculosis Patients**

| Infiltration | | |
|---|---|---|
| | Frequency | Percent |
| absent | 13 | 12.6 |
| present | 90 | 87.4 |
| Total | 103 | 100.0 |

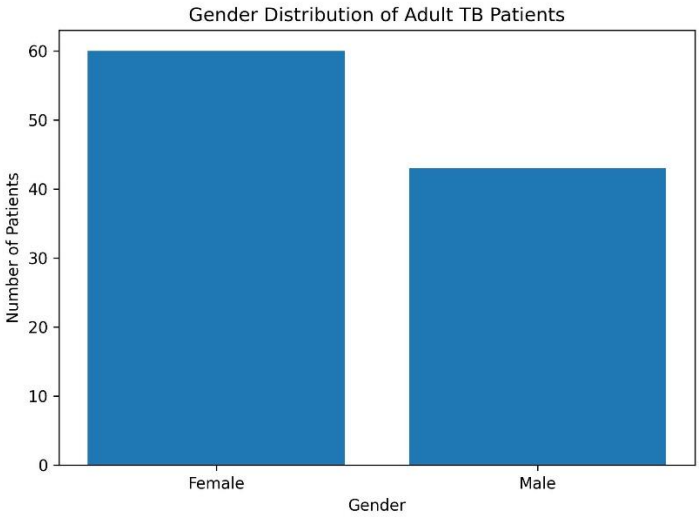


*Figure 2 Gender Distribution of Adult TB Patients*

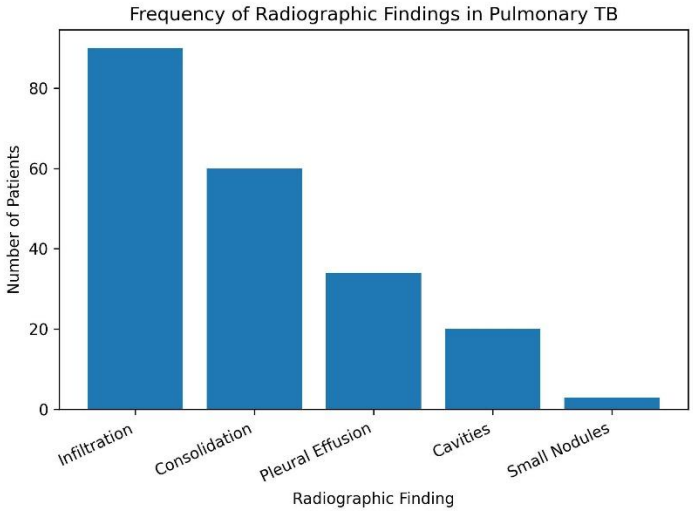


*Figure 2 Frequency of Radiographic Findings in Pulmonary TB*

## DISCUSSION

The present study provided a comprehensive overview of the radiographic and clinical characteristics of adult pulmonary tuberculosis within the studied population, highlighting the continued diagnostic value of chest X-ray imaging. The observation that all enrolled patients demonstrated radiographic abnormalities consistent with tuberculosis reinforces the sensitivity of chest radiography as an initial diagnostic and screening tool, particularly in settings where access to advanced imaging modalities may be limited. This finding is in agreement with existing literature, which consistently emphasizes chest X-ray as a cornerstone investigation in pulmonary tuberculosis due to its ability to detect both early parenchymal changes and advanced disease manifestations (16). The demographic distribution in this cohort showed a higher proportion of female patients compared to males. While many international studies have reported male predominance in tuberculosis, variations in gender distribution have also been described and are often influenced by sociocultural factors, healthcare-seeking behavior, and local epidemiological patterns. These findings suggest that gender-related trends in tuberculosis may not be uniform across populations and underline the importance of region-specific data when planning screening and control strategies (17-19). Differences in occupational exposure, access to healthcare services, and health awareness may have contributed to the observed pattern in this study. The presence of comorbidities and lifestyle-related risk factors, including smoking, substance abuse, and diabetes mellitus, was notable among patients with radiographically confirmed tuberculosis. These factors are well recognized for their role in impairing immune function, increasing susceptibility to infection, and negatively influencing disease severity and treatment outcomes (20,21). The coexistence of such risk factors within a substantial proportion of the study population underscores the need for integrated tuberculosis management strategies that address not only the infection itself but also the broader metabolic and behavioral determinants of health. This aligns with prior research indicating that effective tuberculosis control requires a multidisciplinary approach that combines clinical management with public health interventions targeting modifiable risk factors (22).

Radiographically, the spectrum of findings observed in this study—including infiltrations, consolidations, pleural effusions, and cavitary lesions—reflected the classical manifestations of pulmonary tuberculosis reported globally. Infiltrative changes and consolidations were the most frequent findings, consistent with active parenchymal disease, while cavitation represented more advanced pathology with potential implications for disease transmission. The relatively lower frequency of nodular patterns suggested that miliary or early hematogenous spread was less common in this cohort. These findings reinforce the concept that tuberculosis is a radiologically heterogeneous disease and that careful, systematic image interpretation is essential for accurate diagnosis, staging, and monitoring of treatment response. One of the strengths of this study lay in its prospective design and standardized imaging protocol, which allowed consistent data collection and minimized variability in radiographic assessment. Additionally, the inclusion of clinical risk factors alongside imaging findings provided a more holistic view of tuberculosis presentation in adults. However, several limitations should be acknowledged. The use of a convenient sampling technique and the absence of formal sample size calculation may limit the generalizability of the findings. Furthermore, the study did not include stratified or comparative analysis of radiographic patterns based

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on individual risk factors such as smoking status or diabetes, which could have offered deeper insights into disease behavior across subgroups. The reliance on chest X-ray alone, without routine correlation with advanced imaging or microbiological burden, also restricted the ability to fully characterize disease extent. Future research would benefit from larger, multicenter studies incorporating longitudinal follow-up to assess radiographic evolution during and after treatment (23,24). Comparative analyses between different risk groups, as well as integration of advanced imaging techniques where feasible, could further refine understanding of tuberculosis pathophysiology and outcomes. Genetic, environmental, and socioeconomic determinants should also be explored in greater depth to inform targeted prevention strategies. Overall, the findings of this study contributed valuable local evidence to the existing body of knowledge and emphasized that effective tuberculosis control depends on early detection, accurate radiographic interpretation, and comprehensive management tailored to the population being served.

## CONCLUSION

This study highlights the continued importance of chest radiography as a practical and reliable tool for identifying pulmonary tuberculosis and characterizing its diverse radiographic patterns in adults. By linking imaging findings with key clinical and lifestyle-related factors, the research underscores the value of early detection and comprehensive assessment in guiding timely management and limiting disease transmission. The insights generated support the development of context-specific, evidence-based prevention and control strategies that integrate radiological evaluation with broader clinical care. Collectively, these findings reinforce the role of targeted screening and informed clinical decision-making in strengthening tuberculosis control efforts across varied healthcare settings.

### AUTHOR CONTRIBUTIONS

| Author | Contribution |
|---|---|
| Nimra Arshad* | Substantial Contribution to study design, analysis, acquisition of Data<br>Manuscript Writing<br>Has given Final Approval of the version to be published |
| Aqsa Rao | Substantial Contribution to study design, acquisition and interpretation of Data<br>Critical Review and Manuscript Writing<br>Has given Final Approval of the version to be published |
| Dilshad Maqbool | Substantial Contribution to acquisition and interpretation of Data<br>Has given Final Approval of the version to be published |
| Muhammad Nauman Saleem | Contributed to Data Collection and Analysis<br>Has given Final Approval of the version to be published |

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