COMSERVA: Jurnal Penelitian dan Pengabdian Masyarakat

E-ISSN: 2798-5210
Vol. 6, No. 5, September 2026
pp. 379-393
DOI: 10.59141/comserva.v6i4.3643

Prognostic Factors for Exacerbations and Hospitalization in Post-Tuberculosis Bronchiectasis: A Systematic Review

Henandwita Fadilla Pravitasari[1]*, Kezia Adya Nindita[2], Budi Prasetyo Nugroho[3]
Muhammadiyah Hospital Pamotan, Indonesia[1]
Bethesda Hospital Wonosari, Indonesia[2]
Pati Regional Public Health Center, Indonesia[3]
Email: henandwitafadilla28@gmail.com[1]*, keziaadya@gmail.com[2],
dr_airborne@yahoo.co.id[3]

Keywords:
post-tuberculosis bronchiectasis; prognostic factors; exacerbation; hospitalization; Bronchiectasis Severity Index.

ABSTRACT

Post-tuberculosis bronchiectasis is an important manifestation of post-tuberculosis lung disease and may lead to recurrent exacerbations and hospitalization. However, evidence regarding prognostic factors associated with these outcomes has not been systematically synthesized. This review evaluated prognostic factors and severity scores associated with subsequent exacerbations and hospitalization among adults with post-tuberculosis bronchiectasis. PubMed, Scopus, ScienceDirect, and ProQuest were searched from inception to 1 September 2026. Longitudinal studies evaluating baseline prognostic factors or validated severity scores for subsequent exacerbation, hospitalization, or readmission among adults with radiologically confirmed post-tuberculosis bronchiectasis were eligible for inclusion. Study selection, data extraction, and risk-of-bias assessment were independently conducted by reviewers. Risk of bias was assessed using the Quality In Prognosis Studies (QUIPS) tool. A random-effects meta-analysis was planned when at least two studies reported sufficiently comparable estimates.The searches identified 462 records. After removal of 128 duplicates, 334 records were screened, 37 reports underwent full-text eligibility assessment, and four independent studies comprising 500 participants were included. Two studies were available only in abstract form. Meta-analysis was not performed due to heterogeneity in prognostic factors, outcome definitions, follow-up durations, effect measures, and variance reporting. Evidence regarding prognostic factors in post-tuberculosis bronchiectasis remains limited and heterogeneous. The performance of the Bronchiectasis Severity Index (BSI) and FACED score varied substantially across cohorts, while reduced forced expiratory volume in one second (FEV_1) and Gram-negative bacterial isolation emerged as potential predictors of exacerbation based on findings from a single study. Prospective multicenter studies using standardized outcomes and comprehensive prognostic model reporting are required before reliable risk stratification can be implemented.

INTRODUCTION

Pulmonary tuberculosis (TB) remains a major global health threat, and despite successful microbiological cure, permanent structural lung damage often persists as a chronic sequela known as post-tuberculosis bronchiectasis (PTB) (Fong et al., 2022). Phenotypically, PTB represents a distinct clinical entity compared with bronchiectasis of idiopathic or other

infectious etiologies (Choi et al., 2021; Fong et al., 2022). Patients with PTB typically present with lower body mass index (BMI) (Choi et al., 2021; Fong et al., 2022), localized right upper lobe involvement,(Yang et al., 2023) impaired lung function characterized by a more pronounced decline in forced expiratory volume in one second (FEV_1), (Choi et al., 2021; Fong et al., 2022), and higher rates of hemoptysis (Yang et al., 2023). Furthermore, this population is prone to frequent airway colonization by opportunistic pathogens such as nontuberculous mycobacteria (NTM) and Pseudomonas aeruginosa, (Al-Harbi et al., 2020) which may further perpetuate a cycle of chronic bronchial inflammation and structural lung damage.

The primary clinical burden of PTB is the high frequency of acute exacerbations and subsequent hospitalizations, which significantly impair quality of life and increase healthcare utilization. (Al-Harbi et al., 2020; Choi et al., 2021). To systematically stratify disease severity and guide therapeutic decision-making, multidimensional severity scores such as the Bronchiectasis Severity Index (BSI) and the FACED score have been developed and validated. (Al-Harbi et al., 2020; Deshmukh et al., 2021) However, their predictive performance in the specific context of PTB remains inconsistent. Emerging evidence suggests that although these scoring systems may adequately predict mortality, their ability to predict subsequent readmissions or acute exacerbations is limited, with area under the receiver operating characteristic curve (AUC) values reported as low as 0.52. (Yang et al., 2023) The BSI has also been reported to underestimate 1-year and 4-year exacerbation rates in specific regional cohorts.(Deshmukh et al., 2021) Although modified scores, such as E-FACED and Exa-FACED, may provide marginal improvements in certain settings, their reliability remains limited across geographically diverse PTB populations (Meghji et al., 2016; Ou et al., 2026) .

This prognostic uncertainty is further complicated by a complex network of individual risk factors, including clinical, biological, and behavioral determinants. Recent prospective cohort studies have shown that severe outcomes in patients with PTB are strongly associated with advanced age (particularly $\geqslant$80 years), concurrent chronic pulmonary heart disease, and elevated systemic inflammatory markers, such as discharge interleukin-6 (IL-6) levels. (Xue et al., 2026) More importantly, behavioral factors, including post-discharge smoking, lack of physical activity, and particularly medication nonadherence, which has been identified as the most critical risk factor with an odds ratio (OR) of 8.394, are strongly associated with poor prognosis. Therefore, systematic reviews and meta-analyses are needed to synthesize available evidence, quantify the prognostic value of individual risk factors, and rigorously evaluate the performance of multidimensional severity scores to support personalized clinical management of PTB.

METHOD

Protocol and reporting

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement. The review protocol was prospectively registered in PROSPERO (CRD420261466995).

Eligibility criteria

Studies were eligible if they included adults with radiologically confirmed post-tuberculosis bronchiectasis and evaluated baseline clinical, physiological, microbiological,

radiological, or validated severity-score factors as predictors of subsequent exacerbation or hospitalization/readmission. Eligible outcomes were analyzed separately and included any exacerbation, frequent exacerbations, exacerbation rate, hospitalization, and hospital readmission. A prognostic factor was required to be measured before the outcome occurred.

Prospective and retrospective cohort studies were eligible. Full journal articles and conference or journal abstracts containing sufficient information to establish eligibility and extract relevant outcome data were considered. No language restrictions were applied. Studies were excluded if they were cross-sectional or purely descriptive, compared post-tuberculosis bronchiectasis with other bronchiectasis etiologies without examining within-group prognostic factors, lacked temporal separation between predictor and outcome, or reported only a composite outcome from which exacerbation or hospitalization data could not be separated.

Information sources and search strategy

PubMed, Scopus, ScienceDirect, and ProQuest were systematically searched from database inception to 1 September 2026. The search strategy combined controlled vocabulary and free-text terms related to tuberculosis, post-tuberculosis lung disease, bronchiectasis, prognostic factors, exacerbation, hospitalization, and readmission. The reference lists of eligible articles and relevant reviews were also manually searched to identify additional studies.

Study selection

All identified records were deduplicated before screening. Titles and abstracts were independently screened by two reviewers, followed by independent full-text assessment of potentially eligible reports. Disagreements were resolved through discussion and, when necessary, consultation with a third reviewer. The review team consisted of three reviewers Multiple reports originating from the same or overlapping study population were linked and treated as a single study, with the most complete report used as the primary source.

Data extraction

Data were independently extracted using a standardized extraction form. Extracted information included author, publication year, country, study design and setting, sample size, participant characteristics, definition of post-tuberculosis bronchiectasis, follow-up duration, candidate prognostic factors, outcome definitions, number of outcome events, statistical methods, and effect estimates with corresponding measures of uncertainty.

Adjusted estimates were prioritized over unadjusted estimates. Extracted measures included odds ratios, hazard ratios, risk ratios, regression coefficients, and measures of prognostic discrimination such as the area under the receiver operating characteristic curve. Information unavailable from the source report was recorded as not reported and was not imputed. Data derived solely from abstracts were explicitly identified as abstract-only evidence.

Risk-of-bias assessment

Risk of bias was independently assessed by two reviewers using the Quality In Prognosis Studies (QUIPS) tool. The following domains were evaluated: study participation, study attrition, prognostic-factor measurement, outcome measurement, adjustment for confounding, and statistical analysis and reporting. Each domain was judged as having low, moderate, or high risk of bias. Disagreements were resolved by consensus or consultation with the third reviewer.

Data synthesis

Study characteristics, prognostic factors, outcomes, and effect estimates were summarized in evidence tables. Exacerbation and hospitalization/readmission outcomes were synthesized separately. A random-effects meta-analysis was prespecified when at least two independent studies reported sufficiently comparable prognostic factors, outcome definitions, follow-up periods, and effect measures with adequate variance data. Effect estimates were not statistically pooled when substantial clinical or methodological heterogeneity, incompatible effect measures, or insufficient uncertainty data precluded a meaningful quantitative synthesis. In these circumstances, findings were synthesized narratively, with consideration of effect direction, magnitude, precision, study design, and risk of bias. Reports from overlapping populations were not double-counted.

RESULTS AND DISCUSSION

Study selection

The database searches identified 462 records, including 226 from PubMed, 158 from Scopus, 63 from ScienceDirect, and 15 from ProQuest. After the removal of 128 duplicate records, 334 unique records underwent title and abstract screening. Of these, 297 were excluded, leaving 37 reports for eligibility assessment. Following eligibility assessment, 33 reports were excluded: 13 included mixed populations without extractable post-tuberculosis bronchiectasis data, 16 did not specifically involve post-tuberculosis bronchiectasis, three used a cross-sectional design, and one was a laboratory or animal study (Chalmers et al., 2014; Migliori et al., 2021; Ravimohan et al., 2018) . Ultimately, four independent studies were included in the systematic review. Two were available as full-text publications, while two were included as abstract-only reports (Figure 1).

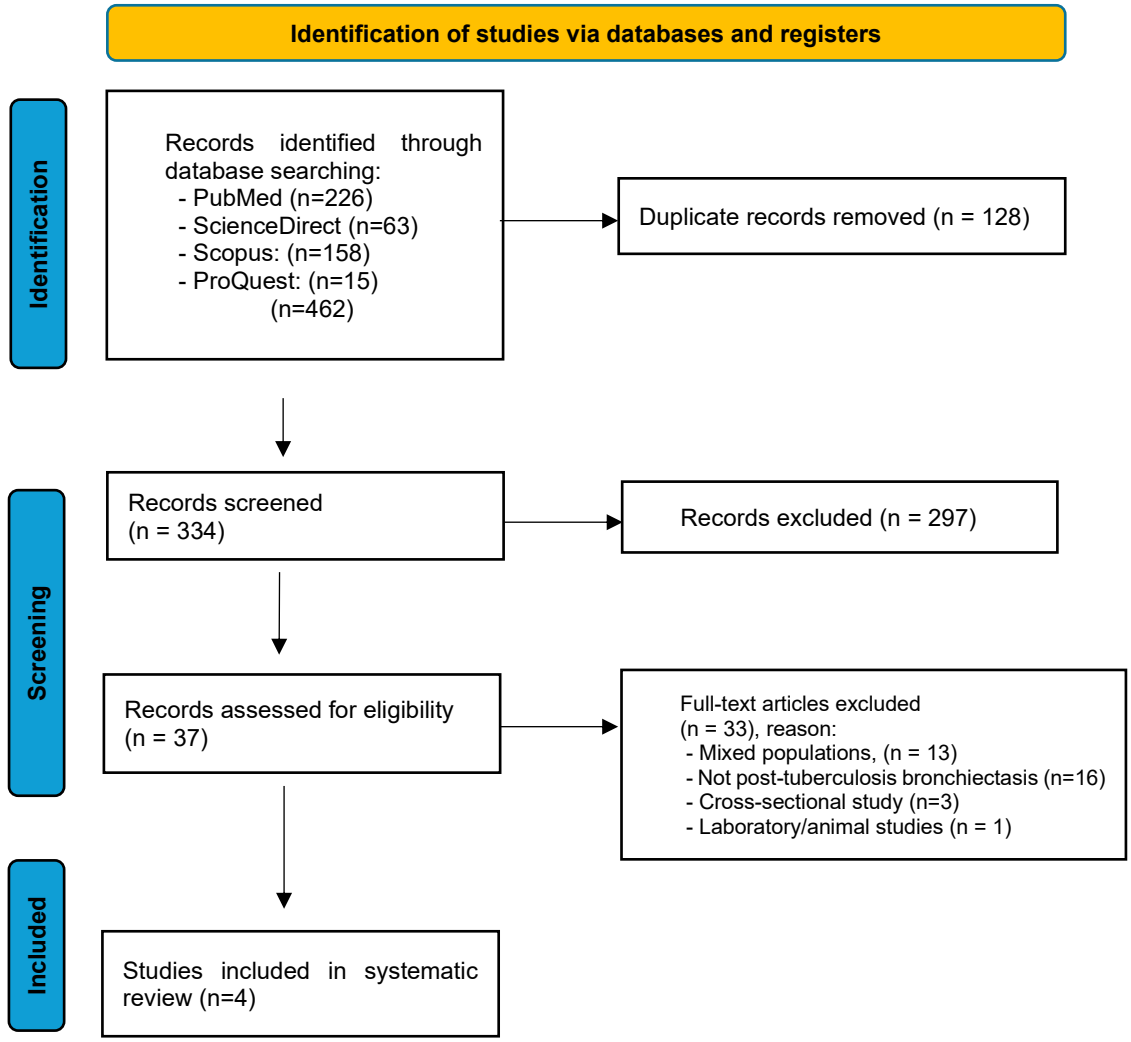

Figure 1. Study Selection Process with PRISMA Flow Diagram.

Study characteristics

The four included studies were published between 2018 and 2026 and comprised 500 participants with post-tuberculosis bronchiectasis. The studies were conducted in Saudi Arabia, China, India, and Taiwan, with sample sizes ranging from 48 to 222 participants. Study designs included prospective and retrospective observational cohorts, and follow-up durations ranged from 1 to 4 years (Chalmers et al., 2014; Dharmawangsa et al., 2023; Martínez-García et al., 2014) .

Al-Harbi et al.[4] included 129 patients and prospectively evaluated the ability of four bronchiectasis severity scores (BSI, FACED, Exa-FACED, and E-FACED) to predict hospitalization and frequent exacerbations during one year of follow-up. Wang et al.[3] retrospectively followed 101 patients for a median of 48 months and assessed the prognostic performance of BSI and FACED for readmission and frequent exacerbations. Deshmukh et al.[5] evaluated 48 patients over four years and examined whether BSI severity categories predicted subsequent exacerbation rates. Ou et al. analyzed registry data from 222 patients and investigated baseline predictors of exacerbation during one year of follow-up.[7]

Table 1. Characteristics of the included studies

Study	Country and setting	Design and study period	Post-TB sample	Participant characteristics	Follow-up	Prognostic factor(s)	Outcome(s)	Source availability
Al-Harbi et al., 2020 [4]	Saudi Arabia; King Abdulaziz Medical City, Riyadh	Prospective observational cohort and score-validation study; January 2010–December 2018	129	Mean age 68 ± 11 years; 79 (61%) female	Up to 1 year for exacerbation and hospitalization	BSI, FACED, Exa-FACED, and E-FACED	Frequent exacerbation (≥2/year); hospitalization for severe exacerbation	Full text
Wang et al., 2018 [3]	China; Shanghai Pulmonary Hospital	Retrospective follow-up cohort and score-validation study; enrolled January 2011–December 2012 and followed until March 2016	101	Mean age 56.8 ± 12.8 years; 54 (53.5%) female	Median 48 months (IQR 43–54)	BSI and FACED	Frequent exacerbation (>2/year); respiratory-related readmission	Full text
Deshmukh et al., 2021 [5]	India; tertiary respiratory hospital in North India	Retrospective observational cohort; recruitment period NR	48	Age and sex distribution NR	4 years; outcomes evaluated at 1 and 4 years	BSI severity category	Exacerbation rate; mortality was also evaluated but was outside the primary outcomes of this review	Abstract only
Ou et al., 2026 [7]	Taiwan; multicenter Taiwan Bronchiectasis Registry	Retrospective observational registry cohort; detailed recruitment period NR in the abstract	222	Age and sex distribution NR in the journal abstract	1 year, based on the linked conference report	FEV1 ≤60% predicted; positive Gram-negative bacilli sputum culture	At least one acute exacerbation	Abstract only

The four independent studies included 500 participants with post-tuberculosis bronchiectasis. The Chan and Ou 2025 conference abstract originated from the same Taiwan registry cohort as Ou et al. 2026 and was treated as a companion report rather than a separate study.

Abbreviations: BSI, Bronchiectasis Severity Index; FACED, FEV1, age, chronic colonization, extension, and dyspnea score; FEV1, forced expiratory volume in one second; IQR, interquartile range; NR, not reported; Post-TB, post-tuberculosis.

The prognostic factors evaluated across the included studies were heterogeneous and comprised multidimensional bronchiectasis severity scores, pulmonary function, and microbiological findings. Three studies assessed the prognostic performance of established severity scores, particularly BSI and FACED, whereas one study evaluated individual clinical and microbiological predictors. The extracted effect estimates and predictive-performance measures for exacerbation and hospitalization or readmission outcomes are summarized in Table 2.

Exacerbation outcomes

Three studies evaluated the performance of bronchiectasis severity scores for predicting exacerbation-related outcomes. In Al-Harbi et al.[4], 75 of 129 participants experienced at least two exacerbations during one year. BSI demonstrated excellent discrimination for frequent exacerbations, with an area under the receiver operating characteristic curve (AUC) of 0.97 (95% CI 0.92–0.99). The corresponding AUCs were 0.74 (95% CI 0.66–0.81) for FACED, 0.84 (95% CI 0.76–0.89) for Exa-FACED, and 0.82 (95% CI 0.75–0.88) for E-FACED.

In contrast, Wang et al.[3] reported limited discrimination of both BSI and FACED for frequent exacerbations, defined as more than two exacerbations per year. The AUC was 0.52 for both scores, and confidence intervals or other measures of uncertainty were not reported. The study reported 11 frequent exacerbators (11.8%), although the denominator used for this percentage could not be determined reliably from the available report.

Deshmukh et al.[5] classified participants as having mild (n=13), moderate (n=12), or severe (n=23) bronchiectasis according to BSI. The authors reported that BSI underestimated the observed exacerbation rates at both one and four years. However, exact observed and predicted rates and measures of uncertainty were unavailable from the accessible abstract; therefore, no quantitative effect estimate could be extracted (Hill, 2000) .

Ou et al.[7] reported that 54 of 222 participants (24%) experienced at least one exacerbation during one year. In multivariable analysis, an FEV1 of ≤60% predicted was associated with increased odds of exacerbation (adjusted odds ratio [aOR] 2.334, 95% CI 1.192–4.572). A positive baseline culture for Gram-negative bacteria was also independently associated with exacerbation (aOR 3.075, 95% CI 1.362–6.942).

Hospitalization and readmission outcomes

Two studies evaluated hospitalization or readmission. In Al-Harbi et al. [4], 67 of 129 participants were hospitalized during the one-year follow-up period. BSI showed excellent discrimination for hospitalization, with an AUC of 0.98 (95% CI 0.93–0.99). Discrimination was lower for FACED (AUC 0.74, 95% CI 0.65–0.81), Exa-FACED (AUC 0.81, 95% CI 0.74–0.88), and E-FACED (AUC 0.83, 95% CI 0.75–0.89).

Wang et al.[3] reported an AUC of 0.56 for both BSI and FACED in predicting readmission. Confidence intervals were not provided. The study reported 38 admissions (40.9%), but the exact denominator corresponding to this percentage was unclear.

Table 2. Extracted prognostic and predictive-performance results

Study	Outcome and follow-up	Prognostic factor or score	Effect measure	Estimate (95% CI)	Outcome frequency	Interpretation
Al-Harbi et al., 2020	Frequent exacerbation (≥2/year); 1 year	BSI	AUC	0.97 (0.92–0.99)	75/129 (58%)	Excellent discrimination
Al-Harbi et al., 2020	Frequent exacerbation (≥2/year); 1 year	FACED	AUC	0.74 (0.66–0.81)	75/129 (58%)	Moderate discrimination
Al-Harbi et al., 2020	Frequent exacerbation (≥2/year); 1 year	Exa-FACED	AUC	0.84 (0.76–0.89)	75/129 (58%)	Good discrimination
Al-Harbi et al., 2020	Frequent exacerbation (≥2/year); 1 year	E-FACED	AUC	0.82 (0.75–0.88)	75/129 (58%)	Good discrimination
Al-Harbi et al., 2020	Hospitalization for severe exacerbation; 1 year	BSI	AUC	0.98 (0.93–0.99)	67/129 (52%)	Excellent discrimination
Al-Harbi et al., 2020	Hospitalization for severe exacerbation; 1 year	FACED	AUC	0.74 (0.65–0.81)	67/129 (52%)	Moderate discrimination
Al-Harbi et al., 2020	Hospitalization for severe exacerbation; 1 year	Exa-FACED	AUC	0.81 (0.74–0.88)	67/129 (52%)	Good discrimination
Al-Harbi et al., 2020	Hospitalization for severe exacerbation; 1 year	E-FACED	AUC	0.83 (0.75–0.89)	67/129 (52%)	Good discrimination
Wang et al., 2018	Frequent exacerbation (>2/year); median 48 months	BSI	AUC	0.52 (CI NR)	11 events (11.8%); exact denominator unclear	Discrimination close to chance
Wang et al., 2018	Frequent exacerbation (>2/year); median 48 months	FACED	AUC	0.52 (CI NR)	11 events (11.8%); exact denominator unclear	Discrimination close to chance
Wang et al., 2018	Respiratory-related readmission; median 48 months	BSI	AUC	0.56 (CI NR)	38 events (40.9%); exact denominator unclear	Poor discrimination
Wang et al., 2018	Respiratory-related readmission; median 48 months	FACED	AUC	0.56 (CI NR)	38 events (40.9%); exact denominator unclear	Poor discrimination

Study	Outcome and follow-up	Prognostic factor or score	Effect measure	Estimate (95% CI)	Outcome frequency	Interpretation
Deshmukh et al., 2021	Exacerbation rate at 1 and 4 years	BSI severity category	Calibration comparison	Numeric estimate NR	Mild BSI: n=13; moderate: n=12; severe: n=23	BSI reportedly underestimated observed exacerbation rates; exact observed and predicted rates were not extractable from the abstract
Ou et al., 2026	At least one acute exacerbation; 1 year	FEV1 ≤60% predicted versus >60%	Adjusted OR	2.334 (1.192–4.572)	54/222 (24%)	Lower lung function was independently associated with increased exacerbation risk
Ou et al., 2026	At least one acute exacerbation; 1 year	Positive versus negative Gram-negative bacilli culture	Adjusted OR	3.075 (1.362–6.942)	54/222 (24%)	Positive culture was independently associated with increased exacerbation risk

Adjusted estimates were prioritized when available. The complete set of covariates included in the Ou et al. multivariable model was not reported in the abstract. Estimates from Wang et al. were not accompanied by confidence intervals or standard errors. Consequently, these values should not be assigned imputed variance.

Abbreviations: AE, acute exacerbation; AUC, area under the receiver operating characteristic curve; BSI, Bronchiectasis Severity Index; CI, confidence interval; FACED, FEV1, age, chronic colonization, extension, and dyspnea score; FEV1, forced expiratory volume in one second; NR, not reported; OR, odds ratio.

Risk of bias

Using the QUIPS tool, Al-Harbi et al. and Ou et al. were judged to have an overall moderate risk of bias, whereas Wang et al. and Deshmukh et al. were judged to have a high risk of bias. The principal concerns included limited adjustment for potential confounders, incomplete reporting of participant selection and attrition, unclear outcome denominators, and insufficient reporting of statistical precision. For the abstract-only studies, assessment of several QUIPS domains was constrained by the limited methodological information available. The risk-of-bias judgments for these studies should therefore be interpreted cautiously. Risk-of-bias assessment of the included studies can be seen in Table 3.

Table 3. Risk-of-bias assessment of the included studies using QUIPS

Study	Study participation	Study attrition	Prognostic-factor measurement	Outcome measurement	Study confounding	Statistical analysis and reporting	Overall judgment
Al-Harbi et al., 2020	Moderate	Moderate	Moderate	Low	Moderate	Moderate	**Moderate**
Wang et al., 2018	High	High	Moderate	Moderate	High	High	**High**
Deshmukh et al., 2021	Unclear	Unclear	Moderate	Unclear	High	High	**High**
Ou et al., 2026	Unclear	Unclear	Moderate	Moderate	Moderate	Moderate	**Moderate**

Judgments were made independently by the reviewers, with disagreements resolved by discussion and consensus. "Unclear" indicates insufficient information in the available report and does not necessarily indicate that the study methods were inadequate.
Abbreviation: QUIPS, Quality In Prognosis Studies.

Evidence synthesis

A quantitative meta-analysis was not performed because no prognostic factor–outcome combination was reported by at least two independent studies using sufficiently comparable outcome definitions, effect measures, and variance estimates. Outcomes varied across studies and included any exacerbation, frequent exacerbations, exacerbation rate, hospitalization, and readmission. The studies also differed in follow-up duration and reported prognostic performance using AUCs, adjusted odds ratios, or qualitative comparisons of observed and predicted event rates.

Narratively, the performance of BSI and FACED was inconsistent. Al-Harbi et al.[4] reported excellent discrimination of BSI for frequent exacerbations and hospitalization, whereas Wang et al.[3] found that both BSI and FACED performed only marginally better than chance. Deshmukh et al.[5] additionally suggested that BSI may underestimate longer-term exacerbation risk. Evidence from Ou et al.[7] indicated that impaired lung function and positive Gram-negative bacterial culture may independently predict subsequent exacerbation in patients with post-tuberculosis bronchiectasis. However, these predictors were reported by only one study, and the certainty and generalizability of the findings remain limited.

This systematic review identified only four independent studies evaluating prognostic factors for exacerbation or hospitalization specifically among patients with post-tuberculosis bronchiectasis. The principal findings were threefold. First, the predictive performance of established multidimensional bronchiectasis severity scores was inconsistent across populations. Second, reduced lung function and isolation of Gram-negative bacilli were identified as independent predictors of exacerbation in one registry cohort. Third, the marked heterogeneity in outcome definitions, follow-up periods, and reported measures of association prevented a meaningful quantitative meta-analysis.

The limited number of eligible studies contrasts with the substantial burden of structural lung disease among tuberculosis survivors. A systematic review of imaging-defined post-

tuberculosis lung disease reported bronchiectasis in approximately 35–86% of patients evaluated using computed tomography, although prevalence estimates varied considerably across populations and study methods.(Flume et al., 2018; McShane et al., 2011; Polverino et al., 2017) Persistent structural abnormalities may result from airway destruction, fibrosis, cavitation, and dysregulated inflammatory and tissue-remodelling responses occurring during active tuberculosis. Despite this burden, prognostic research in post-tuberculosis bronchiectasis remains substantially less developed than research concerning its prevalence and clinical phenotype. International clinical standards have consequently emphasized the need for systematic assessment of tuberculosis survivors for residual respiratory symptoms, functional impairment, and structural lung disease.[10]

Performance of multidimensional severity scores

The results suggest that established bronchiectasis severity scores may not perform consistently in post-tuberculosis populations. Al-Harbi et al. found that BSI had excellent discrimination for both frequent exacerbations and hospitalization, whereas Wang et al. reported AUC values close to chance for BSI and FACED. Deshmukh et al. further reported that BSI underestimated observed exacerbation rates, although the absence of exact numerical results prevented assessment of the magnitude and precision of this miscalibration.3–5

BSI was originally developed to predict mortality, hospitalization, and exacerbations in heterogeneous bronchiectasis populations. Its components include age, body mass index, lung function, previous hospitalization and exacerbation history, dyspnoea, microbiological (Chalmers et al., 2015; King, 2009; Pasteur et al., 2010) colonization, and radiological extent.11 FACED was principally developed to predict mortality and contains five variables: FEV1, age, chronic Pseudomonas aeruginosa colonization, radiological extent, and dyspnoea.12 External evaluation in seven European cohorts subsequently demonstrated that both scores predicted mortality, but BSI was generally more informative for exacerbations, hospital admissions, symptoms, exercise capacity, and lung-function decline.

Several factors could explain the conflicting performance observed in post-tuberculosis cohorts. Differences in age, healthcare access, microbiological profiles, baseline disease severity, and admission thresholds may modify the transportability of a prognostic score. Moreover, BSI incorporates previous exacerbations and hospital admissions, which are themselves strong predictors of future events. Its performance may consequently vary according to the accuracy and completeness of retrospective event ascertainment. Differences between the definitions used by Al-Harbi et al. and Wang et al., including ≥2 versus >2 exacerbations per year and one-year hospitalization versus longer-term readmission—further limit direct comparison.3,4

Post-tuberculosis bronchiectasis may also constitute a distinct phenotype that is insufficiently represented in the populations used to develop these scores. Observational studies have reported that patients with post-tuberculosis bronchiectasis may have more extensive radiological disease, lower lung function, lower body mass index, and different microbiological characteristics than patients with other bronchiectasis etiologies.1,2 These differences support the need for external validation and recalibration before BSI or FACED is used to make individual prognostic decisions in post-tuberculosis populations.

Lung function and microbiological predictors

Ou et al. found that FEV1 ≤60% predicted was independently associated with approximately 2.3-fold higher odds of exacerbation. This association is biologically and clinically plausible. Reduced FEV1 may reflect greater structural airway damage, airflow obstruction, impaired mucus clearance, and reduced pulmonary reserve. Studies of general bronchiectasis populations have similarly identified impaired FEV1 as a predictor of recurrent exacerbations and adverse outcomes. In a large international cohort, previous exacerbations were the strongest predictor of future events, while FEV1, radiological severity, chronic obstructive pulmonary disease, and airway infection provided additional prognostic information.

The importance of impaired lung function is particularly relevant following pulmonary tuberculosis. A systematic review and meta-analysis of spirometry involving 14,621 tuberculosis survivors found persistent obstructive, restrictive, and mixed ventilatory impairment after tuberculosis treatment, with greater impairment among survivors of drug-resistant disease.15 Nevertheless, the FEV1 threshold identified by Ou et al. requires independent validation because dichotomizing a continuous measure may reduce prognostic information, and the selected threshold may not generalize across populations.7

Ou et al. also reported that positive Gram-negative bacilli culture was associated with approximately threefold greater adjusted odds of exacerbation. This result is consistent with the concept that chronic airway infection contributes to persistent inflammation, impaired mucociliary clearance, and progressive structural injury. In the EMBARC-India registry, infection with Gram-negative pathogens was associated with increased mortality, while P. aeruginosa infection predicted severe and overall exacerbations.16 A meta-analysis of 21 observational cohorts also found that P. aeruginosa colonization was associated with more exacerbations, substantially higher hospital-admission risk, worse quality of life, and increased mortality in adults with bronchiectasis.

However, the Ou abstract did not provide species-level results, a detailed definition of persistent or chronic infection, sampling frequency, or the complete multivariable adjustment set. A single positive sputum culture may represent transient isolation rather than persistent infection. Future studies should distinguish between single isolation, intermittent detection, and chronic infection and should separately analyze P. aeruginosa, Enterobacterales, and other Gram-negative organisms.

Outcome heterogeneity and clinical implications

Variation in exacerbation definitions was a major barrier to evidence synthesis. The included studies used any exacerbation, at least two exacerbations per year, more than two exacerbations per year, exacerbation rates, severe exacerbation requiring hospitalization, and respiratory readmission. These outcomes represent related but clinically distinct events. An international consensus definition recommends defining a bronchiectasis exacerbation for clinical research as deterioration in at least three key symptoms for at least 48 hours together with a clinician-determined change in treatment.18 Future post-tuberculosis studies should adopt standardized definitions and report non-severe exacerbations, severe exacerbations, hospitalization, and readmission separately.

Clinically, the current findings do not justify relying on a single severity score to predict outcomes in all patients with post-tuberculosis bronchiectasis. Nevertheless, the components

highlighted across the included studies—lung function, previous exacerbations, prior hospitalization, microbiology, dyspnoea, nutritional status, and radiological extent—remain reasonable elements of a comprehensive baseline assessment. Patients with impaired FEV1 or potentially pathogenic Gram-negative organisms may warrant closer follow-up, optimization of airway-clearance therapy, repeated microbiological surveillance, and assessment for other modifiable risk factors. These findings should not, however, be interpreted as evidence that treatment based solely on these predictors improves outcomes.

Strengths and limitations

This review applied a focused prognostic question requiring the prognostic factor to precede the outcome and requiring post-tuberculosis-specific results. This approach reduced the risk of incorrectly treating cross-sectional disease-severity associations or comparisons between bronchiectasis etiologies as prognostic evidence. Reports originating from the same Taiwan cohort were also linked to prevent double-counting.

Several limitations should be acknowledged. Only four independent studies with 500 participants were included, and two were available only as abstracts. Important methodological information regarding recruitment, attrition, missing data, outcome ascertainment, adjustment variables, and model performance was therefore unavailable. The included studies differed substantially in design, follow-up duration, predictor definitions, outcome thresholds, and statistical measures. Confidence intervals were unavailable for the Wang AUC estimates, and numerical calibration data could not be extracted for Deshmukh. Risk of bias was moderate or high across the evidence base, particularly because of participant selection, attrition, confounding, and incomplete statistical reporting. Publication bias and small-study effects could not be assessed because too few comparable studies were available.

Research implications

Future research should use prospective, multicenter cohorts with standardized definitions of post-tuberculosis bronchiectasis and exacerbation outcomes. Candidate predictors should be measured at a clearly defined baseline, while outcome ascertainment should distinguish any exacerbation, frequent exacerbations, severe exacerbations, hospitalization, and readmission. Studies evaluating BSI, FACED, or other prediction models should report discrimination with confidence intervals, calibration plots and statistics, missing-data methods, and both apparent and internally validated performance. Existing scores should first undergo external validation and recalibration before developing a new post-tuberculosis-specific model. Adequate adjustment should include previous exacerbations, lung function, microbiological status, radiological extent, dyspnoea, nutritional status, smoking, comorbidities, and treatment exposure.

CONCLUSION

Evidence regarding prognostic factors for exacerbations and hospitalization in post-tuberculosis bronchiectasis remains limited and methodologically heterogeneous. The Bronchiectasis Severity Index (BSI) and FACED score demonstrated inconsistent performance across the included cohorts, indicating limited certainty regarding their applicability to post-tuberculosis bronchiectasis populations. Reduced forced expiratory volume in one second (FEV_1) and positive Gram-negative bacilli cultures emerged as potential independent predictors of exacerbations; however, each finding was supported by only one cohort reported

in abstract form. Larger prospective studies using standardized outcomes and comprehensive prognostic model reporting are required before reliable risk stratification can be implemented in this population.

REFERENCES

Al-Harbi, A., Al-Ghamdi, M., Khan, M., Al-Rajhi, S., & Al-Jahdali, H. (2020). Performance of Multidimensional Severity Scoring Systems in Patients with Post-Tuberculosis Bronchiectasis. *International Journal of Chronic Obstructive Pulmonary Disease*, *15*, 2157–2165. https://doi.org/10.2147/COPD.S261797

Chalmers, J. D., Aliberti, S., & Blasi, F. (2015). Management of bronchiectasis in adults. *European Respiratory Journal*, *45*(5), 1446–1462. https://doi.org/10.1183/09031936.00140614

Chalmers, J. D., Goeminne, P., Aliberti, S., McDonnell, M. J., Lonni, S., & Davidson, J. (2014). The bronchiectasis severity index. An international derivation and validation study. *American Journal of Respiratory and Critical Care Medicine*, *189*(5), 576–585. https://doi.org/10.1164/rccm.201309-1575OC

Choi, H., Lee, H., Ra, S. W., Kim, H. K., Lee, J. S., & Um, S. J. (2021). Clinical Characteristics of Patients with Post-Tuberculosis Bronchiectasis: Findings from the KMBARC Registry. *Journal of Clinical Medicine*, *10*(19), 4542. https://doi.org/10.3390/jcm10194542

Deshmukh, A., Vadala, R., & Talwar, D. (2021). Utility of Bronchiectasis severity index (BSI) as prognostic tool in patients with post tubercular bronchiectasis: An experience from a tertiary care hospital in North India. *Indian Journal of Tuberculosis*, *68*(2), 261–265. https://doi.org/10.1016/j.ijtb.2020.09.010

Dharmawangsa, J., Jayadi, R., & Santoso, K. P. (2023). Optimasi Pengaturan Release Waduk Wonogiri Berbasis Neraca Air Simultan Pada Dua Tampungan Waduk Terpadu. *Jurnal Teknik Sumber Daya Air*.

Flume, P. A., Chalmers, J. D., & Olivier, K. N. (2018). Advances in bronchiectasis: end-of-year summary. *European Respiratory Review*, *27*(150), 180012. https://doi.org/10.1183/16000617.0012-2018

Fong, I., Low, T. B., & Yii, A. (2022). Characterisation of the post-tuberculous phenotype of bronchiectasis: A real-world observational study. *Chronic Respiratory Disease*, *19*. https://doi.org/10.1177/14799731221098714

Hill, H. (2000). Indonesia: The Strange and Sudden Death of a Tiger Economy. *Oxford Development Studies*, *28*(2), 117–139. https://doi.org/10.1080/713688310

King, P. T. (2009). The pathophysiology of bronchiectasis. *International Journal of Chronic Obstructive Pulmonary Disease*, *4*, 411–419. https://doi.org/10.2147/COPD.S6133

Martínez-García, M. A., de Gracia, J., & Vendrell Relat, M. (2014). Multidimensional approach to non-cystic fibrosis bronchiectasis: the FACED score. *European Respiratory Journal*, *43*(5), 1357–1367. https://doi.org/10.1183/09031936.00026313

McShane, M. K., Nair, A., & Rustambekov, E. (2011). Does enterprise risk management increase firm value? *Journal of Accounting, Auditing & Finance*, *26*(4), 641–658.

Meghji, J., Simpson, H., Squire, S. B., & Mortimer, K. (2016). A Systematic Review of the Prevalence and Pattern of Imaging Defined Post-TB Lung Disease. *PLoS ONE*, *11*(8), e0161176. https://doi.org/10.1371/journal.pone.0161176

Migliori, G. B., Marx, F. M., Ambrosino, N., Zampogna, E., & Schaaf, H. S. (2021). Clinical standards for the assessment, management and rehabilitation of post-TB lung disease. *International Journal of Tuberculosis and Lung Disease*, *25*(10), 797–813. https://doi.org/10.5588/ijtld.21.0425

Ou, W. F., Chu, C. H., Sheu, C. C., Chang, C. L., Wang, P. H., & Hsieh, M. H. (2026). Lower FEV1 and gram-negative bacilli isolation as independent risk factors for exacerbations in post-TB bronchiectasis. *International Journal of Tuberculosis and Lung Disease*, *30*(2), 63–69. https://doi.org/10.5588/ijtld.25.0336

Pasteur, M. C., Bilton, D., & Hill, A. T. (2010). British Thoracic Society guideline for non-CF bronchiectasis. *Thorax*, *65*(Suppl 1), i1–i58. https://doi.org/10.1136/thx.2010.136119

Polverino, E., Goeminne, P. C., McDonnell, M. J., Aliberti, S., Marshall, S. E., & Loebinger, M. R. (2017). European Respiratory Society guidelines for the management of adult bronchiectasis. *European Respiratory Journal*, *50*(3), 1700629. https://doi.org/10.1183/13993003.00629-2017

Ravimohan, S., Kornfeld, H., Weissman, D., & Bisson, G. P. (2018). Tuberculosis and lung damage: from epidemiology to pathophysiology. *European Respiratory Review*, *27*(147), 170077. https://doi.org/10.1183/16000617.0077-2017

Xue, W., Chengming, Y., Ziyun, W., & Zhong, Z. (2026). Analysis on Prognosis and Influencing Factors in Patients with Post-tuberculosis Bronchiectasis. *Chinese General Practice*, *29*(5), 606. https://doi.org/10.12114/j.issn.1007-9572.2024.0678

Yang, S., Wang, C., Zhang, B., Hou, J., Huang, S., & Wang, K. (2023). Clinical Effects of Surgical Left Atrial Reduction and Concomitant Mitral Valve Replacement in Patients with Giant Left Atrium. *Brazilian Journal of Cardiovascular Surgery*, *38*(5). https://doi.org/10.21470/1678-9741-2022-0469