



PREVALENCE OF POST-TUBERCULOSIS LUNG DISEASE (PTLD) IN PATIENTS ATTENDING RESPIRATORY OUTPATIENT DEPARTMENTS AT A TERTIARY CARE HOSPITAL IN RAJASTHAN

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ABSTRACT

Background: Advances in tuberculosis (TB) diagnosis and treatment have led to improved survival; however, a considerable proportion of TB survivors experience persistent respiratory impairment known as post-tuberculosis lung disease (PTLD). PTLD encompasses a range of chronic structural and functional lung abnormalities that adversely affect quality of life and long-term health outcomes. Data on PTLD prevalence and patterns remain limited in many high-burden regions, including Rajasthan.

Objectives: To estimate the prevalence of post-tuberculosis lung disease among patients attending a respiratory outpatient department at a tertiary care hospital in Rajasthan, and to describe their clinical, radiological, and spirometric profiles, along with factors associated with PTLD.

Methods: A hospital-based cross-sectional study was conducted from January 2023 to June 2024 in the respiratory outpatient department of a tertiary care hospital in Rajasthan. Adults aged ≥ 18 years with a history of microbiologically confirmed pulmonary TB who had completed anti-tuberculosis treatment at least six months prior were enrolled using consecutive sampling. Sociodemographic details, TB-related history, risk factors, clinical symptoms, and comorbidities were recorded using a structured proforma. All participants underwent chest radiography, and spirometry was performed according to ATS/ERS guidelines. PTLD was defined as the presence of persistent respiratory

symptoms, radiological sequelae, and/or abnormal spirometry after exclusion of active TB. Data were analyzed using descriptive statistics and inferential tests, including chi-square test and logistic regression.

Results: Out of 240 participants, 86 patients (35.8%) were identified as having PTLD. Persistent respiratory symptoms were present in 83.7% of PTLD patients, radiological abnormalities in 75.6%, and spirometric abnormalities in 80.2%. Among those with abnormal spirometry, obstructive patterns were most common (49.3%), followed by restrictive (30.4%) and mixed defects (20.3%). PTLD was more frequently observed among older individuals, smokers, those with recurrent TB episodes, and patients with a history of drug-resistant TB.

Conclusions: PTLD is common among post-TB patients attending tertiary respiratory services. Routine post-treatment assessment and long-term follow-up should be integrated into TB care to address the growing burden of chronic respiratory morbidity.

Keywords: Post-tuberculosis lung disease; Pulmonary tuberculosis; Spirometry; Respiratory morbidity; Tertiary care hospital

INTRODUCTION

Tuberculosis (TB) remains a leading cause of infectious disease morbidity and mortality worldwide despite substantial advances in diagnosis and treatment. The World Health Organization's Global Tuberculosis Report 2023 documented a continued high global burden, with millions of people newly diagnosed and substantial numbers surviving after successful treatment each year [1]. As TB survival improves, attention has shifted from short-term treatment outcomes to the long-term health of TB survivors. A growing body of evidence shows that many individuals cured of pulmonary TB are left with chronic respiratory problems collectively described as post-tuberculosis lung disease (PTLD) — a heterogeneous condition that includes airflow obstruction, bronchiectasis, pulmonary fibrosis, cavitation, reduced gas transfer and exercise impairment [2]. PTLD not only causes persisting symptoms such as cough and dyspnea, but is also associated with reduced functional capacity, poorer quality of life and increased healthcare utilization long after microbiological cure [3].

Estimates of the prevalence and patterns of PTLD vary widely between studies because of differences in case definitions, study populations, diagnostic methods (symptom questionnaires, spirometry, chest radiography or computed tomography) and timing of assessment after treatment completion. Systematic reviews and meta-analyses indicate that a substantial proportion of TB survivors show objective lung impairment on spirometry — pooled estimates of abnormal lung function after treatment range broadly but commonly exceed 30–50% in many settings [4,5]. Imaging-based reviews similarly describe high frequencies of structural sequelae, notably fibrotic scarring, bronchiectasis and residual cavitation, which correlate imperfectly with symptoms and spirometric abnormalities but together contribute to long-term morbidity [2,6]. These data highlight PTLD as a neglected sequela of the global TB epidemic that has important individual and public health consequences [5].

Pathophysiologically, PTLD arises from a combination of infection-driven tissue destruction, dysregulated host inflammatory responses and repair processes that cause permanent structural change; factors such as disease severity, delayed diagnosis, recurrent or drug-resistant TB, smoking, air-pollution and comorbidities modify risk and the clinical phenotype [7]. The clinical spectrum ranges from mild spirometric abnormalities with negligible symptoms to severe, disabling disease characterised by destroyed lung segments, chronic bronchiectasis with recurrent infections or fixed airflow obstruction resembling chronic obstructive pulmonary disease (COPD) [6–8]. Importantly, many patients with PTLD remain unrecognised in routine care because follow-up after TB treatment is limited, spirometry is unavailable in many primary and secondary care settings, and standard TB programmes are primarily oriented towards bacteriological cure rather than long-term respiratory outcomes [5,6].

In India — which accounts for a large fraction of the global TB burden — several hospital-based and community studies have documented a notable burden of post-TB respiratory sequelae. Indian cohorts

using spirometry and imaging have reported frequent obstructive and restrictive patterns and structural changes on CT or chest radiograph that correlate with persistent respiratory symptoms [8,9]. A recent regionally-focused analysis further emphasises that TB adds to the already heavy burden of chronic respiratory disease in India, interacting with high background exposure to biomass fuel, ambient air pollution and tobacco use to amplify long-term risk [10]. Despite this, standard national TB programmatic follow-up seldom includes routine functional testing or structured pulmonary rehabilitation pathways, creating a policy and service gap for TB survivors who develop chronic lung disease [5].

From a methodological perspective, accurate identification of PTLD requires standardized approaches to history taking, symptom quantification (for example mMRC dyspnea scale), spirometry performed and interpreted according to international technical standards, and consistent radiological categorization [11]. The ERS/ATS interpretive standards for pulmonary function testing provide an accepted framework for defining obstruction, restriction and mixed patterns and for grading severity — a necessary prerequisite for producing comparable prevalence estimates and for studying determinants of functional impairment after TB [11]. Moreover, although most PTLD research has focused on adults, growing evidence shows that children and adolescents may also suffer structural and functional consequences after pulmonary TB, underscoring the need for age-inclusive surveillance and care pathways [12].

Despite accumulating evidence, regional data remain limited in many high-burden settings and there is heterogeneity in study designs, making it difficult to generate locally-relevant prevalence estimates that can inform service planning. In Rajasthan, tertiary respiratory clinics commonly see patients with post-infectious sequelae, but systematic data on the prevalence and pattern of PTLD among attendees are scarce. The present study — conducted from January 2023 to June 2024 at a tertiary care hospital in Rajasthan — aims to estimate the prevalence of PTLD among patients attending the respiratory outpatient department, to describe their clinical, radiological and spirometric profiles, and to identify risk factors associated with persistent respiratory impairment. Generating robust local data will help inform integration of post-TB assessment, targeted rehabilitation and longer-term respiratory care into regional TB and respiratory services.

ATERIALS & METHODS

Study Design and Setting: A hospital-based cross-sectional study was conducted in the Respiratory Outpatient Department (OPD) of a tertiary care hospital in Rajasthan, India.

Study Period: The study was carried out over a period of eighteen months, from January 2023 to June 2024.

Study Population: The study population comprised adult patients attending the respiratory OPD with a documented history of pulmonary tuberculosis who had completed anti-tuberculosis treatment.

Eligibility Criteria

Inclusion criteria:

- Patients aged 18 years and above
- History of microbiologically confirmed pulmonary tuberculosis (smear, CBNAAT/GeneXpert or culture positive)
- Completion of anti-tuberculosis treatment at least 6 months prior to enrollment
- Willingness to provide written informed consent

Exclusion criteria

- Evidence of active pulmonary tuberculosis at the time of evaluation
- Known diagnosis of chronic lung diseases preceding tuberculosis (e.g., bronchial asthma, interstitial lung disease)
- Inability to perform acceptable spirometry
- Pregnant women and critically ill patients

Sample Size: The sample size was calculated based on previously published literature reporting a prevalence of post-tuberculosis lung disease (PTLD) of approximately 30–40% among treated pulmonary tuberculosis patients. Assuming an expected prevalence of 30%, a 95% confidence level, and an absolute precision of 6%, the minimum required sample size was estimated to be 224. After accounting for a potential non-response or incomplete data rate of 5%, the final sample size was rounded to 240 participants. Accordingly, 240 eligible post-tuberculosis patients attending the respiratory outpatient department between January 2023 and June 2024 were included in the study.

Sampling Technique: Eligible participants were recruited using consecutive sampling, wherein all patients fulfilling the inclusion criteria and attending the respiratory OPD during the study period were enrolled until the required sample size was reached.

Data Collection Tools and Procedure: Data were collected using a pre-designed, pre-tested structured proforma through face-to-face interviews and review of medical records. The proforma included the following components:

- Sociodemographic details: age, sex, residence, education, occupation
- Risk factors: smoking status, biomass fuel exposure, occupational exposure
- Clinical details: respiratory symptoms (cough, sputum production, dyspnea, wheeze, hemoptysis), duration of symptoms, and modified Medical Research Council (mMRC) dyspnea grade
- Tuberculosis-related history: year of diagnosis, number of TB episodes, drug-sensitivity status, treatment duration, adherence, and time since treatment completion
- Comorbidities: diabetes mellitus, HIV, and other chronic illnesses

Radiological Assessment: All participants underwent chest radiography. Radiological findings suggestive of post-tuberculosis sequelae—such as fibrosis, bronchiectasis, cavitary lesions, volume loss, or pleural thickening—were documented. High-resolution computed tomography (HRCT) of the chest was reviewed when available or clinically indicated.

Spirometry: Pulmonary function testing was performed using spirometry in accordance with American Thoracic Society/European Respiratory Society (ATS/ERS) guidelines. Pre- and post-bronchodilator measurements were recorded. Spirometric patterns were classified as obstructive, restrictive, or mixed based on standard interpretative criteria, and severity was graded using predicted values.

Operational Definition of Post-Tuberculosis Lung Disease (PTLD): Post-tuberculosis lung disease was defined as the presence of one or more of the following in a patient with prior pulmonary TB, after exclusion of active disease:

- Persistent respiratory symptoms attributable to previous TB
- Radiological abnormalities consistent with post-tubercular sequelae
- Abnormal spirometry (obstructive, restrictive, or mixed pattern)

Outcome Measures: The primary outcome was the prevalence of post-tuberculosis lung disease among patients attending the respiratory OPD. Secondary outcomes included the pattern of spirometric abnormalities, radiological findings, and factors associated with PTLD.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using appropriate statistical software. Categorical variables were expressed as frequencies and percentages, while continuous variables were summarized using mean and standard deviation or median and interquartile range, as appropriate. Associations between PTLD and independent variables were assessed using chi-square test or Fisher's exact test for categorical variables and t-test or Mann–Whitney U test for continuous variables. Multivariable logistic regression analysis was performed to identify independent predictors of PTLD. A p-value <0.05 was considered statistically significant.

Ethical Considerations: Written informed consent was obtained from all participants prior to enrollment. Confidentiality and anonymity of participant data were strictly maintained throughout the study.

RESULTS

A total of 240 patients with a history of treated pulmonary tuberculosis attending the respiratory outpatient department during the study period (January 2023 to June 2024) were included in the analysis. Among the 240 participants, the largest proportion belonged to the 46–60 years age group (33.8%), followed by 31–45 years (30.0%). Males constituted 65.0% of the study population. A majority of participants (62.1%) were from rural areas. Smoking exposure (current or former) was reported by 42.5% of participants. Table 1 shows the socio-demographic characteristics of study participants.

Table 1. Socio-demographic characteristics of study participants (N = 240)			
Variable		Frequency (n)	Percentage (%)
Age group (years)	18–30	46	19.2
	31–45	72	30.0
	46–60	81	33.8
	>60	41	17.0
Gender	Male	156	65.0
	Female	84	35.0
Residence	Rural	149	62.1
	Urban	91	37.9
Smoking status	Current/Former smoker	102	42.5
	Never smoker	138	57.5

Most participants (71.3%) had experienced a single episode of tuberculosis, while 28.7% reported two or more episodes. Drug-resistant TB was documented in 15.8% of cases. The time since completion of anti-tuberculosis treatment was less than two years for 40.8% of participants. Table 2 shows the tuberculosis-related clinical characteristics.

Table 2. Tuberculosis-related clinical characteristics (N = 240)			
Variable		Frequency (n)	Percentage (%)
Number of TB episodes	One episode	171	71.3
	Two or more episodes	69	28.7
Drug resistance history	Drug-sensitive TB	202	84.2
	Drug-resistant TB	38	15.8

Table 2. Tuberculosis-related clinical characteristics (N = 240)			
Time since completion of ATT	6 months–2 years	98	40.8
	>2–5 years	79	32.9
	>5 years	63	26.3

Out of 240 participants, 86 patients (35.8%) met the operational criteria for post-tuberculosis lung disease, while 154 patients (64.2%) did not show features consistent with PTLD. Table 3 shows the prevalence of Post-Tuberculosis Lung Disease (PTLD) (N = 240).

Table 3. Prevalence of Post-Tuberculosis Lung Disease (PTLD) (N = 240)		
PTLD status	Frequency (n)	Percentage (%)
PTLD present	86	35.8
PTLD absent	154	64.2

Among the 86 patients with PTLD, persistent respiratory symptoms were recorded in 72 patients (83.7%). Radiological abnormalities suggestive of post-tubercular sequelae were observed in 65 patients (75.6%). Spirometric abnormalities were detected in 69 patients (80.2%). Table 4 shows the clinical, radiological and spirometric findings among PTLD patients (n = 86).

Table 4. Clinical, radiological and spirometric findings among PTLD patients (n = 86)		
Finding*	Frequency (n)	Percentage (%)
Persistent respiratory symptoms	72	83.7
Radiological abnormalities	65	75.6
Abnormal spirometry	69	80.2

*Multiple responses

Among PTLD patients with abnormal spirometry (n = 69), obstructive ventilatory defect was observed in 34 patients (49.3%), restrictive defect in 21 patients (30.4%), and a mixed pattern in 14 patients (20.3%). Table 5 shows the distribution of spirometric patterns among PTLD patients.

Table 5. Distribution of spirometric patterns among PTLD patients (n = 69)		
Spirometric pattern	Frequency (n)	Percentage (%)
Obstructive	34	49.3
Restrictive	21	30.4
Mixed	14	20.3

Among participants aged 45 years or older, 54 (62.8%) had PTLT. Smoking history was reported in 49 (57.0%) PTLT patients compared to 53 (34.4%) patients without PTLT. Recurrent TB episodes (two or more) were present in 38 (44.2%) PTLT patients, and drug-resistant TB was observed in 22 (25.6%) PTLT patients. Corresponding p-values for these comparisons are shown in Table 6.

Table 6. Association between selected variables and PTLT (N = 240)				
Variable	PTLT present n (%)	PTLT absent n (%)	χ^2	p-value
Age ≥ 45 years	54 (62.8)	68 (44.2)	7.12	0.008
Male gender	61 (70.9)	95 (61.7)	2.01	0.156
Smoking history	49 (57.0)	53 (34.4)	12.46	<0.001
≥ 2 TB episodes	38 (44.2)	31 (20.1)	15.89	<0.001
Drug-resistant TB	22 (25.6)	16 (10.4)	10.23	0.001

Statistical test: Chi-square test

DISCUSSION

In this hospital-based study of 240 post-tuberculosis (post-TB) patients attending a tertiary respiratory OPD in Rajasthan (January 2023–June 2024), 86 patients (35.8%) met the operational criteria for post-tuberculosis lung disease (PTLT). This prevalence lies within the range reported across recent systematic reviews and hospital cohorts. Ivanova et al (2023) reported substantial post-TB spirometric impairment across pooled studies, with estimates of persistent abnormal lung function commonly in the range of ~30–50% depending on case definitions and timing of assessment [4]. Similarly, Yarbrough et al (2024) noted wide variability in reported prevalence but emphasized that many studies find one-third or more of TB survivors have measurable impairment on spirometry or imaging [5]. Our finding of 35.8% therefore aligns with these aggregated estimates and with other single-centre series from India and similar settings.

Patterns of functional abnormality in our cohort showed predominance of obstructive defects among those with abnormal spirometry (49.3% obstructive, 30.4% restrictive, 20.3% mixed). This distribution is consistent with several hospital-based Indian reports that document a high proportion of obstructive physiology after TB. Patil et al (2018) measured pulmonary function in post-TB subjects and reported a high overall burden of abnormal spirometry, with mixed and obstructive defects commonly observed [13]. Shanmugasundaram et al (2022) also found marked impairment on spirometry in PTLT patients and demonstrated that airway dysfunction is a frequent manifestation [14]. The predominance of obstruction in many post-TB cohorts has been attributed to small airway involvement, bronchiectasis-related airway changes, and fixed airflow limitation from remodeling after cavitory and bronchial damage [2,6,11].

Radiological sequelae were also prominent in our PTLT subgroup: 75.6% had imaging abnormalities while 83.7% reported persistent respiratory symptoms. Imaging-based systematic reviews (Meghji et al, 2016) described fibrotic scarring, bronchiectasis and residual cavitation as common post-TB findings, and noted that structural disease often persists despite microbiological cure [2]. The imperfect correlation between symptoms, spirometry and imaging—seen also in our series where many patients had multiple concurrent abnormalities—has been emphasized in prior work and underlines the multidimensional nature of PTLT (symptom burden, structural damage, functional impairment) [3,4,6].

Our analyses identified several factors associated with PTLT in bivariate comparisons: older age (≥ 45 years), smoking history, history of two or more TB episodes, and prior drug-resistant TB. These associations echo findings from other observational studies and reviews. Patil et al (2018) summarised patient-level risk factors for post-TB sequelae and included older age, treatment delay and recurrent

disease among consistent predictors [13]. Smoking has been repeatedly implicated as both a risk factor for adverse TB outcomes and as a modifier of long-term lung function: tobacco exposure may promote more extensive airway damage and diminishes recovery, and meta-analytic data link smoking to greater risks of recurrence and worse respiratory outcomes after TB [5,15]. In our cohort, 57% of PTLD patients had a history of smoking compared with 34.4% among those without PTLD ($p<0.001$), a difference consistent with the hypothesis that tobacco contributes to persistent airflow limitation after TB.

Recurrent TB and drug resistance were also more common among PTLD patients in our study (≥ 2 TB episodes: 44.2% vs 20.1%, $p<0.001$; drug-resistant TB: 25.6% vs 10.4%, $p=0.001$). Multiple prior episodes and drug resistance are plausible drivers of more extensive lung destruction due to prolonged disease duration, earlier cavitation, and greater intensity of inflammatory injury; similar patterns appear in other Indian hospital series where recurrent disease and severe initial disease correlated with bronchiectasis and worse spirometry [15,16]. For example, Agarwal et al (2021) reported that post-TB bronchiectasis and obstructive physiology were frequent among patients with prior severe or recurrent TB episodes [15].

The proportion of patients with abnormal spirometry among PTLD cases in our study (80.2%) is consistent with many symptomatic-patient cohorts that have reported high rates (often $>70\%$) of physiological impairment among those presenting for care after TB [13,14]. However, community-based studies and screening at treatment completion tend to report lower prevalence, reflecting the influence of selection: tertiary OPD samples are enriched for symptomatic or referred patients. This sampling context should be borne in mind when comparing across studies; Ivanova et al (2023) highlighted heterogeneity in prevalence estimates driven by setting, timing and measurement methods [4]. Our study findings have potential implications for post-TB care. The coexistence of symptoms, structural abnormalities and functional impairment in a substantial minority of cured TB patients reinforces calls by recent policy-oriented analyses to integrate routine post-treatment assessment (including symptom screening and spirometry where available) and referral pathways for pulmonary rehabilitation in TB programs [5]. Pragmatically, simple measures—smoking cessation interventions, vaccination, and availability of spirometry in district-level services—may help identify and mitigate long-term disability among TB survivors.

Strengths of our work include a defined hospital OPD population, use of standardized spirometric definitions, and concurrent documentation of radiology and clinical features. Limitations include the cross-sectional design, absence of pre-TB baseline lung function, and potential referral/selection bias inherent to tertiary care sampling; these factors limit causal inference and generalizability to all TB survivors. Future work should prioritise prospective cohorts with baseline measures, and intervention trials of pulmonary rehabilitation and integrated follow-up to determine whether earlier detection and care can modify the long-term trajectory of PTLD.

CONCLUSION

Post-tuberculosis lung disease represents a significant burden among patients attending respiratory outpatient services even after completion of anti-tuberculosis treatment. In this tertiary care hospital-based study from Rajasthan, more than one-third of previously treated pulmonary tuberculosis patients exhibited features consistent with PTLD. A substantial proportion demonstrated persistent respiratory symptoms, radiological sequelae, and spirometric abnormalities, highlighting the chronic and multifactorial nature of post-TB morbidity. Obstructive ventilatory defects were the most frequently observed spirometric pattern. Older age, smoking history, recurrent tuberculosis episodes, and drug-resistant tuberculosis were commonly observed among PTLD patients. These findings underscore the need to move beyond bacteriological cure as the sole endpoint of TB care. Incorporation of systematic post-treatment respiratory assessment, including symptom screening, spirometry, and appropriate imaging, may facilitate early identification and management of PTLD. Strengthening post-TB follow-up and integrating rehabilitative and preventive strategies could help reduce long-term respiratory disability among TB survivors.

Declarations

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