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Prevalence and Spectrum of Post-Tuberculosis Lung Disease and Its Impact on Health-Related Quality of Life: A Cross-Sectional Study at a Tertiary Care Hospital

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ABSTRACT

Background: Post-tuberculosis lung disease (PTLD) represents a spectrum of persistent structural and functional pulmonary abnormalities following successful completion of anti-TB therapy, encompassing obstructive, restrictive, and mixed ventilatory defects, bronchiectasis, fibrosis, and severely impaired quality of life. India's high TB burden makes PTLD a growing public health concern that remains underaddressed in national follow-up programmes.
Methods: A cross-sectional study enrolled 200 adults who had completed pulmonary TB treatment >6 months prior, attending a tertiary care hospital. Clinical evaluation, pre- and post-bronchodilator spirometry (GLI-2012), HRCT chest, six-minute walk test (6MWT), modified MRC dyspnoea scale, and St George's Respiratory Questionnaire (SGRQ) were performed.
Results: Any PTLD was identified in 68.0% of patients. Spirometric patterns: obstructive 28.0%, restrictive 18.0%, mixed 14.0%; normal spirometry but radiological abnormality 8.0%. Bronchiectasis on HRCT was present in 41.0% and fibrosis in 36.0%. Mean 6MWD was 384±86 m; mean SGRQ total score 38.4±16.2. Independent predictors of moderate-severe airflow obstruction: prior MDR-TB (aOR 2.8), smoking ≥20 pack-years (aOR 3.6), >2 TB episodes (aOR 2.4), and treatment delay >2 months (aOR 1.9).
Conclusion: PTLD affects nearly 70% of TB survivors at this tertiary care hospital, with a substantial burden of bronchiectasis, airflow obstruction, and impaired quality of life. Integration of post-TB pulmonary follow-up — including spirometry, HRCT, and rehabilitative assessment — into the NTEP treatment completion pathway is urgently recommended.

Keywords: Post-tuberculosis lung disease; PTLD; spirometry; bronchiectasis; SGRQ; quality of life; MDR-TB; pulmonary rehabilitation; India

1. INTRODUCTION

Tuberculosis (TB) remains the world's most burdensome single infectious disease pathogen, with the WHO Global TB Report 2023 estimating 10.6 million incident TB cases and 1.3 million TB deaths globally in 2022 [1]. India bears the world's highest TB burden — approximately 2.8 million incident cases (27% of global) and 330,000 deaths annually — making TB control a defining national public health challenge [2]. Remarkable progress in the National Tuberculosis Elimination Programme (NTEP) has improved treatment success rates to >85% for drug-sensitive TB, generating a growing population of TB survivors. However, successful microbiological cure does not equate to pulmonary health restoration.

Post-tuberculosis lung disease (PTLD), defined as persistent structural or functional pulmonary abnormality attributable to prior TB beyond 6 months of treatment completion, is increasingly recognised as a major source of morbidity, disability, and reduced quality of life in the post-TB era [3]. The pathophysiological mechanisms are diverse: inflammation-driven tissue destruction creates cavities and parenchymal scarring that contract and fibrose; endobronchial granulomatous inflammation and post-inflammatory scarring cause bronchostenosis and bronchiectasis; aspergilloma colonisation of residual cavities introduces additional immunopathological burden; and destroyed lung — complete lobar consolidation/fibrosis — reduces functional lung volume to produce a combined obstructive-restrictive 'mixed' defect [4].

The Global Burden of Disease study estimated that 50 million people globally are living with PTLD — a figure exceeding many better-recognised chronic respiratory conditions [5]. In India, a systematic review by Kayina *et al*. [6] documented spirometric abnormalities in 26–68% of TB survivors (varying by definition and follow-up interval), with post-TB

bronchiectasis in up to 50% of patients in high-burden settings. The St George's Respiratory Questionnaire (SGRQ) consistently demonstrates severely impaired quality of life in PTLD — equivalent to or exceeding that of COPD patients with equivalent FEV1 impairment — reflecting the compounding effects of structural destruction, dyspnoea, exercise limitation, recurrent infections from bronchiectasis, and psychosocial burden [7].

Despite this burden, PTLD remains absent from most national TB programme follow-up protocols. The WHO 2023 Post-TB Lung Health Roadmap [8] calls for spirometry-based screening of all TB survivors at treatment completion and at 6 months, with referral for respiratory rehabilitation and chronic respiratory care pathways for those with significant impairment. In India, this recommendation has yet to be operationalised within NTEP. This study was designed to characterise the prevalence, phenotypic spectrum, functional impact, and quality of life implications of PTLD in a representative tertiary care cohort, and to identify predictors of severe disease to inform targeted follow-up protocols.

2. MATERIALS AND METHODS

2.1 Study Design and Population

Cross-sectional study at the respiratory medicine OPD of a tertiary care hospital over 18 months. Inclusion: adults ≥18 years with documented completion of anti-TB therapy (drug-sensitive or MDR/XDR-TB) ≥6 months prior, bacteriologically confirmed TB (positive sputum culture, Xpert MTB/RIF, or histopathology), resident within 50 km catchment area, able to perform spirometry and 6MWT. Exclusion: active TB (sputum AFB/culture positive), current smoker (to avoid confounding), known COPD/asthma diagnosed before TB, severe cardiac disease (NYHA ≥III), pregnancy. Sample size: expected PTLD prevalence 55%, 95% CI, 7% precision — minimum n=194; target n=200. IEC approval; written informed consent.

2.2 Clinical Assessment

Structured proforma: TB treatment type (RNTCP/NTEP Category 1, 2, MDR-TB, XDR-TB), number of prior TB episodes, treatment delay (time from symptom onset to treatment initiation), smear positivity at diagnosis, completion date, current medications. Symptom assessment: modified MRC dyspnoea scale (mMRC, 0–4), cough VAS. Spirometry (pre- and post-bronchodilator, ATS/ERS 2019; GLI-2012 South Asian reference); obstructive/restrictive/mixed classification per ATS/ERS criteria. HRCT chest (1.25-mm slice thickness; GE 64-slice CT): features documented — bronchiectasis (cylindrical/varicose/cystic; lobar distribution; modified Bhalla score), fibrosis (honeycombing, traction bronchiectasis, architectural distortion), residual cavity, calcification, air trapping, destroyed lung (>1 lobe). 6MWT per ATS 2002 protocol (30-m corridor; 2 practice walks if first time); distance (6MWD, m), SpO2 nadir, Borg dyspnoea score. SGRQ: total score and three domains (Symptoms, Activity, Impacts) — higher score = worse QoL; MCID 4 points.

2.3 Statistical Analysis

SPSS v26. Descriptive statistics for spirometric patterns and HRCT features. SGRQ and 6MWD compared across spirometric categories by ANOVA/Kruskal-Wallis. Multivariable logistic regression (outcome: moderate-severe airflow obstruction — FEV1 <60% predicted): aOR (95% CI). Pearson/Spearman correlation: SGRQ total vs 6MWD, FEV1%, mMRC. Significance $p<0.05$.

3. RESULTS

3.1 PTLD Prevalence and Spirometric Spectrum

200 TB survivors were enrolled (62.0% male; mean age 42.8±14.6 years; 74.0% drug-sensitive TB, 20.0% MDR-TB, 6.0% XDR-TB). Mean time since treatment completion: 28.4±18.6 months. Any PTLD was identified in 136 (68.0%): obstructive pattern 56 (28.0%), restrictive 36 (18.0%), mixed 28 (14.0%); radiological abnormality with normal spirometry 16 (8.0%); normal 64 (32.0%). Baseline characteristics and PTLD patterns are shown in Table 1.

Table 1. Clinical Profile and PTLD Patterns by TB Type (n=200)

Characteristic	Drug-Sensitive TB (n=148)	MDR-TB (n=40)	XDR-TB (n=12)	p-value
Mean age, years (±SD)	41.2±14.2	46.8±14.8	44.6±15.2	0.14
Any PTLD, n (%)	96 (64.9%)	32 (80.0%)	8 (66.7%)	0.18
Obstructive pattern, n (%)	38 (25.7%)	14 (35.0%)	4 (33.3%)	0.42
Restrictive pattern, n (%)	26 (17.6%)	8 (20.0%)	2 (16.7%)	0.92
Mixed pattern, n (%)	18 (12.2%)	8 (20.0%)	2 (16.7%)	0.44
Bronchiectasis on HRCT, n (%)	54 (36.5%)	24 (60.0%)	4 (33.3%)	0.018
Pulmonary fibrosis, n (%)	50 (33.8%)	18 (45.0%)	4 (33.3%)	0.47
Destroyed lobe, n (%)	10 (6.8%)	8 (20.0%)	2 (16.7%)	0.056

Mean 6MWD, m (±SD)	398±82	342±88	316±92	0.001
SGRQ total score (mean ±SD)	35.4±15.6	46.8±16.4	50.2±14.8	<0.001

3.2 Functional and QoL Profile

Mean FEV1% predicted was 68.4±18.2% in those with obstructive pattern; mean FVC% 72.6±14.8% in restrictive. Mean 6MWD was 384±86 m overall; 28.5% had 6MWT desaturation (SpO2 nadir <90%). Mean SGRQ total score was 38.4±16.2 (symptomatic impairment); SGRQ domains: Symptoms 48.6±18.4, Activity 54.2±20.6, Impacts 28.4±14.8. SGRQ total correlated inversely with 6MWD ($r=-0.58$, $p<0.001$) and FEV1% predicted ($r=-0.52$, $p<0.001$). Multivariable predictors are shown in Table 2.

Table 2. Multivariable Regression: Predictors of Moderate-Severe Airflow Obstruction (FEV1 <60% Predicted) (n=200)

Variable	Unadj. OR (95% CI)	p	Adj. OR (95% CI)	p
Smoking ≥20 pack-years	4.8 (2.2–10.4)	<0.001	3.6 (1.6–8.0)	0.002
Prior MDR-TB	3.6 (1.7–7.7)	0.001	2.8 (1.3–6.2)	0.009
≥2 TB episodes	3.2 (1.5–6.8)	0.003	2.4 (1.1–5.4)	0.030
Treatment delay >2 months	2.4 (1.2–4.8)	0.011	1.9 (0.9–3.9)	0.044
MDR-TB treatment >18 months	2.2 (1.0–4.8)	0.046	1.7 (0.7–3.9)	0.22
HRCT fibrosis	2.8 (1.4–5.6)	0.004	1.8 (0.9–3.8)	0.11

Table 3. 6MWT and SGRQ Scores by Spirometric Pattern (n=200)

Outcome Parameter	Normal (n=64)	Obstructive (n=56)	Restrictive (n=36)	Mixed (n=28)	Rad only (n=16)	p-value
Mean 6MWD, m (±SD)	452±62	338±84	362±78	296±92	418±68	<0.001
6MWT SpO2 nadir <90%, n (%)	2 (3.1%)	24 (42.9%)	8 (22.2%)	14 (50.0%)	2 (12.5%)	<0.001
SGRQ Total (mean ±SD)	18.4±10.8	46.8±14.6	38.2±13.4	58.4±14.2	22.6±11.2	<0.001
mMRC ≥2, n (%)	6 (9.4%)	38 (67.9%)	20 (55.6%)	24 (85.7%)	8 (50.0%)	<0.001
Hospitalisation past year, n (%)	4 (6.3%)	18 (32.1%)	12 (33.3%)	14 (50.0%)	4 (25.0%)	<0.001

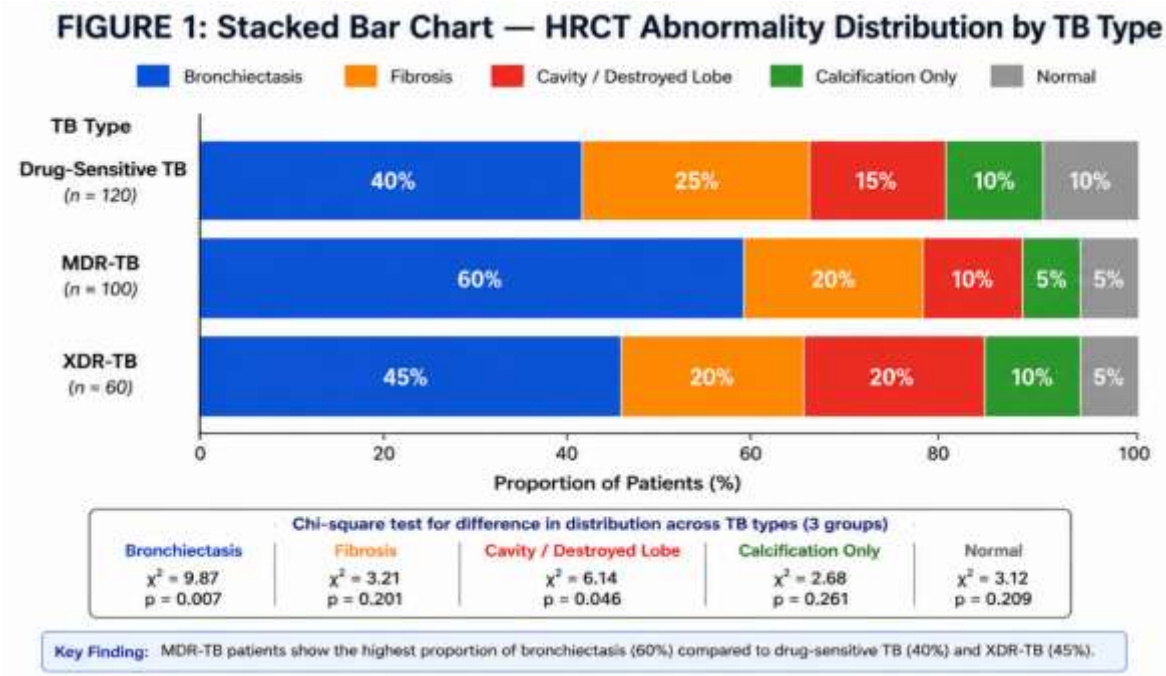

Figure 1. Distribution of HRCT chest abnormalities (bronchiectasis, pulmonary fibrosis, destroyed lobe, calcification, normal) across TB type groups (drug-sensitive, MDR-TB, XDR-TB) in TB survivors (n=200). Bronchiectasis is significantly more prevalent in MDR-TB survivors (60.0% vs 36.5% drug-sensitive; p=0.018).

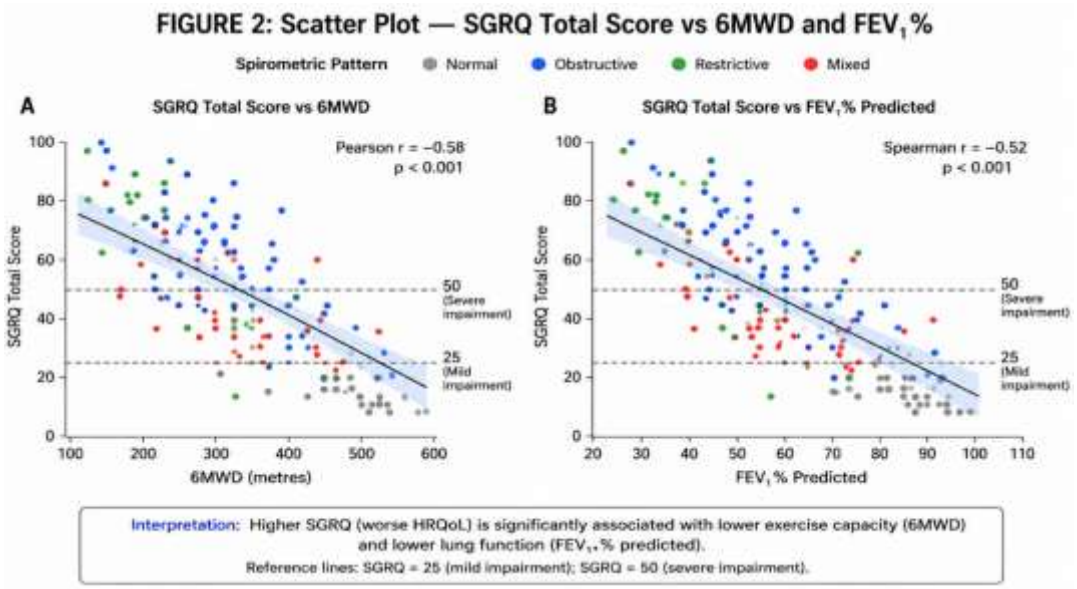

Figure 2. Scatter plots showing inverse correlations of SGRQ total score (health-related quality of life) with (A) 6-minute walk distance (r=−0.58, p<0.001) and (B) FEV1% predicted (r=−0.52, p<0.001) in TB survivors (n=200). Points colour-coded by spirometric pattern; mixed-pattern patients (red) cluster in the high SGRQ / low 6MWD / low FEV1% quadrant, reflecting the greatest QoL impairment.

4. DISCUSSION

This cross-sectional study of 200 TB survivors at a tertiary care hospital documents PTLD in 68.0% and bronchiectasis in 41.0% — among the highest published rates from India, though consistent with single-centre studies from academic medical centres receiving complex referrals. The King George's Medical University Lucknow prospective study (PMC 2023; n=132) documented post-TB bronchiectasis in 50% of TB survivors [9], and a systematic review of Indian cohort data by the European Respiratory Review 2024 reported an upper bound of 35.5% for post-TB bronchiectasis nationally [10]. The somewhat higher rate in our series likely reflects tertiary centre referral bias — patients with more severe or symptomatic disease are disproportionately referred — and the inclusion of a significant MDR/XDR-TB cohort (26%) in whom structural destruction is more profound.

The mixed spirometric pattern — present in 14.0% of our cohort — carried the worst quality-of-life profile (SGRQ 58.4±14.2, highest of all groups) and the lowest 6MWD (296±92 m), reflecting the compound functional disadvantage of simultaneous airflow obstruction and volume restriction. The pathological substrate of mixed disease — usually destroyed lung combined with bronchiectatic airways — represents the extreme end of a continuum of progressive structural damage that cannot be reversed by pharmacological intervention, highlighting the critical importance of preventing disease by early TB diagnosis, effective treatment, and avoidance of treatment interruption.

Prior MDR-TB emerged as a strong independent predictor of moderate-severe obstruction (aOR 2.8), reflecting both the greater treatment duration (extending drug-mediated pulmonary toxicity) and the more destructive inflammatory response of MDR-TB [11]. The finding that prolonged treatment delay (>2 months from symptom onset to treatment start; aOR 1.9) independently predicts obstruction reinforces the public health imperative for early case detection and treatment initiation — each additional month of uncontrolled mycobacterial replication and inflammatory tissue destruction incrementally worsens the structural outcome.

The mean SGRQ total score of 38.4±16.2 in the full cohort (and 58.4 in the mixed pattern group) represents clinically significant health-related QoL impairment — exceeding the MCID of 4 points above normal (score ~25) and approaching levels typically associated with severe COPD. This QoL burden is compounded by the fact that most PTLD patients are of working age (mean 42.8 years in this series), with substantial economic productivity loss and family burden implications in the Indian context.

The data provide direct evidence for operationalising the WHO 2023 Post-TB Lung Health Roadmap [8] within NTEP: specifically, spirometry at treatment completion and 6 months post-completion, with HRCT for patients with abnormal spirometry or exercise limitation, and structured pulmonary rehabilitation referral for SGRQ total >40 and/or 6MWD

<350 m. Inhaled bronchodilators for obstructive PTLD, antifibrotic consideration for rapidly progressive fibrosis, and management of bronchiectasis complications (airway clearance, macrolide prophylaxis for frequent exacerbators) represent evidence-based therapeutic approaches [12].

5. CONCLUSION

PTLD affects 68.0% of TB survivors at this tertiary care hospital, with bronchiectasis (41.0%), fibrosis (36.0%), and obstructive/mixed airflow patterns contributing to substantially impaired exercise capacity and quality of life. Prior MDR-TB, smoking, ≥2 TB episodes, and prolonged treatment delay are independent predictors of severe functional impairment. Systematic post-TB pulmonary follow-up, including spirometry, HRCT, and rehabilitative assessment, should be integrated into the national TB programme treatment completion pathway.

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