What Happens after Completion of TB Treatment?

Post-TB Lung Disease

24/OCT/2026

6th KATRD TB/NTM International Symposium

Jeongha Mok, Pusan National University Hospital

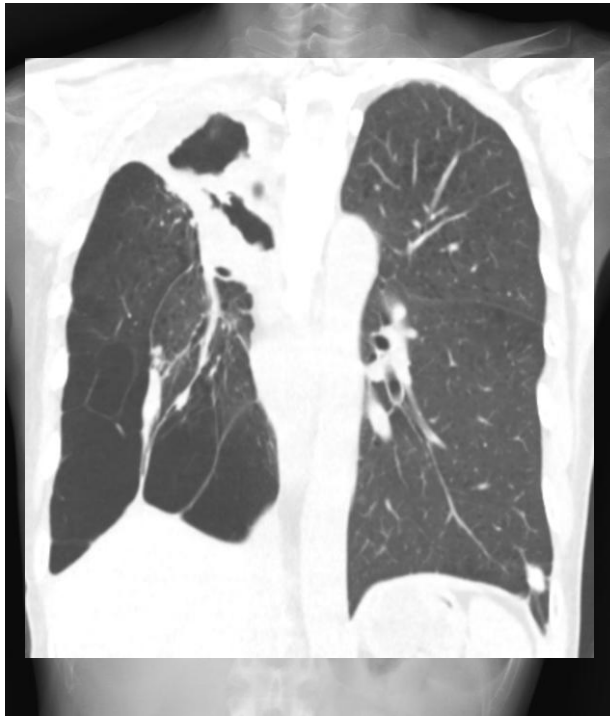
The End is NOT the End !!

45Y/F, DS-TB



May/2022

HR(ZE) for 6M
→ cure



Dec/2022

- Dyspnea (mMRC 3)
- Hemoptysis
- FEV1 = 58%
- FVC = 43%

Long-term oxygen
Bronchodilator
Itraconazole for CPA
Pulmonary rehab.

Estimated number of TB survivors

Estimated **155 million** TB survivors worldwide

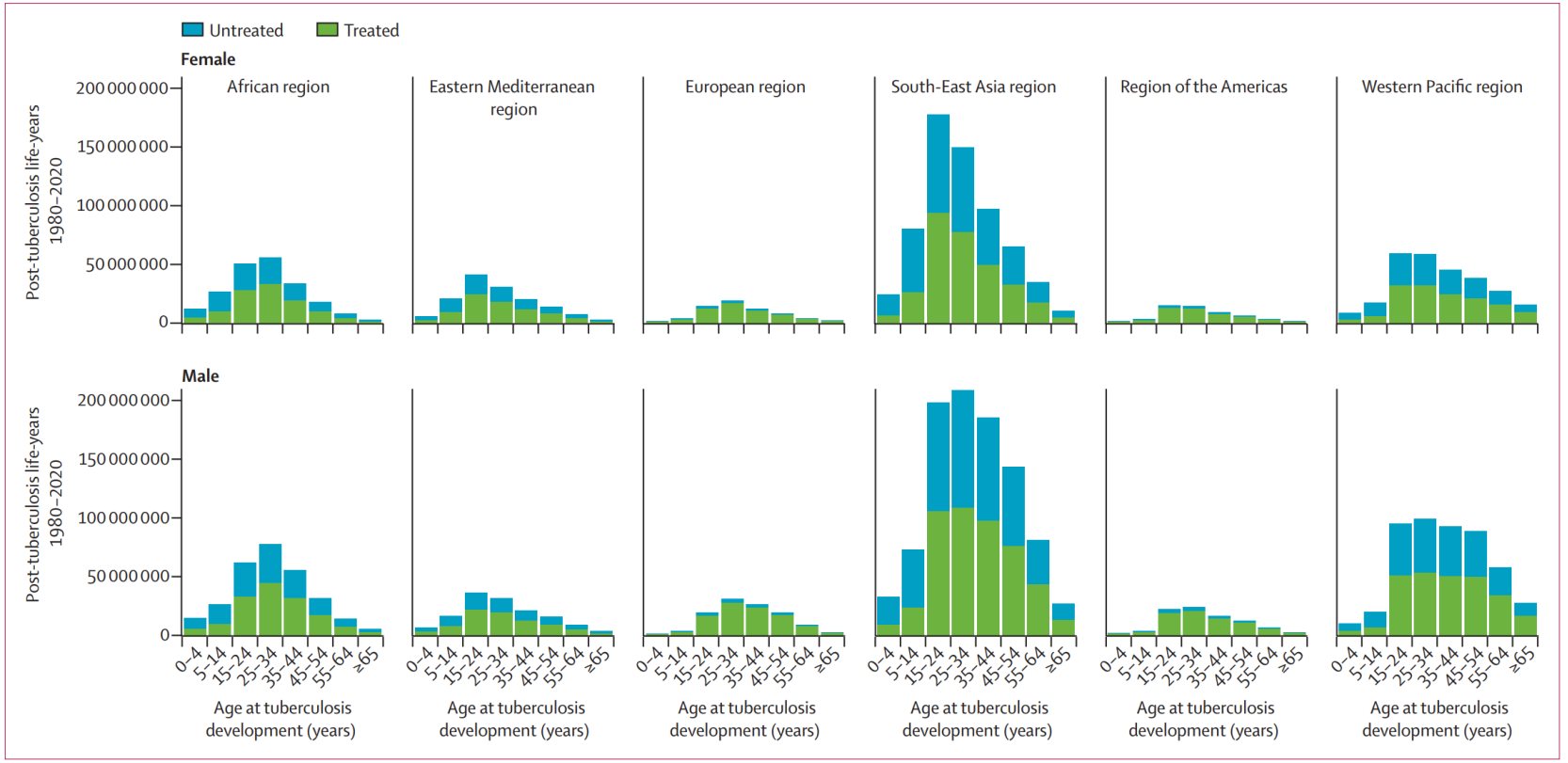


Figure 2: **Life-years lived after tuberculosis by age at first-episode tuberculosis, sex, WHO region, and tuberculosis treatment status, 1980–2020**

Lancet Infect Dis. 2021;21:984-92.

Definition of PTLD



"***Evidence of chronic respiratory abnormality,***

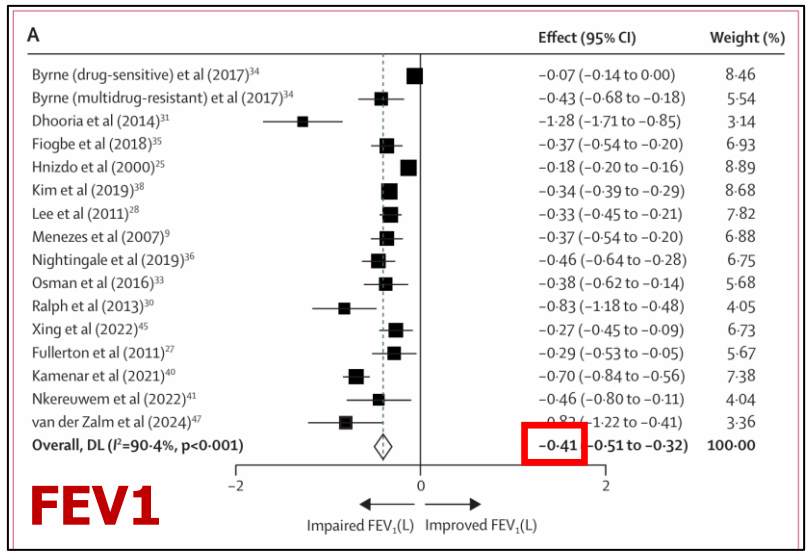
with or without symptoms,

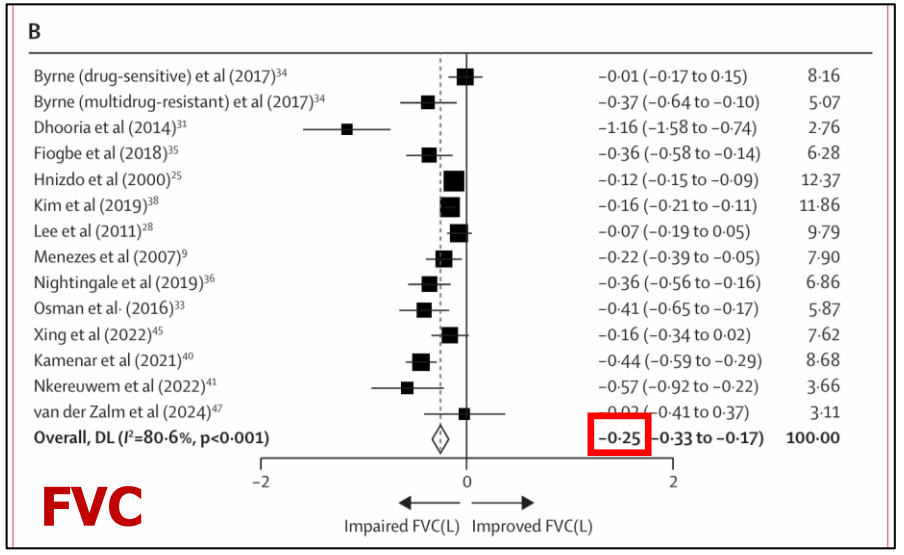
attributable at least in part to previous TB"

Int J Tuberc Lung Dis. 2020;24:820-8.

Lung function impairment after TB

Meta-analysis	Number of study populations	Proportion of participants (n/N)	Pooled estimate (95% CI)	Prediction intervals	I^2
All TB patients					
Abnormal	42	4082/9864	59.1% (48.8%–68.7%)	8.4%–95.8%	98.3%
Obstruction	41	1882/9803	17.8% (13.4%–23.1%)	2.5%–64.5%	96.6%
Restriction	35	1339/5822	21.3% (15.3%–28.9%)	2.3%–75.7%	95.4%
Mixed pattern	30	861/5095	12.7% (8.2%–19.2%)	1.0%–68.9%	93.2%
Controls					
Abnormal	4	794/21,804	5.4% (2.6%–10.8%)	0.2%–67.7%	97.4%
Obstruction	4	794/21,804	5.4% (2.6%–10.8%)	0.2%–67.7%	97.4%
Restriction/Mixed	0	–	–	–	–





EClinicalMedicine. 2023;59:101979.
Lancet Glob Health. 2025;13:e1020-9.

Malawian cohort

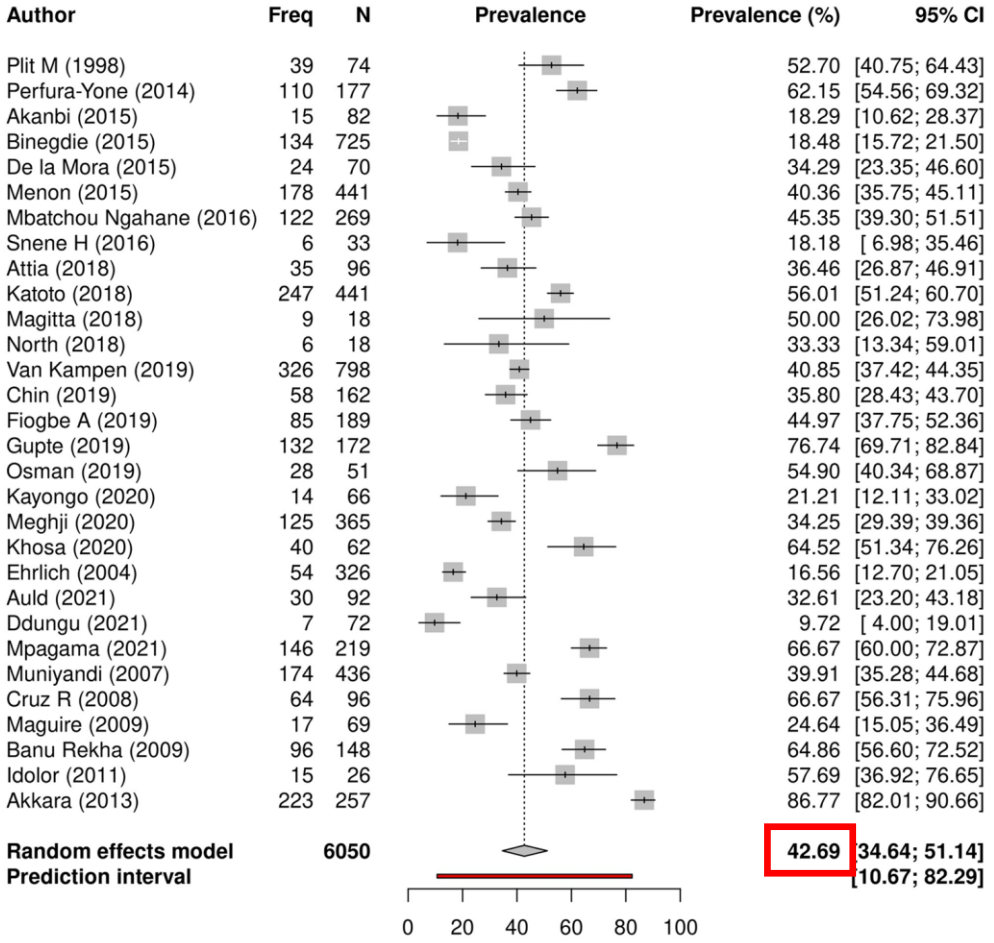
Prospective cohort study (n=405)

	At Tx completion	At 12-month visit
Any respiratory Sx, ≥ monthly	60.7%	30.7%
Spirometry, obstruction	14.2%	17.9%
Spirometry, restriction	20.0%	12.8%
Bronchiectasis ≥ 1 lobe	44.2%	
Lung destruction on HRCT ≥ 1 lobe	9.4%	
Acute respiratory event ≥ 1		16.3%
Symptoms affecting their ability to work		12.2%

Thorax. 2020;75:269-78.

Estimated prevalence of PTLD

- Low- and middle-income countries
- One of 3 domains:
  Abnormal lung function (47%)
  → Persistent respiratory symptoms (41%)
  → Radiological abnormalities (65%)



PLOS Glob Public Health. 2022;2:e0000805.

Mortality among TB survivors

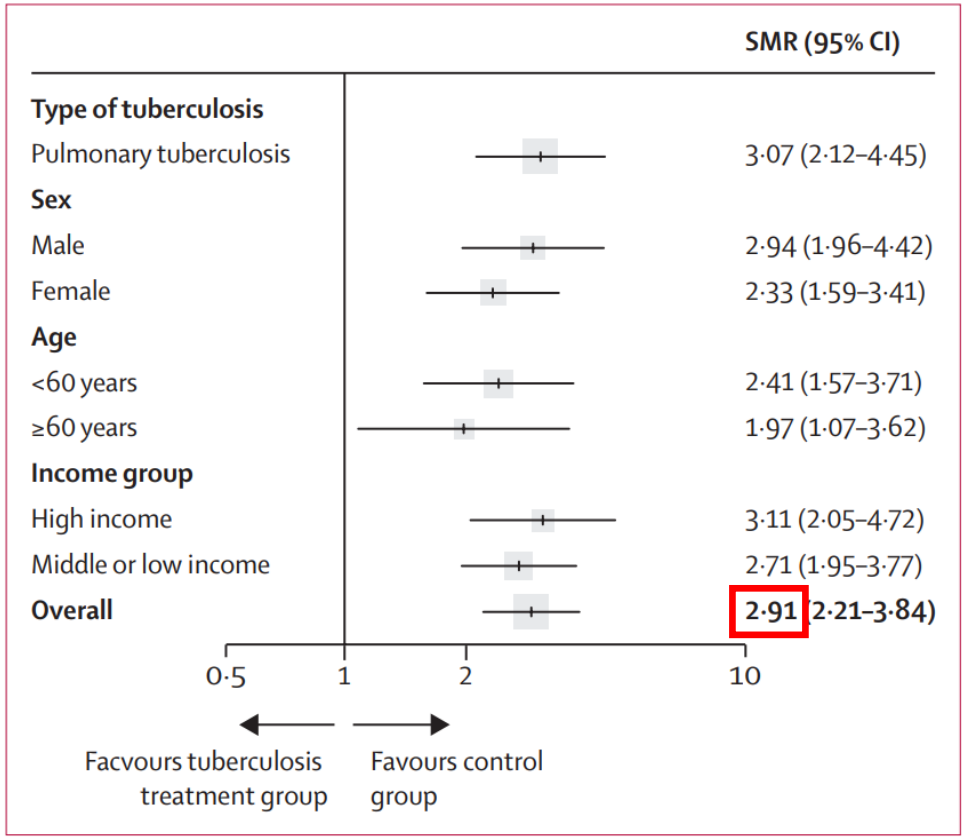


***Figure 3*: SMR estimates for subgroup analysis**
SMR=standardised mortality ratio.

Cardiovascular disease
> Cancer
> Respiratory disease
> Infectious disease
> Trauma

Lancet Infect Dis. 2019;19:1129-37.

Mortality among TB survivors (KOREA)

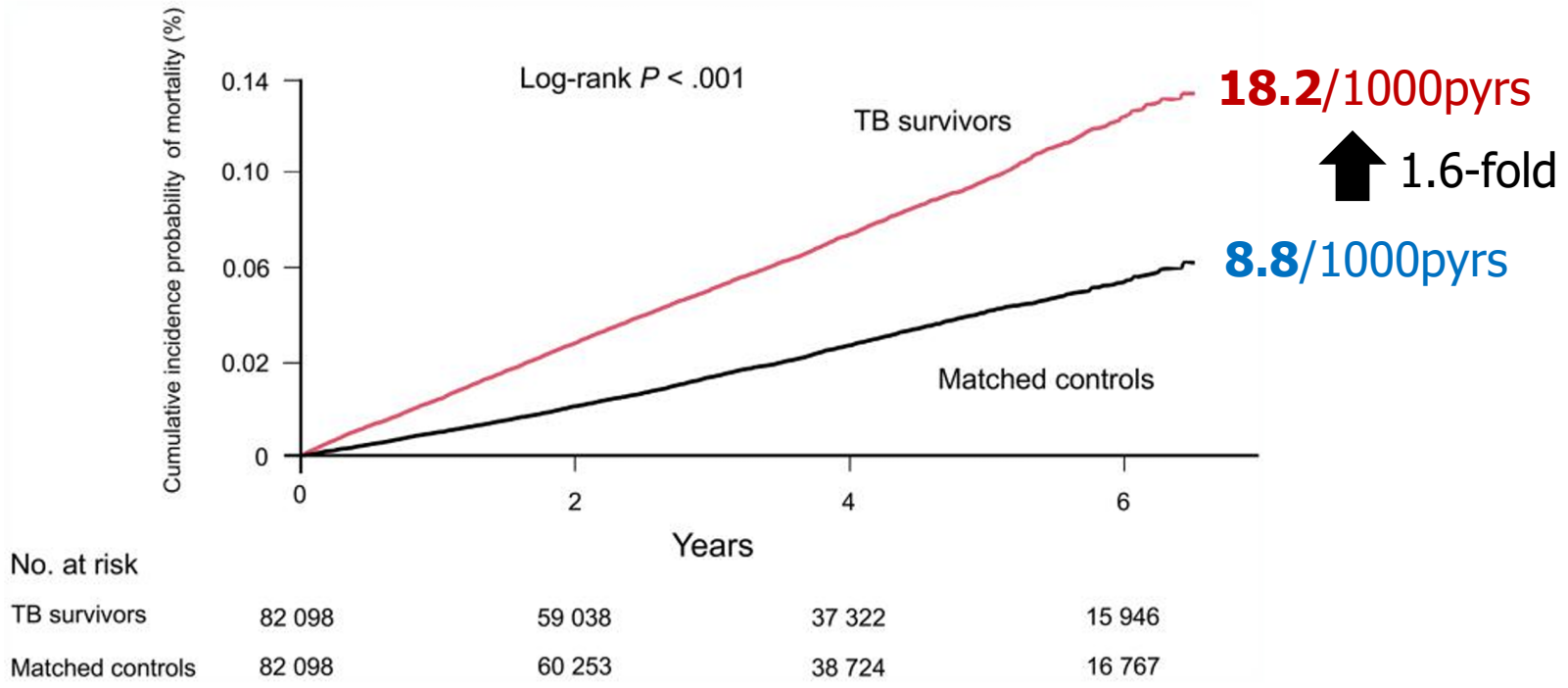
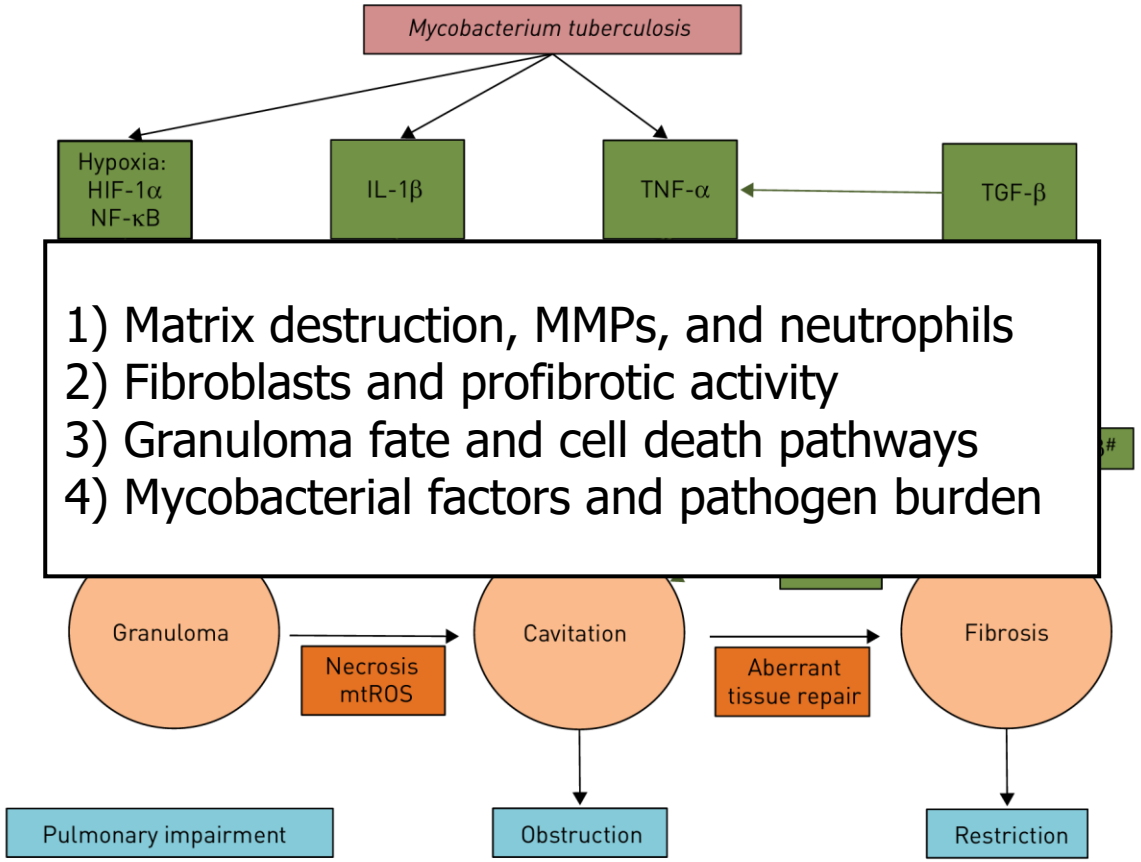


Figure 2. Cumulative incidence probability (%) of mortality in tuberculosis (TB) survivors versus matched controls. Year 0 indicates 1 year after TB diagnosis in TB survivors and 1 year after the time of being matched in matched controls, respectively.

Clin Infect Dis. 2023;76:e973-1.

Pathophysiology of PTLD



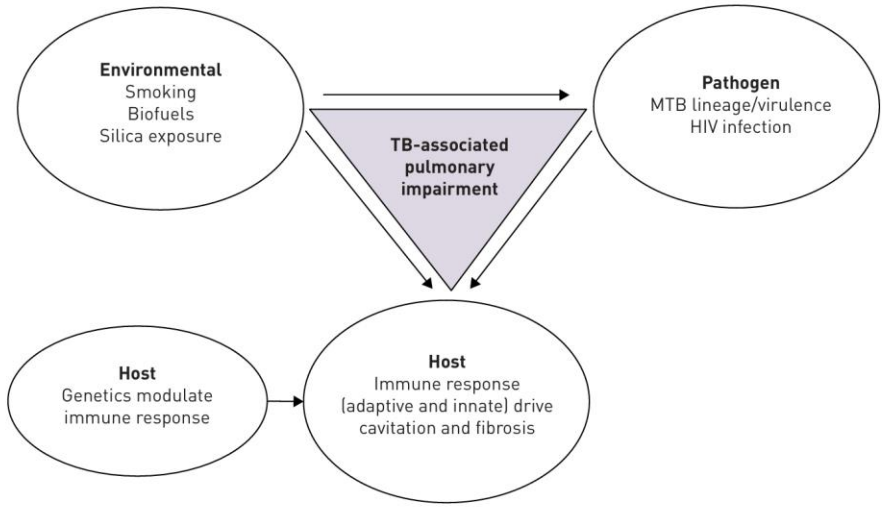
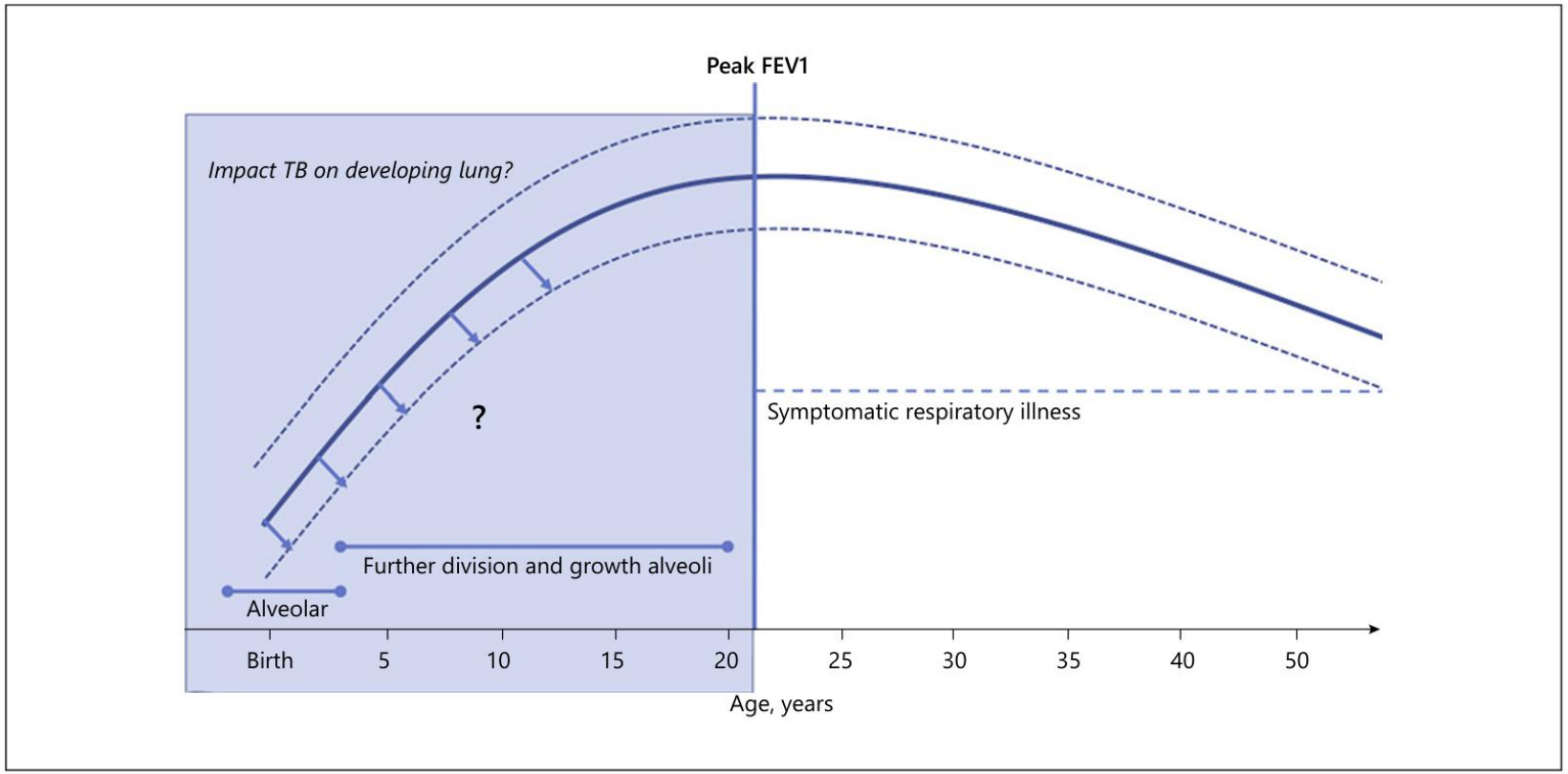


FIGURE 3 Conceptual model of factors that potentially contribute to lung impairment after tuberculosis (TB). MTB: *Mycobacterium tuberculosis*.

FIGURE 2 Immune mediators of tissue remodelling and lung function impairment in tuberculosis. Transcription factors, cytokines and chemokines that drive expression of tissue-degrading enzymes or directly mediate cavitation and/or fibrosis are shown in green. Matrix metalloproteinases (MMP) that promote granuloma and cavitation are depicted in purple. HIF: hypoxia inducible factor; NF: nuclear factor; IL: interleukin; TNF: tumour necrosis factor; TGF: transforming growth factor; IFN: interferon; mtROS: mitochondrial reactive oxygen species. #: IL-1β regulates fibrogenesis in idiopathic pulmonary fibrosis and may play a role in tuberculosis. Pathological processes contributing to the progression of lesions may influence the development of airflow obstruction and restrictive ventilatory patterns of pulmonary impairment.

Eur Respir Rev. 2018;27:170077.

Childhood PTLD and lung development



Respiration. 2021;100:751-63.

Clinical pattern of PTLD

Table 3 Suggested PTLD clinical patterns with preliminary definitions (all categories are assumed to meet basic PTLD minimum case definition)

Compartment	Clinical patterns	Suggested definition*
Airways	TB-associated obstructive lung disease / Stenosis	Airway obstruction (FEV_1/FVC ratio $<$ 0.7 OR $<$ LLN) thought to be primarily related to small airway disease
	Bronchiectasis	CT definition (evidence of airway dilatation) $>$ diameter of adjacent vessel, or non-tapering, OR CXR definition (evidence of ring and tramlines)
Parenchyma	Cavitation	A gas-filled space either within an area of pulmonary consolidation, or surrounded by a thin wall
	Parenchymal destruction	Extensive destruction of lung tissue, with a gas-filled space occupying the volume of $\geq$1 lobe
	Fibrotic change	Areas of parenchymal scarring, with associated volume loss
	Aspergillus-related lung disease	Evidence of aspergilloma on imaging OR chronic pulmonary aspergillosis on imaging and blood testing
Pleural	Chronic pleural disease	Evidence of pleural thickening on CXR or CT imaging
Pulmonary vascular	Pulmonary hypertension	Elevated pulmonary artery pressures as estimated using doppler echocardiography or measured at right heart catheterisation
Other	Other	Other pathology, not meeting the criteria above

* These definitions were not discussed at the Symposium, but are included as suggestions, and are expected to evolve as new data emerge.
PTLD = post-TB lung disease; TB = tuberculosis; FEV_1 = forced expiratory volume in 1 s; FVC = forced vital capacity; LLN = lower limit of normal; CT = computed tomography; CXR = chest X-ray.

Int J Tuberc Lung Dis. 2020;24:820-8.

Assessment of PTLD

(and Every 6-12M, if possible)

Table 1 Standard 1: Recommended examinations to be conducted at the end of treatment and in special settings and situations because of legal, organisational or economic reasons

	Essential and conditional examinations/investigations	Adaption for special settings and situations
Clinical assessment	• Clinical history, symptom assessment and clinical examination	• Clinical history, symptom assessment and clinical examination
Imaging	• Chest radiography (digital) • Computed tomography	• Chest radiography
Functional evaluation	• Spirometry, including pre- and post-bronchodilator test • Plethysmography • Diffusion capacity assessment (DLCO, KCO) • Tidal breathing techniques (oscillometry/MBW) • Arterial blood gas analysis, and pulse oximetry (SpO_2) • 6MWT • CPET	• Spirometry • SpO_2 • 6MWT
Subjective evaluation	• QoL questionnaire • Frequent symptoms score	• QoL questionnaire • Frequent symptoms score

DLCO = diffusing capacity of the lungs for carbon monoxide; KCO = carbon monoxide transfer coefficient; MBW = multiple breath washout; SpO_2 = peripheral capillary oxygen saturation; 6MWT = six-minute walking test; CPET = cardiopulmonary exercise testing; QoL = quality of life.

Cavitary TB - evaluation for TB relapse or other infections (NTM, CPA, etc)

Int J Tuberc Lung Dis. 2021;25:797-813.

Management and prevention

Early diagnosis and treatment	Active case finding / Monitoring of TB recurrence

Tracheobronchial stenosis	Bronchoscopic (balloon) dilatation, stent placement
Obstructive small airway disease	Bronchodilator (LABA, LAMA) / ICS only when indicated
Bronchiectasis	Sputum clearance techniques / Antibiotics for exacerbations
Hemoptysis	Tranexamic acid / Bronchial artery embolization / Surgical treatment
Chronic pulmonary aspergillosis	Azole therapy (e.g., itraconazole) / Surgical treatment

Pulmonary rehabilitation
Smoking cessation, nutritional support, vaccination (e.g., influenza, pneumococcus)

Modifying host immune response	Host-directed therapy

Chronic pulmonary aspergillosis

Uganda / Treated pulmonary TB (n=285)

TABLE 4 Frequency of chronic pulmonary aspergillosis (CPA)

	All patients	HIV-positive	HIV-negative	p-value
Subjects	285	135	150	
CCPA	10 (3.5 (1.8–6.1))	2 (1.5 (0.3–4.7))	8 (5.3 (2.6–9.8))	0.108
CFPA	3 (1.1 (0.3–2.8))	1 (0.7 (0.1–3.4))	2 (1.3 (0.3–4.2))	1
Simple aspergilloma	1 (0.4 (0–1.6))	1 (0.7 (0.1–3.4))	0 (0 (0–1.7))	0.474
All definite CPA	14 (4.9 (2.8–7.9))	4 (3.0 (1–6.9))	10 (6.7 (3.5–11.5))	0.177
Seronegative fungal ball	2 (0.7 (0.1–2.2))	1 (0.7 (0.1–3.4))	1 (0.7 (0.1–3.1))	1
Probable CPA in non-CT group	2 (0.7 (0.1–2.2))	2 (1.5 (0.3–4.7))	0 (0 (0–1.7))	0.223
All definite and probable CPA	18 (6.3 (3.9–9.6))	7 (5.2 (2.3–9.9))	11 (7.3 (4–12.3))	0.478



Eur Respir J. 2019;53:1801184.

Host-directed therapy

Author, Yr	N	Timing of interv.	Intervention	Dis-ability	Lung func-tion	Radio -logy	Bio marker	Histo-pathol ogy
Host directed therapy – other than corticosteroids and vitamin D								
Adewole (2023)*	150	During	Atorvastatin			CXR		
Cross (2023)*	150	During	Rosuvastatin	Sx	PFT	CXR		
Cross (2024)*	24	During	Rosuvastatin				TLG	
Dawson (2009)*	90	During	Recombinant Interferon gamma	Sx		CT		
Johnson (2003)*	110	During	Interleukin 2	Karnofsky		CXR		
Johnson (2000)*	120	During	M. vaccae			CXR		
Mily (2015)	288	During	Phenlybutyrate (without Vitamin D)	TB score		CXR		
Mily (2015)	288	During	Phenylbutyrate plus Vitamin D	TB score		CXR + TB score		
Miow (2021)	30	During	Doxycylin			CXR	MMP 1, 8,9	
Padmapriydarsini (2022)	322	During	Metformin			CXR	CRP, TNFα*	
Wallis (1996)	107	During	Pentoxyphylline	Sx				
Wallis (2004)*	16	During	Etanercept			CXR		
Wallis (2021)	200	During	CC 11050, Everolimus		PFT			
Wallis (2022)	200	During	Everolimus			PET CT	TLG	
Wallis (2024)*	140	During	N-Acytylcysteine		PFT			

Improvement
No effect
Worsened
No data

TABLE 1 | Host-directed therapies potentially inhibiting lung damage and/or promoting lung repair.

Host-directed inhibiting lung damage	Potential mechanism
Steroids	↓ INF-γ, TNF-α, IL-1β (and IL-6, IL-10, IL-12p40, and IP-10 in TB-IRIS)
	↓ MMP-7 (in TB-IRIS)
Doxycycline	↓ MMP-1, -3, and -9
Vitamin D	↓ MMP-7 and -9
	↓ IFN-γ, IL-6, IL-10, TNF-α
	↑ autophagy
Rapamycin, everolimus	↓ MMP-1 and -3
	↑ autophagy
NSAIDs	↓ PGE2[1] and ↑ LXA4
Zileuton	↓ 5-LOX
Phosphodiesterase-4 inhibitors	↓ TNF-α
	↓ neutrophil recruitment
Metformin	↓ TNF-α
	↑ autophagy
Statins	↑ autophagy
TNF-α blockers	↓ TNF-α
PGE2	↑ PGE2[1]
IFN-γ	↑ IFN-γ
Mesenchymal stromal cells	Control inflammation and mediate tissue repair

[1] *The effect of inhibiting or increasing PGE2 on lung damage could vary depending on the stage of the disease.*

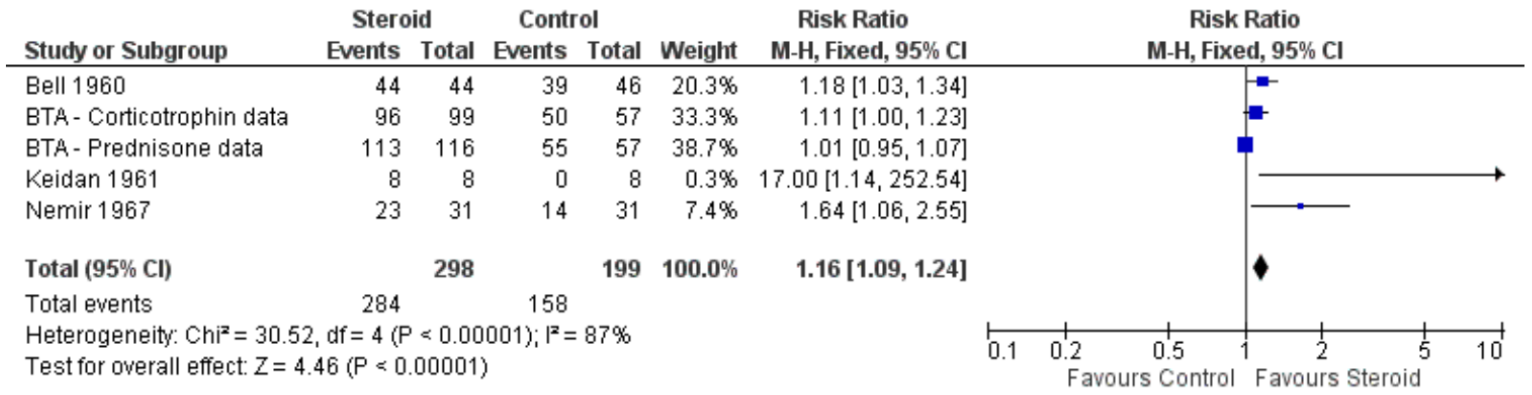
BMC Pulm Med. 2026;26:345.
Front Microbiol. 2018;9:2603.

Corticosteroids

Table 2 Outcome measures in literature studies involving patients with pulmonary tuberculosis receiving systemic corticosteroids*

Author and reference	No. of patients (controls)	Clinical time to defervescence	Weight gain	Serum albumin	ESR	Hospital stay	Microbiologic Sputum AFB count	Sputum conversion	Radiographic Parenchymal infiltrates	Cavity closure	Bacteriologic relapse
Weinstein & Koler[7]	51 (49)	—	—	—	—	|	—	|	|*	|*	—
Horne[8]	87 (91)	—	T	—	|	—	—	|†	|†	NS	—
Bell & Brown[9]	45 (46)	|§	NS	—	—	—	—	NS	NS	NS	—
Angel et al.[10]	54 (50)	|	|	—	—	—	—	SL	|¶	T	—
BTA[11]	227 (119)	|	|	—	|	—	—	NS	|#	NS	—
Marcus et al.,[13]	49 (51)	|	|	—	|	—	—	NS	|**	|††	—
USPHS[14]	851 (424)	—	—	—	—	—	—	NS	|‡‡	|§§	—
Johnson et al.[15]	2 (50)	|	|¶¶	—	—	NS	—	NS	|##	|***	NS†††; |‡‡‡
Malik & Martin[16]	46 (58)	—	|	—	—	—	—	|	|§§§	|¶¶¶	—
TRC, India[17]	261 (339)	—	—	—	—	—	—	NS	NS	NS	NS
Bilaceraglu et al.,[18]	91 (87)	|	|	|	—	|	|	NS	|‖	|###	—

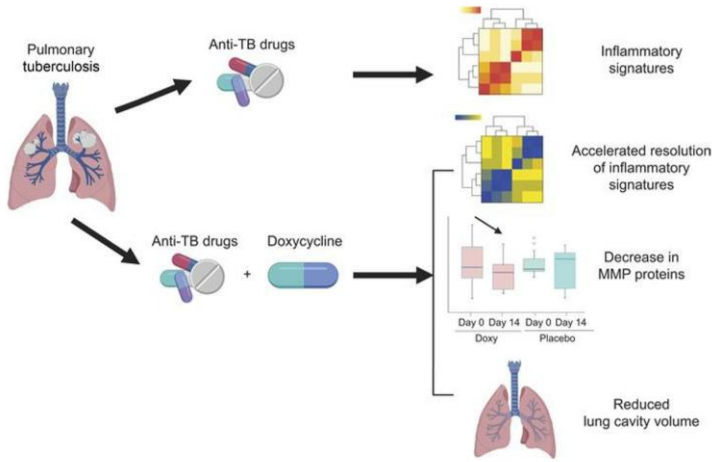
Figure 9. Forest plot of comparison: 1 Steroid therapy comparative to either no therapy or placebo, outcome: 1.6 Clinical Improvement at 1 month.



Int J Tuberc Lung Dis. 2003;7:208-13.
Cochrane Database Syst Rev. 2014;2014:CD011370.

Doxycycline

- Matrix metalloproteinase inhibitor
- doxycycline 100mg bid daily for 2weeks vs. placebo



Outcomes	Placebo (n = 13)	Doxycycline (n = 13)	Total (n = 26)	
Clinical outcomes				
Median BMI, day 14, kg/m^2 (IQR)	22.2 (19.4–24.5)	20.6 (18.5–22.8)	20.8 (19.1–23.2)	0.31[A]
Median BMI, day 28, kg/m^2 (IQR)	22.0 (20.1–24.3)	21.1 (19.1–22.8)	21.3 (20.0–23.5)	0.34[A]
Median BMI, day 56, kg/m^2 (IQR)	22.3 (20.2–24.2)	21.5 (19.3–23.2)	21.9 (20.1–23.8)	0.36[A]
Radiological outcomes				
Median CXR score, day 14 (IQR)	2.5 (1.0–4.5)	2.5 (1.3–4.5)	2.5 (1.0–4.5)	0.87[A]
Median CXR score, day 56 (IQR)	2.0 (1.0–3.0)	1.5 (1.0–3.0)	2.0 (1.0–3.0)	0.73[A]
Cavities resolved, day 56 (%)	2 (22%)[E]	4 (57%)[F]	6 (38%)	0.30[C]
Microbiological outcomes				
Median *Mtb* CFU/mL at day 14 (IQR)	100 (0–1063)	25 (0–125)	38 (0–513)	0.32[A]
TB culture positive at second month (%)	2 (15%)	1 (8%)	3 (12%)	1.00[C]

J Clin Invest. 2021;131:e141895.

N-acetyl cysteine

- Anti-oxidant and immunomodulatory agent
- NAC 1,200mg bid daily for 112days vs. placebo

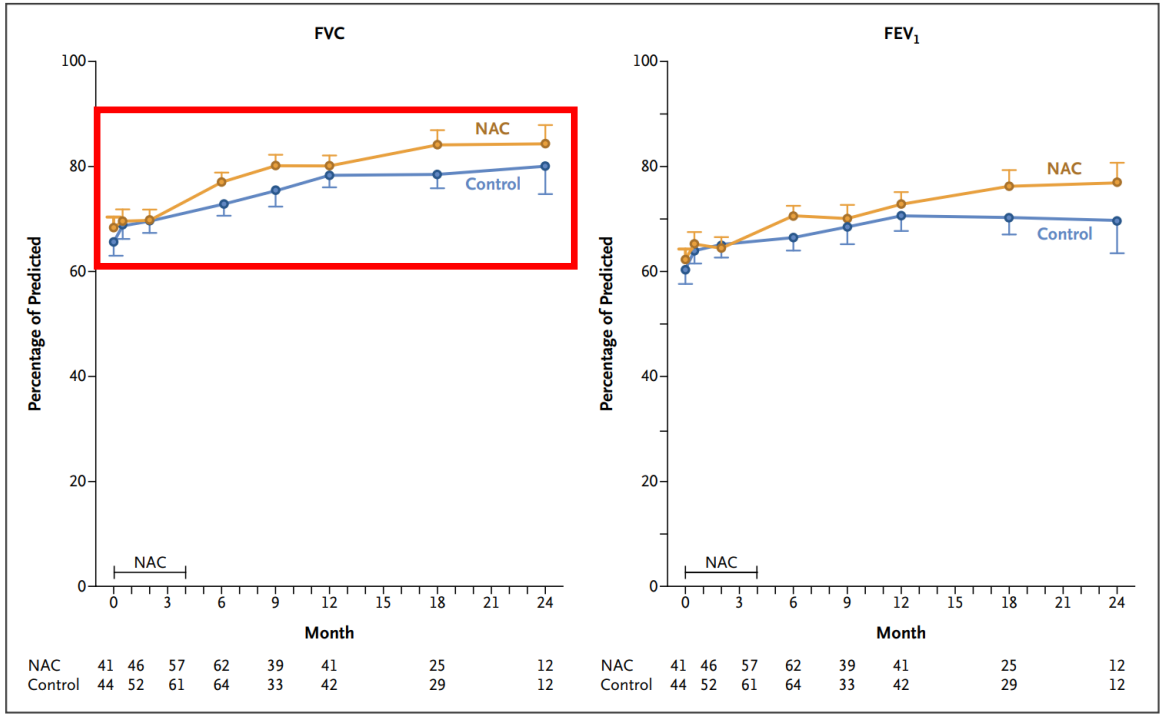
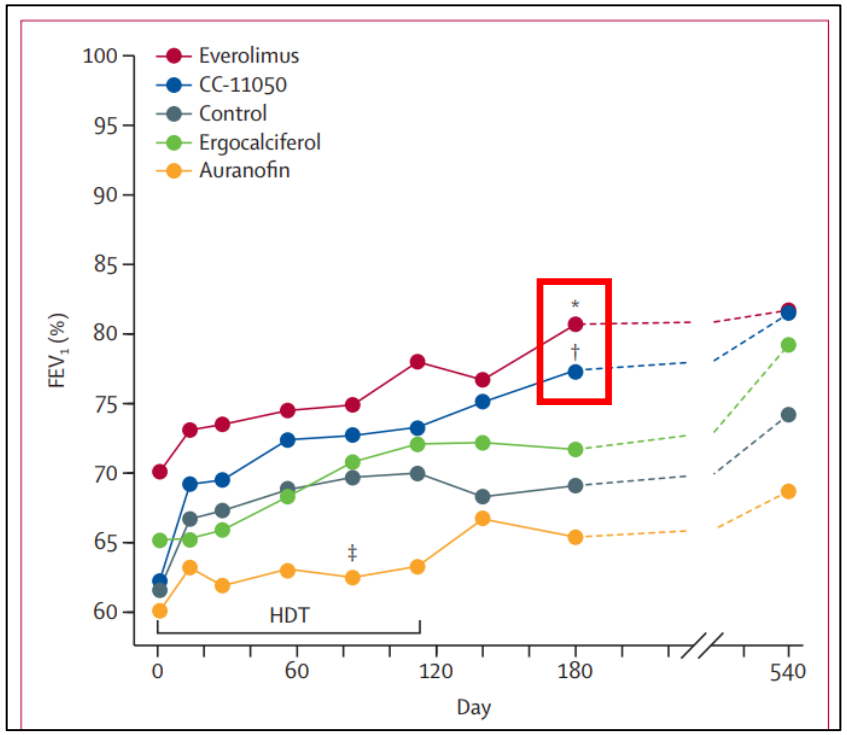


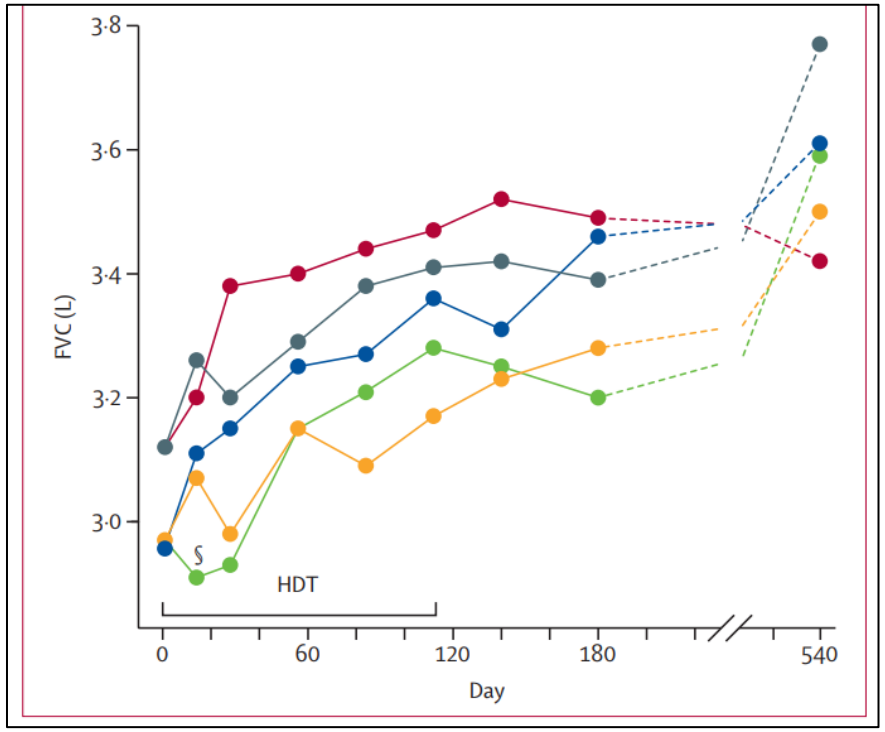
Figure 3. Mean Spirometry Values by Treatment Group in the Modified Intent-to-Treat Population.

NEJM Evid. 2024;3:EVIDoa2300332.

CC-11050 and everolimus

- CC-11050: anti inflammatory agent and type 4 phosphodiesterase inhibitor
- Everolimus: mTOR inhibitor

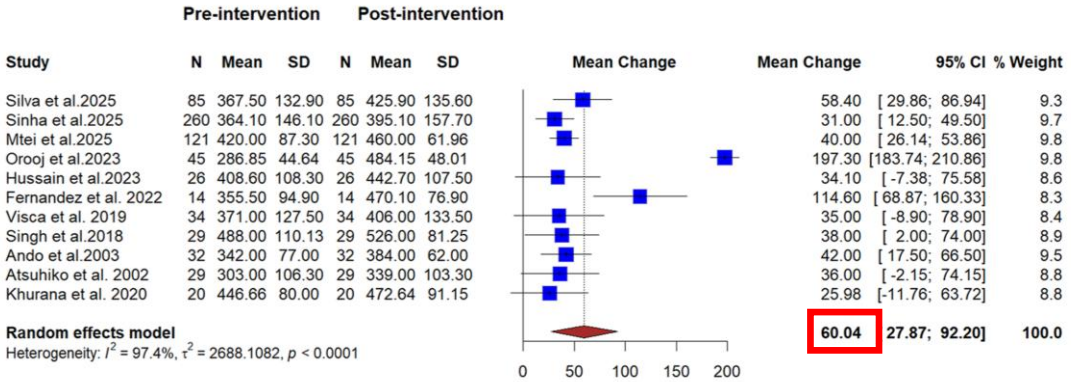




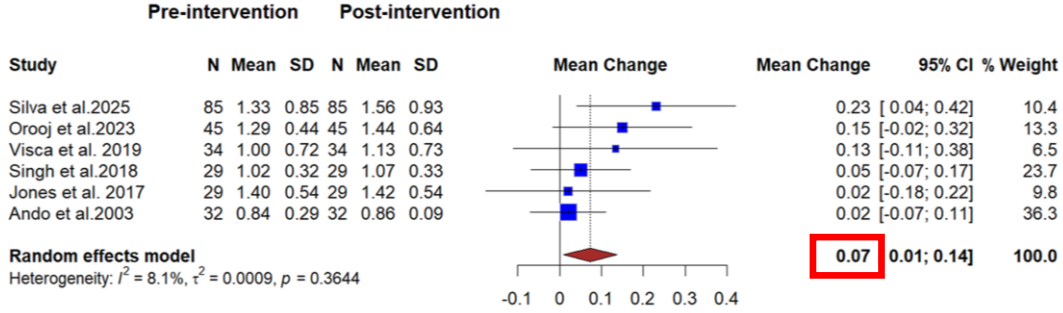
Lancet Respir Med. 2021;9:897-908.

Pulmonary rehabilitation

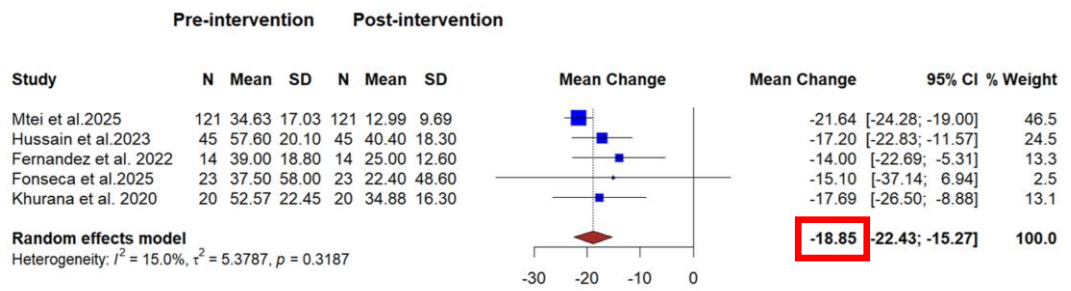
6MWD



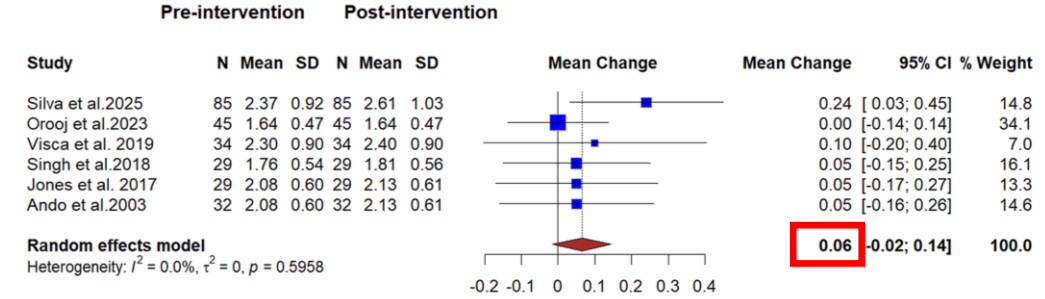
FEV1



SGRQ



FVC



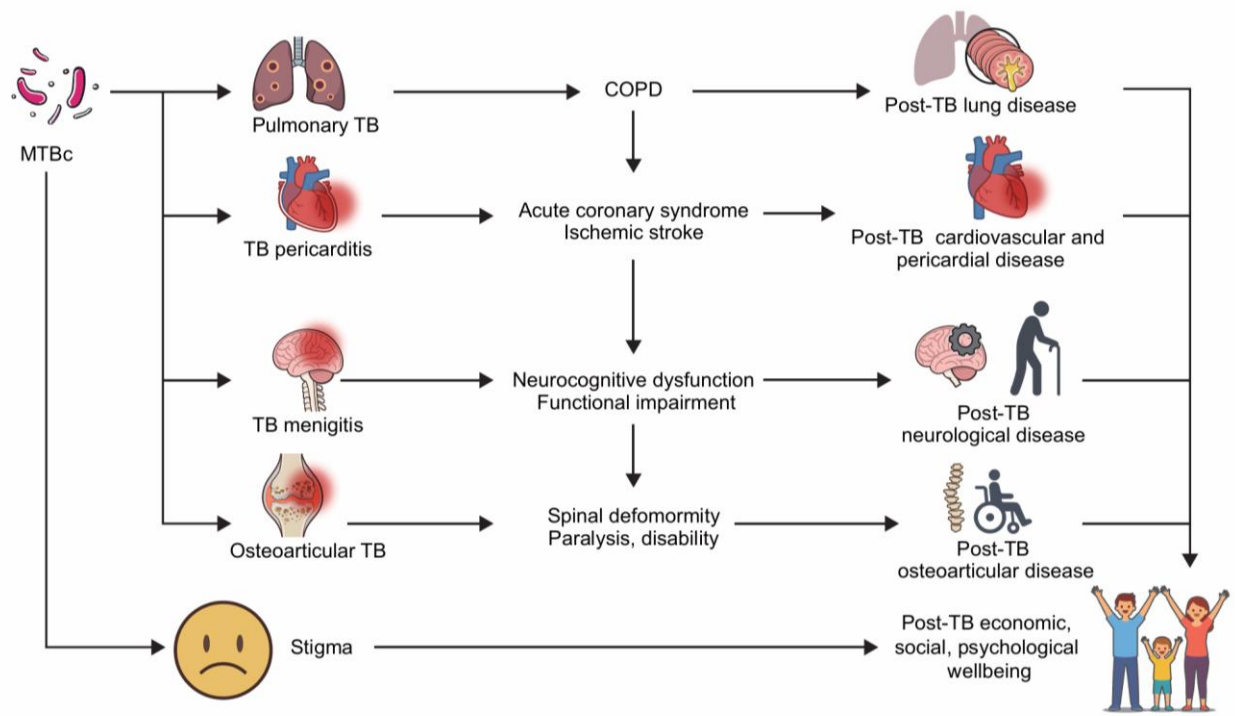
BMC Pulm Med. 2026;26:215.

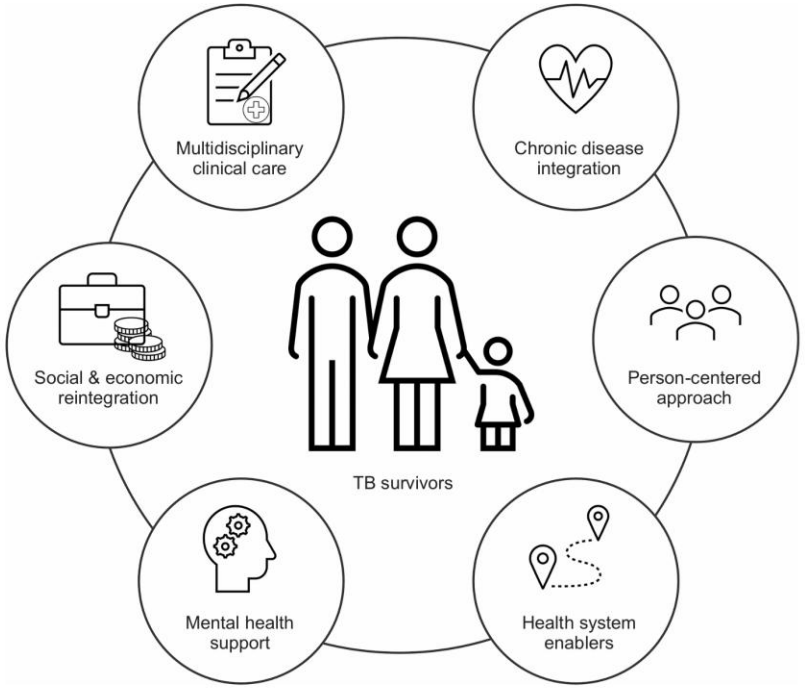
Core components of PR

Components	Examples
Aerobic exercise	Walking, treadmill, cycling
Strength training	Dumbbells, ankle weights
Inspiratory muscle training	Threshold loading devices
Airway clearance	Individualized sputum clearance techniques
Long term oxygen therapy	Supplemental oxygen when indicated
Long-term non-invasive ventilation	Nocturnal NIV when indicated
Nutritional support	Dietary advice, nutritional supplements
Psychological support	Counselling, self-help groups

Int J Tuberc Lung Dis. 2021;25:797-813.

Beyond the lungs

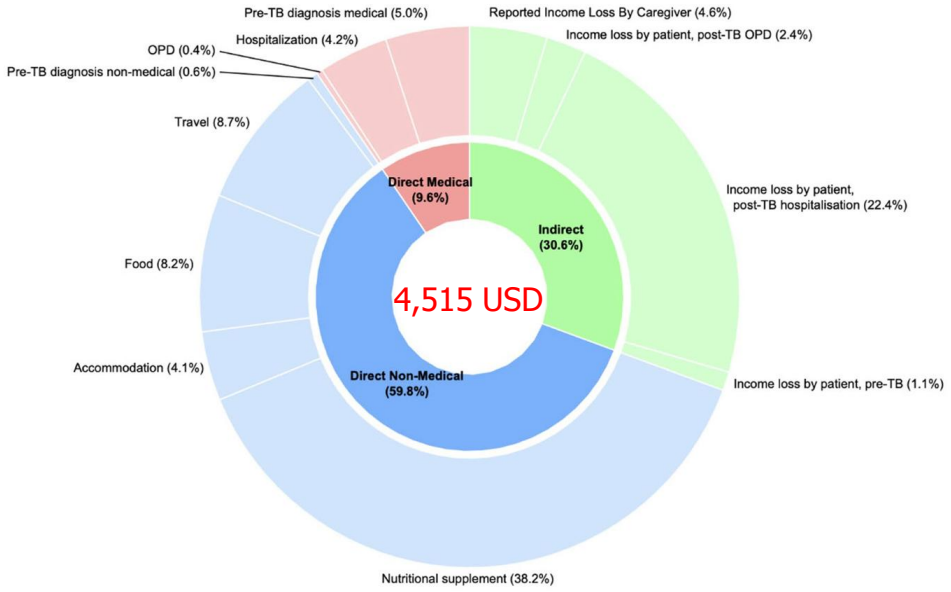




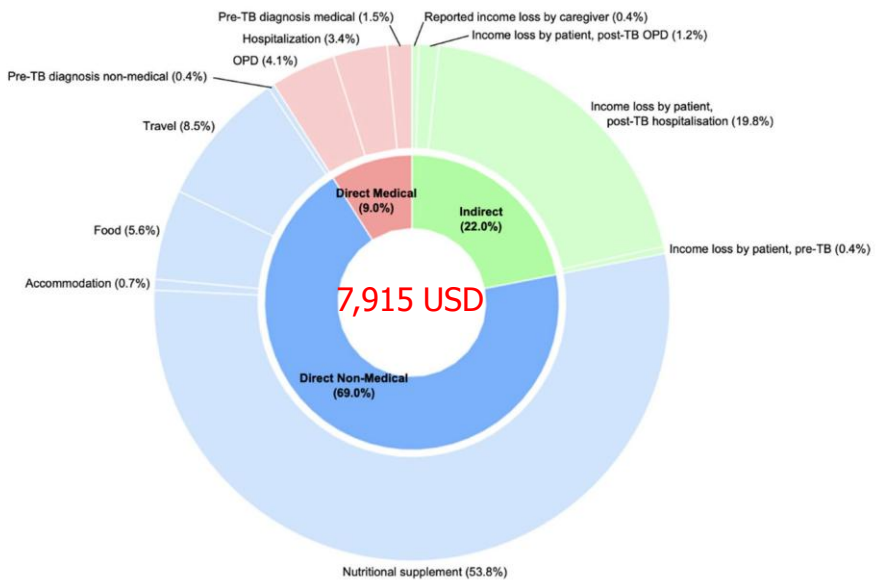
Tuberc Respir Dis (Seoul). 2026;89:202–14.

Catastrophic costs by TB in Korea

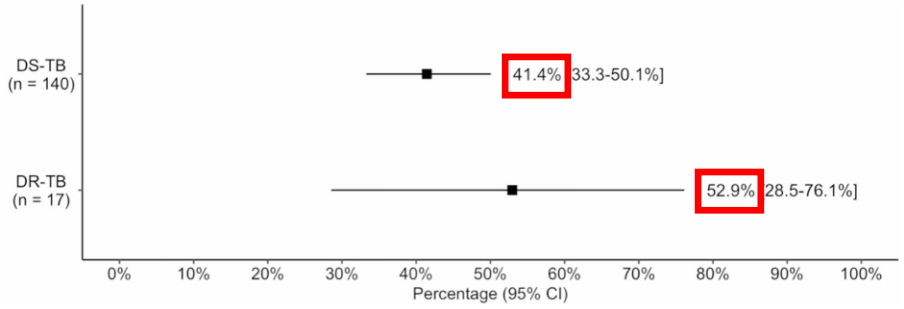
DS-TB



DR-TB



TB-affected households facing catastrophic costs (%)



BMC Public Health (article in press)

LIFE-TB study

Long-term Impacts on Lung Health and LiFE after TuBerculosis in Korea

- Nationwide, prospective, multicenter observational cohort study
- Study objectives
  - To assess PTLD prevalence
  - To identify factors associated with poor outcomes
  - To evaluate changes in lung function, quality of life, and healthcare use over time

Table 1. Timeline of data collection

	Baseline	Month 6	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Informed consent	•							
Anthropometric measurements	•	•	•	•	•	•	•	•
Medical history	•	•	•	•	•	•	•	•
Sputum study	•	•	•	•	•	•	•	•
Drug susceptibility test	•							
Chest imaging	•	•	•	•	•	•	•	•
Blood tests	•	•						
Serologic tests	•							
Urinalysis	•							
Electrocardiogram	•							
Spirometry		•	•	•	•	•	•	•
Quality of life questionnaire	•	•	•	•	•	•	•	•

4th International Post-Tuberculosis Symposium

일정: **2027-04-12 (월) ~ 2027-04-15 (목)**

장소: 서울대학교 관악캠퍼스 (서울 관악구 신림동)
호암교수회관 / 삼성컨벤션 센터

주제: Shaping a healthier future beyond TB

Early bird 등록: 2026-12-18

정규 등록 마감: 2027-04-02

초록 접수 마감: 2026-11-15

