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Post-Tuberculosis Lung Disease: Chronic Morbidity, Quality of Life and Rehabilitation Strategies

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Abstract: Background: Successful completion of tuberculosis treatment is traditionally equated with cure. However, many survivors experience persistent respiratory symptoms, structural lung damage, impaired exercise capacity and reduced quality of life after microbiological cure. These sequelae are collectively described as post-tuberculosis lung disease (PTLD). **Objective:** This narrative review critically examines the burden, clinical spectrum, functional consequences and management of PTLD, with particular emphasis on quality of life, pulmonary rehabilitation and implications for high-burden countries such as India. **Key findings:** PTLD may involve the airways, parenchyma, pleura, pulmonary vasculature and respiratory muscles, producing obstructive, restrictive or mixed physiological impairment. Bronchiectasis, fibrosis, cavitation, chronic pulmonary aspergillosis and pulmonary hypertension are important complications. Systematic evidence indicates that a considerable proportion of pulmonary tuberculosis survivors have abnormal spirometry, with severe impairment in approximately 10%–15% in many cohorts. Persistent breathlessness, cough, fatigue, exercise intolerance, anxiety, stigma and loss of income substantially impair health-related quality of life. Clinical assessment at treatment completion should exclude recurrent or resistant tuberculosis and identify treatable complications. Pulmonary rehabilitation—comprising individualized exercise, education, breathing strategies, nutritional assessment, psychological support and self-management—improves exercise capacity and quality of life, although current evidence is dominated by small, uncontrolled studies. **Conclusion:** PTLD should be recognized as a major component of the global tuberculosis burden. Tuberculosis programmes must extend their definition of successful treatment beyond bacteriological cure to include functional recovery, quality of life and long-term lung health.

Keywords: Post-tuberculosis lung disease; pulmonary rehabilitation; chronic respiratory disease; quality of life; tuberculosis survivors; India.

INTRODUCTION

Tuberculosis (TB) programmes have historically concentrated on diagnosis, treatment completion, microbiological cure and interruption of transmission. These objectives remain essential, yet they provide an incomplete account of recovery. A person may complete effective anti-tuberculosis treatment and remain free of viable *Mycobacterium tuberculosis*, while continuing to experience disabling cough, breathlessness, fatigue, recurrent respiratory infections or haemoptysis.

Post-tuberculosis lung disease is broadly defined as evidence of chronic respiratory abnormality, with or without symptoms, attributable at least partly to previous pulmonary tuberculosis.[1] The definition intentionally includes structural, physiological and symptomatic abnormalities because the clinical phenotype is heterogeneous. PTLD may resemble chronic obstructive pulmonary disease (COPD), bronchiectasis, interstitial or restrictive lung disease, but it is not synonymous with any one of these conditions.

The growing recognition of PTLD represents an important change in global TB policy. The World Health Organization's 2025 policy brief on integrated tuberculosis and lung health identifies post-TB morbidity as an important reason to connect TB services with chronic respiratory care.[2] This shift is especially relevant because millions of people complete TB treatment each year, including large numbers of young and working-age adults who may live for decades with residual disability.

PTLD is not a rare, unavoidable scar of severe disease. It is a spectrum ranging from minor radiographic abnormalities without functional limitation to extensive bilateral destruction, respiratory failure and recurrent hospitalization. Earlier diagnosis and effective TB treatment may prevent some damage, but inflammatory injury can continue despite microbiological control. A public health response must therefore combine prevention, early identification, treatment of complications and long-term rehabilitation.

Pathogenesis and Clinical Spectrum

Pulmonary tuberculosis damages the lung through direct infection, immune-mediated inflammation, tissue necrosis and abnormal repair. Caseous destruction and cavitation may disrupt normal architecture, while healing can produce fibrosis, calcification, airway distortion and volume loss. Endobronchial involvement may cause bronchial stenosis, and destruction of elastic tissue can contribute to airflow obstruction.

The resulting abnormalities can involve several anatomical compartments. Airway disease includes bronchiectasis, small-airway obstruction and fixed stenosis. Parenchymal disease includes fibrosis, cavities, destroyed lung and restrictive impairment. Pleural involvement can produce thickening, adhesions or fibrothorax. Pulmonary vascular injury, hypoxic vasoconstriction and loss of vascular bed may contribute to pulmonary hypertension.

Persistent cavities can become colonized by *Aspergillus*, leading to aspergilloma or chronic pulmonary aspergillosis. Bronchiectatic airways predispose to bacterial infection, recurrent exacerbations and haemoptysis. In severe disease, reduced ventilation, gas-exchange abnormalities and respiratory-muscle deconditioning interact to produce chronic respiratory failure.

The pattern varies considerably between patients. Spirometry may show obstruction, restriction or mixed impairment. A systematic review and meta-analysis of 14,621 people found pooled estimates of obstructive, restrictive and mixed abnormalities after pulmonary tuberculosis, while approximately 10%–15% of survivors in many studies had severe lung impairment.[3] Interpretation is complicated by variable timing of assessment, smoking prevalence, HIV status, pre-existing lung disease and diagnostic definitions.

Drug-resistant tuberculosis, repeated TB episodes, delayed diagnosis, extensive cavitation, low body mass index and severe disease at presentation are commonly associated with worse post-treatment outcomes. However, clinically important impairment can occur after apparently uncomplicated drug-susceptible TB. Normal spirometry also does not exclude PTLD because bronchiectasis, gas-transfer impairment, exertional desaturation or severe symptoms may occur despite preserved routine lung volumes.

Burden and Epidemiological Uncertainty

The true burden of PTLD remains uncertain because it is not routinely recorded in national TB surveillance. Estimates of persistent respiratory impairment vary widely—from fewer than one-fifth to a majority of survivors—depending on whether the outcome is defined by symptoms, spirometry, imaging or clinician diagnosis.

Much of the available literature is facility based. Individuals with severe symptoms are more likely to attend specialist clinics, which can overestimate population prevalence. Conversely, people with limited access to care may remain undiagnosed, producing underestimation. Studies also differ in whether assessment occurs immediately after treatment or several years later.

The absence of pretreatment lung-function data creates another challenge. Smoking, biomass-fuel exposure, asthma, occupational dust and previous childhood infection may contribute to abnormalities attributed to TB. Nevertheless, longitudinal evidence and the strong relationship between radiographic disease severity and subsequent impairment support a causal role for pulmonary TB.

Survival after treatment is also worse than conventional programme outcomes imply. A systematic review and meta-analysis found that people successfully treated for TB had substantially higher long-term all-cause mortality than comparison populations, particularly during the first years after treatment.[4] Not all excess mortality is caused by PTLD: recurrent TB, HIV, cardiovascular disease,

malignancy, poverty and smoking also contribute. However, persistent respiratory disease is likely an important component.

Symptoms, Functional Limitation and Exacerbations

Breathlessness is among the most disabling symptoms. It may arise from airflow obstruction, restriction, pulmonary vascular disease, deconditioning, anaemia or anxiety. Chronic cough, sputum production, wheeze, chest discomfort and haemoptysis are also common.

Patients may experience episodic worsening resembling COPD or bronchiectasis exacerbations. These episodes can be caused by bacterial or viral infection, mucus retention, air pollution or fungal disease. Repeated empirical anti-tuberculosis treatment is a major concern in high-burden settings, particularly when old radiographic abnormalities and chronic symptoms are mistaken for recurrent TB without microbiological confirmation.

Every significant deterioration should therefore trigger a structured differential diagnosis. Recurrent or drug-resistant TB must be excluded, but clinicians should also consider bronchiectasis exacerbation, pneumonia, chronic pulmonary aspergillosis, malignancy, heart failure, pulmonary embolism and other chronic respiratory diseases. Unnecessary retreatment exposes patients to drug toxicity, delays the correct diagnosis and distorts surveillance data.

Haemoptysis ranges from blood-streaked sputum to life-threatening bleeding. Causes include bronchiectasis, fragile vessels around old cavities, aspergilloma, active TB and malignancy. Massive or recurrent haemoptysis requires urgent specialist assessment, computed-tomography angiography where available and possible bronchial-artery embolization or surgery.

Quality of Life and Social Consequences

PTLD affects much more than pulmonary physiology. Persistent symptoms limit walking, climbing, employment, household work, caregiving and participation in social life. Individuals who were declared "cured" may struggle to explain continuing disability to employers, relatives or health services.

Health-related quality of life is impaired across physical, emotional and social domains. Breathlessness creates fear of exertion, leading to inactivity and further deconditioning. Chronic cough and sputum may cause embarrassment, while haemoptysis can provoke fear of recurrence or death. Patients may continue to experience TB-related stigma even when they are no longer infectious.

Anxiety and depression can arise from prolonged illness, isolation, financial loss and uncertainty about recovery. Psychological distress can, in turn, intensify the perception of breathlessness and reduce adherence to exercise or medical care. Quality-of-life assessment should therefore form part of clinical evaluation rather than being treated as an optional research outcome.[5]

Economic effects may persist after treatment completion. Workers in agriculture, construction and other physically demanding occupations may be unable to resume previous employment. Repeated consultations and hospitalizations create additional out-of-pocket costs. A programme that records treatment success but ignores continuing loss of income substantially overstates recovery.

Assessment at Treatment Completion

The end of anti-tuberculosis treatment is a critical transition point. Clinical standards recommend that people completing treatment for pulmonary TB should be assessed for persistent symptoms and functional limitation and should receive further evaluation when abnormalities are identified.[1]

Assessment should include respiratory symptoms, exacerbations, exercise limitation, smoking, biomass and occupational exposure, nutritional status, mental health and socioeconomic consequences. Pulse oximetry at rest and during exertion may identify hypoxaemia. Spirometry is central where available, but results should be interpreted with symptom and imaging findings.

Chest radiography provides a useful baseline at treatment completion. Computed tomography is not required for every survivor, but it is valuable when bronchiectasis, cavities, fungal disease, unexplained haemoptysis or disproportionate symptoms are suspected. Six-minute walk testing can quantify functional limitation and exertional desaturation.

Sputum testing is indicated when cough, fever, weight loss or radiographic deterioration raises concern for recurrent TB. Microbiological confirmation should be pursued before retreatment whenever clinically feasible. Bacterial culture, fungal serology or sputum fungal testing may be necessary according to presentation and local resources.

A single end-of-treatment assessment will not identify every future complication. Patients need clear advice regarding warning symptoms and where to seek care. Those with moderate-to-severe impairment require planned follow-up rather than discharge into an undefined general health system.

Table 1. Clinical Manifestations and Management Priorities in Post-Tuberculosis Lung Disease

PTLD domain	Common manifestations	Recommended assessment	Management and rehabilitation priorities	Important cautions
Airflow obstruction	Breathlessness, wheeze, prolonged expiration and reduced FEV_1/FVC	Post-bronchodilator spirometry, exposure history and symptom assessment	Trial of bronchodilator when airflow obstruction or symptomatic benefit is demonstrated; smoking cessation and rehabilitation	PTLD obstruction should not automatically be labelled smoking-related COPD
Restrictive or fibrotic disease	Reduced lung volumes, exertional dyspnoea and dry cough	Spirometry, imaging, oximetry and gas-transfer testing where available	Exercise training, oxygen assessment, vaccination and specialist review for severe disease	Inhaled therapy is unlikely to reverse fixed fibrosis
Bronchiectasis	Productive cough, recurrent infection, haemoptysis and coarse crepitations	High-resolution CT, sputum culture and exacerbation history	Airway-clearance training, infection treatment, vaccination and haemoptysis planning	Long-term antibiotics require specialist selection and antimicrobial-stewardship safeguards
Residual cavities and aspergillosis	Chronic cough, weight loss, haemoptysis or fungal ball	CT imaging, *Aspergillus* IgG and microbiological assessment	Antifungal therapy or procedural management according to clinical syndrome	Symptoms can mimic recurrent TB; antifungal treatment is not indicated for incidental colonization alone
Pulmonary vascular disease	Disproportionate dyspnoea, syncope, oedema and low oxygen saturation	Echocardiography and specialist evaluation	Treat hypoxaemia and contributing lung disease; specialist pulmonary-hypertension care	Evidence for disease-specific vasodilators in PTLD is limited
Exercise intolerance and deconditioning	Fatigue, reduced walking distance and avoidance of activity	Six-minute walk test, muscle-strength and activity assessment	Aerobic and resistance training, pacing and home exercise	Exercise prescription should be individualized for hypoxaemia, cardiac disease and haemoptysis
Nutritional impairment	Low BMI, muscle loss and weakness	Weight, BMI, dietary history and food-security assessment	Protein- and energy-adequate diet, micronutrient correction where deficient and social support	Routine supplements should not replace assessment of food insecurity or comorbidity

Psychological and social morbidity	Anxiety, depression, stigma, unemployment and fear of relapse	Validated screening, social and occupational history	Counselling, peer support, social protection and vocational rehabilitation	Symptoms should not be attributed to anxiety before organic complications are assessed
Recurrent respiratory symptoms	Cough, fever, sputum or radiographic change	Molecular TB testing, cultures, imaging and differential diagnosis	Treat confirmed cause and maintain longitudinal review	Avoid empirical repeated TB treatment without adequate reassessment
Severe disease	Resting or exertional hypoxaemia, respiratory failure and frequent admissions	Blood gases, oxygen assessment and multidisciplinary review	Long-term oxygen when evidence-based criteria are met, advanced airway care and palliative support when appropriate	Oxygen should not be prescribed for breathlessness without documented hypoxaemia

Pharmacological and Clinical Management

No medicine reverses the full spectrum of PTLD. Treatment should target the identified physiological abnormality or complication rather than applying a generic COPD regimen to every survivor.

Patients with demonstrable airflow obstruction may benefit from inhaled bronchodilators, although direct PTLD trial evidence is limited. Inhaled corticosteroids should not be used routinely without a clear indication such as asthma, eosinophilic inflammation or selected COPD phenotypes. They may increase the risk of pneumonia and possibly mycobacterial infection.

Bronchiectasis care includes airway-clearance techniques, sputum-guided antibiotic treatment, vaccination and prompt management of exacerbations. Long-term macrolides can reduce exacerbations in selected non-cystic-fibrosis bronchiectasis populations but require exclusion of active mycobacterial infection, electrocardiographic and hearing assessment, and antimicrobial-stewardship oversight.

Chronic pulmonary aspergillosis requires prolonged antifungal therapy in appropriate patients, but diagnosis must distinguish active disease from a stable residual cavity or simple aspergilloma. Drug interactions, hepatotoxicity and access to therapeutic monitoring are important barriers.

Long-term oxygen therapy should be based on documented hypoxaemia rather than breathlessness alone. Vaccination against influenza, COVID-19 and pneumococcal disease should follow national recommendations and individual risk.

Pulmonary Rehabilitation

Pulmonary rehabilitation is a comprehensive intervention based on patient assessment, followed by individualized exercise, education and behavioural support. In PTLD, its goals are to improve exercise capacity, reduce symptoms, restore confidence and enable participation in daily life.

A typical programme includes aerobic training, lower- and upper-limb resistance exercises, breathing and airway-clearance strategies, education about symptoms and exacerbations, nutrition, smoking cessation and psychological support. Programmes should also address occupational goals and return to work.

Rehabilitation should not be defined narrowly as breathing exercises. Many patients have peripheral-muscle weakness and severe deconditioning that require progressive whole-body exercise. Inspiratory-muscle training may benefit selected individuals but is not a substitute for comprehensive rehabilitation.

The evidence is encouraging but methodologically limited. A 2026 systematic review and meta-analysis of 13 studies involving 747 participants found an average improvement of approximately 60 metres in six-minute walk distance and substantial improvement in St George's Respiratory Questionnaire scores. However, most included studies used uncontrolled pre–post designs, and certainty ranged from low to very low.[6] Improvements in spirometry were small and inconsistent, which is unsurprising because rehabilitation enhances conditioning and function more readily than it reverses structural damage.

An Indian multicentre pre–post study published in 2025 reported significant improvements in exercise capacity, symptoms and health-related quality of life after pulmonary rehabilitation.[7] This provides

important operational evidence across Indian clinical settings, but the absence of a control group means that regression to the mean, motivation and concurrent care cannot be excluded.
Community-based programmes led partly by trained TB survivors have recently shown feasibility in African settings. Peer delivery may reduce stigma, improve trust and extend specialist capacity. Home-based and telerehabilitation approaches may improve access, particularly in rural or mountainous areas, but require mechanisms to assess safety and maintain adherence.

Public Health Significance
PTLD challenges the conventional binary classification of TB outcomes as treatment success or failure. Microbiological cure is indispensable, but it is not equivalent to restoration of health.
The condition contributes to the global burden of chronic respiratory disease in populations where cigarette smoking may be relatively uncommon. If PTLD is misclassified as ordinary COPD, the causal importance of delayed TB diagnosis, poverty and structural lung destruction is obscured.
PTLD may also influence TB control. Patients with chronic cough repeatedly enter TB diagnostic pathways, increasing costs and anxiety. Conversely, assuming that symptoms are "old TB damage" can delay recognition of recurrent disease. Integrated respiratory and TB services can reduce both forms of diagnostic error.
Rehabilitation can produce benefits beyond respiratory health by improving mobility, mental well-being and capacity to work. These outcomes are central to universal health coverage because successful care should include protection from disability and financial hardship.

Indian Perspective
India has the world's largest number of notified TB cases and therefore a correspondingly large population at risk of post-treatment morbidity. Yet PTLD is not consistently measured within routine National Tuberculosis Elimination Programme outcomes.
Several features may increase the Indian burden: delayed diagnosis, extensive disease at presentation, undernutrition, indoor and outdoor air pollution, occupational dust, tobacco use, diabetes and repeated TB episodes. These exposures may interact rather than operate independently.
Current NTEP infrastructure offers an opportunity for systematic change. Treatment-completion visits could incorporate a brief symptom and functional screen. Patients with persistent breathlessness, chronic productive cough, recurrent haemoptysis or activity limitation could receive chest radiography, spirometry and referral according to a standardized pathway.
Ayushman Arogya Mandirs and district NCD clinics could support long-term follow-up, but frontline staff require training to distinguish PTLD from active TB, asthma, COPD and other respiratory illnesses. Rehabilitation could be delivered through district hospitals, medical colleges and community or home-based models involving physiotherapists, nurses and trained health workers.
India's 2025 multicentre rehabilitation study demonstrates domestic feasibility and provides a foundation for larger pragmatic trials.[7] Future implementation should determine the minimum effective programme, staffing needs, cost, patient selection and strategies for rural delivery.
Financial and occupational rehabilitation are equally important. Nutritional support that ends with anti-TB treatment may be inadequate for survivors who remain underweight or unable to work. PTLD should be considered in disability assessment and social-protection systems when functional limitation is substantial.

Recent Advances

The major recent advance is conceptual: TB is increasingly understood as a condition with a post-acute phase rather than an infection ending abruptly with the final dose of treatment. WHO's integrated TB and lung-health policy framework reflects this transition.[2]
Research is moving towards multimodal phenotyping using spirometry, computed tomography, exercise testing, inflammatory biomarkers and patient-reported outcomes. Such phenotyping may eventually identify patients most likely to benefit from bronchodilation, airway-clearance treatment or specific rehabilitation models.
Portable spirometers, pulse oximeters and digital six-minute walk tools could support decentralized assessment, but quality control remains critical. Artificial-intelligence interpretation of chest radiographs may help identify extensive residual abnormalities, although algorithms developed for active TB detection are not automatically valid for PTLD classification.

Low-cost community rehabilitation, peer-led groups and telerehabilitation are promising service innovations. Their effectiveness should be evaluated against patient-important outcomes, including daily activity, employment and hospitalization, rather than exercise-test improvement alone.

Challenges and Limitations

PTLD lacks a universally applied operational definition. Studies include different combinations of symptoms, imaging and lung-function impairment, making prevalence estimates difficult to compare.

There is no universally accepted core outcome set. Spirometry, six-minute walk distance, symptom scales and quality-of-life tools capture different domains. Researchers may report statistically significant changes without establishing whether they are clinically meaningful.

The rehabilitation evidence remains weak relative to COPD. Most studies are small, uncontrolled and conducted at specialist centres. Participants able to attend repeated sessions may be healthier, more motivated and financially better positioned than the wider PTLD population.

Clinical treatment is also frequently extrapolated from COPD or bronchiectasis guidelines. This is reasonable when physiological features overlap, but PTLD-specific benefits and risks require direct evaluation.

Finally, integrating post-TB care into TB programmes could increase workload and cost. However, ignoring chronic morbidity transfers costs to patients, families and general health services. Economic evaluations must include these displaced costs.

Future Directions

Countries should incorporate post-treatment health into TB surveillance. Minimum indicators could include persistent respiratory symptoms, activity limitation, spirometric abnormality, rehabilitation referral and quality of life.

Prospective cohorts should begin during TB treatment to identify modifiable predictors of later disease. Earlier diagnosis, host-directed therapies, optimized nutrition and prevention of recurrent TB should be evaluated for their capacity to prevent PTLD.

Large randomized trials are needed to determine the effectiveness, duration and cost-effectiveness of pulmonary rehabilitation. Trials should compare centre-based, community, peer-led and digital models and include long-term follow-up.

Research should also evaluate bronchodilators, airway-clearance strategies, exacerbation prevention and management of pulmonary vascular disease specifically in PTLD populations.

India requires population-based burden estimates and pragmatic implementation research embedded within NTEP. A tiered model could use symptom screening at treatment completion, district-level spirometry and rehabilitation, and specialist referral for severe structural disease.

Most importantly, TB survivors should participate in programme design. Their priorities may include returning to work, reducing fatigue and regaining social confidence rather than improving a laboratory measurement.

CONCLUSION

Post-tuberculosis lung disease is a major but neglected cause of chronic morbidity. It includes airway, parenchymal, pleural and vascular abnormalities that may persist long after microbiological cure.

The consequences extend beyond lung function to exercise limitation, psychological distress, reduced quality of life, recurrent health-care use and loss of livelihood. Assessment at treatment completion should identify persistent symptoms, exclude recurrent TB and detect treatable complications.

Pulmonary rehabilitation is the most promising broadly applicable intervention. Available evidence indicates clinically meaningful improvements in exercise capacity and quality of life, but the certainty remains limited and stronger randomized evidence is required.

India has both a substantial need and an opportunity to lead. Incorporating post-TB assessment and rehabilitation into NTEP and comprehensive primary care would transform the meaning of treatment success from completion of medication to recovery of health and function.

The End TB agenda will remain incomplete if people survive tuberculosis only to live with preventable respiratory disability. Bacteriological cure should mark the beginning of recovery—not the end of care.

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