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EFFECTIVENESS OF ADHERENCE-FOCUSED INTERVENTIONS AND CONTEMPORARY PREDICTORS OF TREATMENT SUCCESS IN DRUG-SENSITIVE TUBERCULOSIS IN LOW- AND MIDDLE-INCOME COUNTRIES: A SYSTEMATIC REVIEW AND META-ANALYSIS (2018–2023)

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Abstract

Background. Drug-sensitive tuberculosis (TB) treatment success in low- and middle-income countries (LMICs) has historically fallen short of the WHO's 85% benchmark. Predictors of treatment success are well described, but newer adherence-focused interventions, including digital tools introduced since 2018, have not been synthesized alongside contemporary evidence on predictors.

Methods. A systematic review and meta-analysis followed PRISMA guidelines and covered the period from January 2018 to April 2023 across PubMed, ScienceDirect, EBSCOhost, Cochrane Library, and CINAHL. Eligible studies reported treatment success rates, predictors, or interventions for drug-sensitive TB in LMICs. Random-effects models yielded pooled odds ratios (ORs) and effect sizes (ESs) with 95% confidence intervals (CIs); heterogeneity was assessed using I^2. Risk of bias was appraised using the Joanna Briggs Institute (JBI) checklist.

Results. Eighty-four studies met inclusion criteria (71 observational, 12 controlled interventional, 1 uncontrolled interventional), covering 806,664 participants. Pooled treatment success was 87.6%, exceeding the WHO benchmark. HIV-negative status (OR 2.05, 95% CI 1.76–2.39), new case status (OR 2.23, 1.88–2.63), directly observed therapy (DOTS) receipt (OR 2.93, 1.74–4.93), and absence of smoking or alcohol use were significantly associated with success; residence, TB site, and bacteriological confirmation were not. Five interventions significantly improved success rates: asynchronous video observed therapy (aVOT) (ES 17.99, 2.47–131.03), medication event monitoring systems (MEMS) (ES 3.55, 1.80–7.00), patient support groups (ES 2.15, 1.86–2.48), pharmaceutical care (ES 2.09, 1.01–4.34), and a modified drug regimen (ES 1.75, 1.05–2.92).

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Conclusion and Implications. This review confirms established predictors and provides the first quantitative synthesis of newer digital adherence interventions, aVOT and MEMS particularly, for drug-sensitive TB in LMICs. Feasibility of digital interventions should be weighed against local digital access and health infrastructure before scale-up.

Registration. This review was not prospectively registered in PROSPERO or another public registry, which is disclosed here as a limitation.

Keywords: *Developing Countries, Medication Adherence, Meta-Analysis, Systematic Review, Treatment Outcome, Tuberculosis*

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Research Highlights

What is the current knowledge?

- Established predictors of drug-sensitive TB treatment success, HIV-negative status, new case status, receipt of DOTS, and absence of smoking or alcohol use, are well described in earlier systematic reviews (Teferi 2021; Chaves Torres et al. 2019).
- Earlier reviews reported pooled treatment success rates below the WHO benchmark of 85% (79% in Africa; 80.1% globally), and did not evaluate the effectiveness of interventions alongside predictors.
- Newer adherence-focused digital interventions, including asynchronous video observed therapy and medication event monitoring systems, have emerged since 2018 but have not been quantitatively synthesized for LMIC settings specifically.

What is new in this study?

- This review provides an updated (2018–2023) pooled treatment success estimate of 87.6%, higher than earlier reviews, and reports the first quantitative synthesis combining contemporary predictor confirmation with intervention-effectiveness estimates in one review.
- Five adherence interventions showed statistically significant effects, with asynchronous video observed therapy showing the largest pooled effect size (17.99) reported to date for this outcome in an LMIC setting.
- The findings clarify which interventions have quantitative support for scale-up in resource-limited settings, and which require further evaluation given feasibility constraints such as digital access.

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INTRODUCTION

According to the 2024 Global Tuberculosis Report, an estimated 10.6 million people fell ill with tuberculosis (TB) in 2023, with over 87% of cases occurring in low- and middle-income countries (LMICs) (World Health Organization, 2024). TB remains among the leading infectious causes of death worldwide, and progress toward global elimination targets has been uneven across regions.

LMICs bear this burden disproportionately while contending with brittle health infrastructure, workforce shortages, and constrained diagnostic capacity, which compound delays in case detection and disrupt sustained treatment follow-through (World Health Organization, 2019, 2024). These structural constraints mean that gains in TB control in such settings depend as much on health-system-level adherence support as on the availability of effective anti-TB regimens.

The World Health Organization's End TB Strategy aims to reduce TB incidence and mortality through integrated, patient-centered care, with improved treatment outcomes as a core target (World Health Organization, 2019). High default rates, treatment interruptions, and therapeutic non-adherence continue to impede progress, despite drug-sensitive TB treatment being highly successful when started promptly and followed consistently for six to nine months (World Health Organization, 2019).

Treatment success, rather than incidence alone, is the outcome most directly actionable by health systems and clinicians: it reflects not only access to diagnosis and medication but also the adherence support, follow-up systems, and patient-level factors that determine whether a course of therapy is completed successfully. Understanding which of these factors and which interventions most reliably improve treatment success is therefore central to closing the gap between TB diagnosis and TB cure.

Poor outcomes are also linked to limited patient awareness of TB (Jing et al., 2024; Craciun et al., 2023). Effective diagnosis, optimal adherence, and appropriate anti-TB medication use remain central to reducing TB transmission and mortality (Adisa et al., 2021).

Chaves Torres et al.'s (2019) global systematic review of 151 studies found a drug-sensitive TB treatment success rate below the WHO criterion, at 80.1% (95% CI 78.4–81.7) for adults and 84.8% (95% CI 77.7–90.7) for children, with treatment default and death as the leading causes of unsuccessful outcomes. Teferi et al.'s (2021) systematic review focused on Africa found a pooled treatment success rate of 79% (95% CI 76–82), below the WHO benchmark of 85%, with HIV co-infection, remote residence, and prior TB treatment substantially linked to poorer outcomes. Both reviews establish HIV-negative status, negative sputum smear conversion, younger age, and abstinence from alcohol as consistent positive predictors of treatment success.

This review therefore had two objectives. The general objective was to provide an updated, quantitative synthesis of both patient-level predictors and adherence-focused interventions associated with drug-sensitive TB treatment success in LMICs. The specific objectives were to (a) estimate pooled treatment success rates and predictor associations using literature published from January 2018 through April 2023, extending the evidence base beyond the search windows of Chaves Torres et al. and Teferi et al.; and (b) quantify the effectiveness of adherence-focused interventions, including newer digital adherence tools, in the same LMIC-specific population, evaluated alongside, rather than separately from, predictor evidence.

This study builds on the existing predictor literature with two extensions: an updated evidence base capturing newer adherence-focused interventions unavailable to earlier reviews, and a single synthesis evaluating intervention effectiveness alongside predictor confirmation, specific to LMICs, where the TB burden remains greatest.

The remainder of this paper proceeds as follows: the Literature Review situates this contribution within four bodies of existing evidence; the Methods section details the search, eligibility, and analytic approach; the Results report pooled predictor and intervention estimates; and the Discussion interprets these findings alongside their limitations and implications for TB programs in LMICs.

LITERATURE REVIEW

Established Predictors of TB Treatment Success

The literature on predictors of treatment success in drug-sensitive TB is comprehensive. In addition to works by Chaves Torres et al. (2019) and Teferi et al. (2021), White et al. (2020) conducted a cross-sectional study in the Philippines on TB comorbidities, identifying patterns of co-occurring conditions relevant for treatment planning—though without directly analyzing their link to treatment outcomes. Many studies note that patients undergoing retreatment tend to have higher failure rates, often due to previous drug resistance, lower adherence, and more advanced disease at diagnosis (Sichen et al., 2023; Tharu et al., 2014; Ade et al., 2016; Win et al., 2012; Wang et al., 2017). Demographic factors have also been broadly studied: Horton et al. (2016) observed a consistent male predominance in TB cases across LMICs, but this likely reflects differences in care-seeking and diagnostic access by sex rather than a direct predictor of treatment success. Overall, HIV status, case type (new versus retreatment), and directly observed therapy are the strongest predictors, while residence type and the method of bacteriological confirmation tend to have weaker or inconsistent associations, a pattern also reflected in this review's findings.

Adherence-Focused Interventions in TB Care

Alipanah et al. (2018) conducted a systematic review and meta-analysis across multiple countries, finding that reminders, digital health tools, psychological support, and patient education significantly boost treatment adherence and outcomes. They also noted that patient-centered, community-based directly observed therapy (DOT) resulted in higher adherence than self-administered therapy. Since this review was published before the wider adoption of asynchronous digital monitoring, it offers a baseline for comparing newer interventions. Specific trials support these findings: electronic reminders modestly increased adherence in China (Liu et al., 2015); SMS reminders improved completion rates in Cameroon (Bediang et al., 2018); a Malawi process evaluation identified barriers to implementing community-delivered interventions (Puchalski Ritchie et al., 2021); and people-centered, take-home dosing achieved clinic-based DOT outcomes in Armenia (Khachadourian et al., 2020).

Emerging Digital Adherence Technologies

Asynchronous video observed therapy (aVOT), where patients record their medication intake on personal devices for later clinician review, and medication event monitoring systems (MEMS), which utilize sensor-equipped pillboxes to transmit real-time adherence data, form a new generation of adherence tools primarily studied in publications from 2018 onward. Early feasibility studies on video monitoring (Story et al., 2016) paved the way for randomized trials demonstrating improved adherence and lower patient costs in Moldova (Ravenscroft et al., 2020), as well as high completion rates for latent TB monitoring (Garfein et al., 2024). On medication monitoring, a multicenter Ethiopian trial (Manyazewal et al., 2022) and a Moroccan cohort study (Park et al., 2019) both showed positive outcomes. Ngwatu et al.'s (2018) WHO review noted limited evidence due to small sample sizes and heterogeneity. More recently, four multi-country pragmatic trials (Jerene et al., 2025) found that digital adherence tools did not significantly reduce poor outcomes at scale, indicating that successes in single

sites may not be generalizable. Since these tools were developed after the search periods of Chaves Torres et al. (2019) and Teferi et al. (2021), their effectiveness in low- and middle-income countries has not been quantitatively integrated with the evidence from those reviews.

Evidence Gaps Motivating this Review

Taken together, the existing literature leaves two gaps this review addresses: an updated pooled estimate of treatment success and its predictors using literature through 2023, and a quantitative synthesis of intervention effectiveness, including newer digital tools, restricted to LMIC settings where implementation constraints differ meaningfully from high-income contexts. This tension between favorable single-site trials and more equivocal multi-country evidence further motivates a pooled, LMIC-specific estimate rather than reliance on any individual trial.

METHODS

Study Design and Reporting

This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ascertain pooled estimates of TB treatment success rates, predictors, and interventions for drug-sensitive TB in LMICs. A pooled estimate refers to a summary measure calculated by statistically combining results from multiple studies, providing an overall effect size that reflects the collective evidence.

Eligibility Criteria

Participants were individuals receiving therapy for pulmonary or extrapulmonary TB who did not have multidrug-resistant TB and who resided in low- or middle-income countries. Low- and middle-income countries were defined operationally according to the World Bank's income classification in effect during the corresponding search year (2018–2023), encompassing low-income, lower-middle-income, and upper-middle-income economies as classified by gross national income (GNI) per capita. Eligible research designs included observational studies (case-control and cohort studies, 2018–2023) and interventional studies (pre-post, quasi-experimental, randomized controlled trials, and quasi-randomized trials, 2018–2023). Successful outcomes were defined as cure or completion of treatment; unsuccessful outcomes included death, default, or loss to follow-up or transfer. Patient-level factors of interest included age, sex, comorbidities (diabetes or other), TB type, HIV status, smoking and alcohol history, and treatment type (new or retreatment). Studies with incomplete or unavailable full texts were excluded.

Search Strategy

A comprehensive literature search was conducted across PubMed, EBSCOhost, ScienceDirect, Cochrane Library, and CINAHL using Medical Subject Headings (MeSH) terms and phrases including “tuberculosis,” “intervention,” “treatment outcome,” “predictive factors,” “predictors,” “risk factors,” and “factors,” refined using Boolean operators: terms representing the same concept were combined with “OR,” and terms representing different concepts were combined with “AND”; searches were further refined by the names of individual low- and middle-income countries. English-language studies were considered. EndNote was used to identify and remove duplicates.

Study Selection

Screening proceeded in three stages: title, abstract, and full-text review. Two reviewers independently screened studies at each stage; disagreements were resolved by discussion. Data were managed and extracted using Microsoft Excel.

Risk of Bias Assessment

Risk of bias was assessed using the Joanna Briggs Institute (JBI) appraisal checklist appropriate to each study design (case series checklist for observational studies without a comparator group; design-specific checklists for interventional studies). Two reviewers independently assessed risk of bias for each included study, with disagreements resolved by discussion; a formal inter-rater agreement statistic (e.g., Cohen's kappa) was not computed.

Data Extraction and Analysis

Data on patient demographics, treatment outcomes, and interventions were extracted. Weighted averages, forest plots, and subgroup analyses were used to evaluate associations between patient characteristics and treatment outcomes. Where data were missing, corresponding authors of included studies were contacted.

Statistical Analysis

The I^2 statistic was used to evaluate heterogeneity across studies. Random-effects models were used to synthesize data given the anticipated clinical and methodological heterogeneity across LMIC settings. Risk ratios and odds ratios with 95% confidence intervals were computed using Review Manager (RevMan) version 5.4, which was also used to generate forest and funnel plots. One exception is noted for transparency: the pooled estimate for smoking history (Figure 8) was generated using a fixed-effect model in RevMan rather than the random-effects model used elsewhere; given the substantial heterogeneity observed for this comparison (I^2 = 84%), this is disclosed as a methodological inconsistency in the Limitations, and the estimate should be interpreted with this in mind pending re-analysis. Subgroup analyses categorized interventions by research design (randomized controlled trial versus cohort) and by digital adherence tools, psychological support, and patient education.

Ethical Considerations

This study synthesized previously published, de-identified aggregate data and did not involve direct contact with human participants; institutional ethics approval was therefore not required.

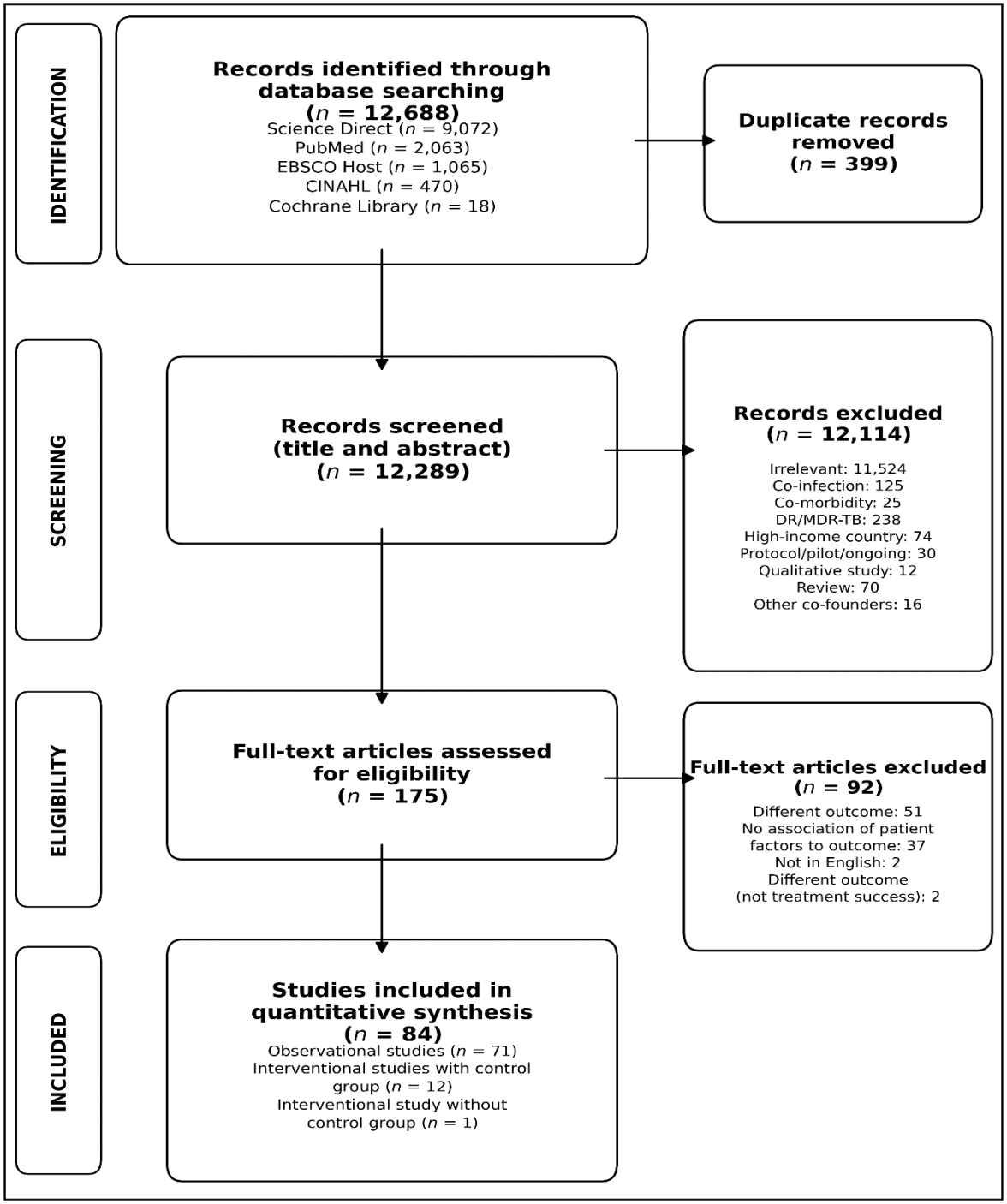
RESULTS

Study Selection

A total of 12,688 records were identified across multiple sources: Science Direct (9,072), PubMed (2,063), EBSCOhost (1,065), CINAHL (470), and Cochrane Library (18). After removing 399 duplicates, 12,289 titles and abstracts were screened. Of these, 12,114 were excluded for reasons such as irrelevance (n=11,524), co-infection (n=125), co-morbidity (n=25), drug-resistant or multidrug-resistant TB (n=238), high-income country setting (n=74), protocol, pilot, or ongoing study (n=30), qualitative study (n=12), review articles (n=70), or other confounding focus (n=16). Out of 176 studies assessed at full text, 92 were excluded due to different outcomes (n=51), lack of association between patient factors and treatment outcome (n=37), non-English language (n=2), or unrelated outcomes (n=2). In the end, 84 studies met the inclusion criteria—71 observational and 13 interventional (12 with control groups, 1 without). The selection process is detailed in Figure 1.

Figure 1.

PRISMA Flow Diagram of Study Identification, Screening, and Inclusion (N = 84)



Note. Figures 2 through 12 were exported directly from RevMan and may display internal reference numbers (e.g., “Figure 3.2,” “Figure 3.12”) from the authors' original analysis file; these do not correspond to the sequential figure numbering used in this manuscript. Readers should rely on the figure numbers and titles provided in the text immediately above each image.

Description of Studies

Observational studies (n=71) encompassed 806,664 participants, with individual sample sizes ranging from 62 to 308,860 (see Table 1). Among these, 370,138 were male and 196,048 female; 90,139 were pediatric and 24,417 were seniors, with age cutoffs varying between ≥55 and ≥65 years across studies. HIV status was reported in only 28 studies (40%), including 24,736 HIV-positive and 127,855 HIV-negative participants. TB case type (new versus retreatment) was detailed in 35 studies (49%), involving 444,696 initial treatments and 35,897 retreatments. TB site information was available for pulmonary TB in 40 studies (56%, 173,747 participants) and extrapulmonary TB in 35 studies (49%, 39,143 participants). Bacteriological confirmation was noted in 37 studies (52%), with 71,619 confirmed cases and 77,109 clinically diagnosed. Treatment modality (DOTS versus SAT) was reported in only 8 studies (11%), with 224,262 receiving DOTS and 28,637 SAT. Residence type data were available in 18 studies (25%), indicating 70,087 urban and 23,778 rural participants. Smoking history was reported in 6 studies (8%, 5,335 participants); alcohol use history in 6 studies (8%, 5,175 participants); and diabetes status in 5 studies (7%, 3,984 participants). Additionally, 4 studies (5%) reported other comorbidities affecting 5,504 participants.

Interventional studies (n=13) comprised 3 randomized controlled trials, 9 cohort interventional studies, and 1 quasi-experimental study, all using DOTS as the standard-of-care comparator (Table 2). Three studies (25%) used cash incentives, three (25%) added health workers (pharmacists or health extension workers) to reinforce adherence, three (25%) used reminder and adherence interventions, and one study each used self-administration monitoring, video-observed therapy, a modified drug regimen, and peer support groups.

Table 1.

Characteristics of Included Observational Studies (N = 71)

No.	Author (Year)	Study Design	Country	Sample Size	Overall Success		Treatment Success Rate Among Different Groups										
					No.	%	Child	Adult	Senior	Male	Female	HIV Pos	HIV Neg	Re-treat	New TB	EPTB	PTB
1	Atekem, et al., (2018)	RCSS	Cameroon	895	726	**81.12**	**85.19**	**81.25**	**70.00**	**80.38**	**81.97**	**77.99**	**85.75**	**86.67**	**80.72**	**41.90**	**79.92**
2	Bao, et al., (2018)	RS	China	1795	1384	**77.10**		**75.58**	**67.07**	**76.20**	**77.96**			**65.14**	**77.88**	**41.90**	**79.92**
3	Diallo, et al. (2018)	Case Control	Burkina Faso	381	305	**80.05**		**79.85**	**80.53**	**79.08**	**81.69**						
4	Ejeta, et al., (2018)	RS	Ethiopia	4170			**86.88**	**86.74**		**83.57**	**86.04**	**79.55**	**86.37**	**80.85**	**84.98**	**83.16**	**85.03**
5	Kirirabwa, et al., (2018)	RS	Uganda	15429	12417	**80.48**		**80.90**	**68.29**	**80.38**	**80.64**	**75.44**	**85.49**			**73.26**	
6	Melese, et al., (2018)	RS	Ethiopia	303	264	**87.13**	**95.00**	**79.86**	**65.52**	**83.24**	**92.31**	**43.21**	**72.07**	**60.00**	**87.64**	**87.18**	**87.10**
7	Muluye, et al. (2018)	RCS	Ethiopia	995	914	**91.86**	**90.91**	**92.21**	**87.50**	**90.27**	**94.13**	**88.24**	**92.80**	**81.58**	**92.33**	**92.54**	
8	Ogbudebe, et al. (2018)	RCS	Nigeria	724	601	**83.01**	**83.01**			**79.01**	**81.25**	**71.30**	**85.06**	**90.91**	**82.89**	**91.45**	**88.33**
9	Pizzol, et al. (2018)	OS	Mozambique	301	239	**79.40**					**75.51**	**70.23**					
10	Rohit, et al., (2018)	PLS	India	133										**78.57**	**95.38**	**92.50**	
11	Santos, et al., (2018)	CSS	Brazil	41279	32607	**78.99**	**83.49**	**78.06**	**81.46**	**76.61**	**83.34**	**59.48**	**81.60**	**59.30**	**82.63**	**86.84**	**78.18**
12	Sauer, et al., (2018)	CCA	Azerbaijan, Belarus, etc.	643	491	**76.36**											
13	Sahyog, et al., (2018)	RS	India	4979	2561	**51.44**											

Note: RS-Retrospective Study, CSS-Cross Sectional Study, RCS-Retrospective Cohort Study, RCSS- Retrospective Cross Sectional Study, OS-Observational Study, PLS-Prospective Longitudinal Study, POS-Prospective Observational Study, CCA-Complete-Case Analysis, PCS-Prospective Cohort Study, CS-Cohort Study

No.	Author (Year)	Study Design	Country	Sample Size	Overall Success		Treatment Success Rate Among Different Groups										
					No.	%	Child	Adult	Senior	Male	Female	HIV Pos	HIV Neg	Re-treat	New TB	EPTB	PTB
14	Paras, et al., (2018)	RS	Mexico	4090	3507	**85.75**											
15	Velayutham, et al. (2018)	PLS	India	1565	1210	**77.32**											
16	Wen, et al, (2018)	RS	China	22998	21851	**95.01**	**97.61**	**95.70**	**92.68**	**95.16**	**95.54**						
17	Worku, et al., (2018)	RS	Ethiopia	746	672	**90.08**	**88.41**	**87.93**	**86.27**	**88.43**	**91.88**	**88.07**	**90.81**	**92.42**	**89.87**	**90.39**	**89.89**
18	Abdulkader, et al., (2019)	RS	Ethiopia	2911	2605	**89.49**										**90.88**	
19	Abebe, et al. (2019)	RS	Ethiopia	1249	1103	**88.31**	**83.33**	**88.99**	**66.67**	**88.10**	**88.71**	**86.57**	**88.81**			**87.61**	**88.73**
20	Berry, et al., (2019)	RS	South Africa	182890	152672	**83.48**	**90.70**	**82.37**									
21	Cohen, et al., (2019)	PCS	Malawi	158	108	**68.35**	**68.75**	**68.25**		**72.55**	**60.71**	**66.41**	**77.78**	**74.60**		**57.69**	**70.45**
22	Gupta, et al., (2019)	RCS	India	72	69	**95.83**		**95.52**	**100.00**								
23	Hailekiros, et al., (2019)	RS	Ethiopia	105	93	**88.57**	**95.24**	**85.88**							**87.62**	**90.20**	**85.45**
24	Hamid, et al., (2019)	RCS	Pakistan	1665	1421	**85.35**											
25	Laghari, et al., (2019)	POS	Pakistan	508	483	**95.08**	**95.08**			**95.83**	**94.40**			**78.26**	**95.88**		
26	Ma, et al. (2019) Ethiopia	RCSS	Ethiopia	5603	5154	**91.99**					**86.73**	**80.54**	**91.40**	**62.11**	**87.60**	**89.04**	**84.78**
27	Ma, et al. (2019) China	RCSS	China	4527	4373	**96.60**					**95.87**			**94.22**	**95.97**		**95.92**

Note: RS-Retrospective Study, CSS-Cross Sectional Study, RCS-Retrospective Cohort Study, RCSS- Retrospective Cross Sectional Study, OS-Observational Study, PLS-Prospective Longitudinal Study, POS-Prospective Observational Study, CCA-Complete-Case Analysis, PCS-Prospective Cohort Study, CS-Cohort Study

No	Author (Year)	Study Design	Country	Sample Size	Overall Success		Treatment Success Rate Among Different Groups										
					No.	%	Child	Adult	Senior	Male	Female	HIV Pos	HIV Neg	Re-treat	New TB	EPTB	PTB
28	Mirutse, et al. (2019)	RCSS	Ethiopia	841	746	**88.70**	**88.70**			**91.81**	**87.14**	**91.23**	**90.94**			**91.43**	**84.18**
29	Nanzaluka, et al. (2019)	RS	Zambia	1724	985	**57.13**	**67.53**	**57.05**	**49.46**	**55.23**	**60.57**	**56.09**	**61.04**	**48.28**	**59.58**	**57.30**	**57.05**
30	Ohene, et al. (2019)	RS	Ghana	214	194	**90.65**	**90.65**			**91.89**	**88.89**	**86.32**	**93.91**			**94.29**	**96.10**
31	Prudhivi, et al., (2019)	RS	India	1113	922	**82.84**		**84.97**	**75.69**	**80.11**	**88.13**	**62.11**	**88.45**	**64.29**	**88.96**		
32	Rahimi, et al., (2019)	RCS	Afghanistan	1416	1040	**73.45**				**70.33**	**75.40**			**27.27**	**74.18**	**73.56**	**73.38**
33	Ramos, et al., (2019)	RCSS	Ethiopia	1282	814	**63.49**	**63.49**			**62.02**	**65.13**	**77.78**	**63.68**	**69.57**	**63.38**	**68.81**	**60.90**
34	Rashak, et al., (2019)	RCSS	Mexico	5508	4593	**83.39**		**89.51**	**83.40**	**86.68**	**91.34**					**83.03**	**89.26**
35	Sadykova, et al., (2019)	RCS	Kazakhstan	36926	26228	**71.03**		**74.03**	**68.80**	**70.43**	**77.91**	**49.30**	**74.22**	**64.64**	**79.67**	**86.93**	**82.91**
36	Tola, et al., (2019)	RS	Ethiopia	1236	1143	**92.48**	**91.18**	**93.36**	**75.93**	**91.61**	**93.76**	**82.27**	**95.49**	**86.49**	**92.66**	**92.08**	**92.72**
37	Wobudeya, et al. (2019)	RS	Uganda	516	422	**81.78**	**81.78**			**83.22**	**79.31**	**61.29**	**83.09**				
38	Ahmad, et al. (2020)	RCS	Pakistan	515	444	**86.21**	**89.19**	**87.45**	**71.19**	**84.81**	**87.41**			**70.00**	**86.41**	**80.11**	
39	Alao, et al. (2020)	RS	Nigeria	3358	2556	**76.12**	**84.04**	**77.36**		**76.13**	**80.43**	**71.71**	**77.11**	**68.54**	**79.13**	**83.00**	**77.14**
40	Awaluddin, et al. (2020)	RS	Malaysia	3550	3198	**90.08**	**90.08**			**89.11**	**90.95**	**72.92**	**90.29**			**89.36**	**90.32**
41	Carvalho, et al. (2020)	RS	Brazil	592	503	**84.97**	**84.97**			**87.65**	**90.57**	**76.67**	**89.25**			**91.61**	**88.36**

Note: RS-Retrospective Study, CSS-Cross Sectional Study, RCS-Retrospective Cohort Study, RCSS- Retrospective Cross Sectional Study, OS-Observational Study, PLS-Prospective Longitudinal Study, POS-Prospective Observational Study, CCA-Complete-Case Analysis, PCS-Prospective Cohort Study, CS-Cohort Study

No.	Author (Year)	Study Design	Country	Sample Size	Overall Success		Treatment Success Rate Among Different Groups										
					No.	%	Child	Adult	Senior	Male	Female	HIV Pos	HIV Neg	Re-treat	New TB	EPTB	PTB
42	Charoensakulchai, et al., (2020)	CSS	Thailand	768	639	83.20		82.71	78.70	79.78	84.91	76.74	81.56	65.77	81.67		
43	Oliveira, et al., (2020)	RS	Brazil	725	610	84.14	84.14			81.96	86.65	35.71	86.66	58.33	85.84		
44	DesJardin, et al. (2020)	CSS	Zimbabwe	853	486	56.98	56.98			55.77	58.12	57.01	56.79	42.86	57.28	61.15	56.02
45	Dorji, et al. (2020)	RSCSS	Nepal	634	567	89.43	96.88										
46	Izudi, et al., (2020)	RCS	Uganda	987	800	81.05		81.05		78.34	86.31	73.85	83.95				
47	Khan, et al. (2020)	RS	Malaysia	9337	7243	77.57											
48	Khunthason, et al., (2020)	RS	Thailand	770	619	80.39		87.12	87.88	86.80	87.69					87.21	87.11
49	Li, et al, (2020)	CSS	China	40561	38085	93.90	93.45			93.44	94.38			62.37	94.04	86.78	94.74
50	Sadana, et al., (2020)	CSS	India	62	58	93.55	93.55			90.00	95.24					90.32	96.77
51	Sariem, et al., (2020)	RS	Nigeria	10156	6845	67.40	59.23	72.05		66.16	69.40	73.69	75.38	62.60	67.66	64.37	67.77
52	Tesema, et al, (2020)	RS	Ethiopia	281	227	80.78	70.59	81.44				68.57	88.11			78.38	81.64
53	Umueokonkwo	RS	Nigeria	1070	604	56.45		56.44		53.89	60.00	47.80	61.01	65.79	55.87	57.99	61.47
54	Abdullah, et al., (2021)	RS	Pakistan	1941	1725	88.87	88.87			89.19	88.61					81.03	93.17
55	Gadoev, et al., (2021)	RS	Uzbekistan	35122	27682	78.82	86.75	78.15	75.93	78.84	78.79	47.37	81.87			87.85	76.96
56	Kassim, et al., (2021)	CSS	Somalia	400	340	85.00		87.54	71.43	82.82	89.13	81.25	85.16				

Note: RS-Retrospective Study, CSS-Cross Sectional Study, RCS-Retrospective Cohort Study, RCSS- Retrospective Cross Sectional Study, OS-Observational Study, PLS-Prospective Longitudinal Study, POS-Prospective Observational Study, CCA-Complete-Case Analysis, PCS-Prospective Cohort Study, CS-Cohort Study

No.	Author (Year)	Study Design	Country	Sample Size	Overall Success		Treatment Success Rate Among Different Groups										
					No.	%	Child	Adult	Senior	Male	Female	HIV Pos	HIV Neg	Re-treat	New TB	EPTB	PTB
57	Oladimeji, et al., (2021)	RS	Lagos	1337	1044	78.09	34.84	78.27	59.74	75.67	81.47	69.70	81.70			50.00	78.53
58	Schoenbachler, et al., (2021)	CS	Guinea	3969	3006	75.74	77.78	76.12	72.78	75.53	76.10	58.44	79.92	71.06	76.28	74.42	76.03
59	Sharma, et al., (2021)	RS	India	2347	2020	86.07	83.95	86.41						80.33	86.38		
60	Teferi, et al., (2021)	RS	Ethiopia	232	191	82.33	83.02	83.52		82.93	83.18	79.49	83.77				
61	Woldemichael, et al., (2021)	RS	Ethiopia	7205	6325	87.79	90.43	87.63	82.54								
62	Woldesmayat, et al., (2021)	RS	Ethiopia	731	675	92.34	91.84	93.97	95.24	93.16	91.21	79.84	94.89	83.93	93.04		
63	Afrane, et al. (2022)	RS	Ghana	407	278	68.30	146.40			68.27	68.34	67.82	68.67	100.00	67.99	64.49	70.26
64	Araia, et al., (2022)	RS	Eritrea	1227	1109	90.38	94.41	91.00	78.57	91.51	89.17	86.49	90.81	84.29	90.75	92.37	89.45
65	Gilmour, et al., (2022)	RS	China	308860	301461	97.60				98.13	98.54			94.24	98.27		
66	Kamble, et al., (2022)	RS	India	5257	4899	93.19		93.19						82.11	95.65	98.57	89.82
67	Osorio, et al., (2022)	RS	Mozambique	3012	2863	95.05		94.94	97.43	93.37	95.93	93.24	96.88			94.34	94.63
68	Vukugah, et al., (2022)	RS	Cameroon	610	488	80.00	80.00			80.86	79.15	65.36	80.97			77.97	81.06
69	Debash, et al., (2023)	RS	Ethiopia	552	518	93.84	92.73	93.44	98.18	93.07	94.60	86.14	95.57	93.55	93.86	95.88	92.74
70	Ngah, et al., (2023)	RS	Lesotho	1781	1369	76.87	69.01	91.83	32.11	77.01	74.95					67.40	79.07
71	Zenatti, et al., (2023	RS	Ethiopia	3545	3026	85.36	86.17	79.27	76.05	82.25	86.43	76.64	86.88	74.43	85.17	86.06	83.23
			Total:	806,664		89	90	81	77	91	90	71	80	75	93	85	82

Note: RS-Retrospective Study, CSS-Cross Sectional Study, RCS-Retrospective Cohort Study, RCSS- Retrospective Cross Sectional Study, OS-Observational Study, PLS-Prospective Longitudinal Study, POS-Prospective Observational Study, CCA-Complete-Case Analysis, PCS-Prospective Cohort Study, CS-Cohort Study

Note. This table was exported directly from the authors' original analysis file and may display an internal reference number (e.g., “Table 3.2”) from the underlying dataset; this does not correspond to the sequential table numbering used in this manuscript. The same applies to Table 2.

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Table 2.

Characteristics of Included Interventional Studies (N = 12)

No	Author (Year)	Country	Study Design & Setting	Standard Care	Population	Outcome	Intervention Group	Control Group
1	Durovni, et al, (2018)	Brazil	Retrospective cohort study. Poorest neighbourhoods of Rio de Janiero.	DOTS. With or without Cash Transfer Program.	Adult, > 15 years old.	Treatment outcome. Association of treatment outcome with Cash Transfer Program.	Participants registration to Brazilian Family Health (FHS) clinics.	Standard of Care
2	Tang, et al., (2018)	China	Prospective, randomized, case-control study.	Directly Observed Therapy Short-Course (DOTS)	Newly diagnosed PTB patients. Receiving less than 1 month of antituberculosis drugs	Medication Adherence, Treatment Outcome	Pharmacists provided pharmaceutical care to the patients shortly before discharge (PC group). After discharge, appointments were scheduled. Follow-up visits were conducted either face to face or via telephone by a pharmacist, physician, or shared pharmacist/physician appointment. Pharmaceutical care included, patient education, urine analysis, medication counting, monitoring laboratory tests, and addressing patient-reported pharmaceutical care issues. Patient education material was prepared by pharmacist & was given to patient.	Usual Care group (UC group). Received only routine medical and nursing care.
3	NoorHaslinda, et.al., (2019)	Malaysia	Randomized controlled trial.	Directly Observed Therapy Short-Course (DOTS)	Newly diagnosed PTB cases	Medication Adherence, Treatment Outcome	Using Health Education Module named TB@Clicks delivered through WhatsApp to enhance treatment adherence & successful outcome among PTB patients.	Standard of Care
4	Oliosi, et.al., (2019)	Brazil	Prospective cohort study, Health care centers in 7 cities (Manaus, Fortaleza, Recife, Salvador, Vitoria, Sao Paulo & Porto Alegre)		Newly diagnosed PTB cases. Less than 30 days of starting treatment.	Treatment Outcome	Enrollment to the Bolsa Familia Program (BFP). Conditional cash transfer for	Standard Care. No conditional cash transfer.
5	Park, et al., (2019)	Morocco	Retrospective cohort study. Non-Randomized. Health centers of Sale, Temara, Casablanca, and Khemisset Morocco.	DOTS.	Newly diagnosed PTB cases	Medication Adherence, Treatment Outcome	Participants was provided with a smart pillbox with a web-based medication monitoring system, called MEMS, which reminded patients to take medication at certain times. MEMS is a medication storage device that sends the data real-time to a website via SIM card to a web baed application on a tele-cimmunication interface. When patient failed to take their medication, staffs made phone calls or home visits to patients.	Standard of Care.
6	Bhatt, et. Al., (2020)	India	Non-concurrent retrospective cohort study. Vellore district, South India, India.	Thrice weekly DOTS. Free of cost.	Newly diagnosed with TB, residents of Vellore district HIV negative, sputum positive.	Treatment Outcome	Daily Self-Administered Antituberculosis.	Thrice weekly DOTS. Standard Care.

No	Author (Year)	Country	Study Design & Setting	Standard Care	Population	Outcome	Intervention Group	Control Group
7	Baluku, et. al., (2021)	Uganda	Quasi-experiment that consisted of a prospective two-arm pragmatic randomized open-label non-placebo controlled trial & a retrospective cohort at Masaka Regional Referral Hospital in rural central Uganda.	Directly Observed Therapy Short-Course (DOTS)	Adults (>18 years old). Initiating a 6 month TB treatment regimen at the study site.	Treatment Outcome	Participants in this group received 4,000 Uganda shillings (1.00 US Dollars) as cash incentive for follow-up every visit. They were informed that they can spend the incentive as the wished. The incentive was only conditioned on turning up for the clinic visit in addition to the standard care.	Participants in this group received the usual standard of care but did not receive any money or other incentives.
8	Doltu, et. al., (2021)	Moldova	Cohort study that combined data from the RCT on Treatment Strategy and DOT data under operational conditions in Chisinau.	DOTS. Free of cost. In addition, all adherent to TB treatment patients receives vouchers for food and hygienic products (2 US Dollars per day).	Patients who had previously been enrolled in the RCT and those who were registered in the TB national registry. Adult, >18 years old. < 3 months of starting Antituberculosis medication.	Treatment Outcome (Long term/Short term)	Used Asynchronous Video Observed Therapy (aVOT) instead of standard DOTS. Patients are observed swallowing their medication recorded via smartphones, tablets, or computers.	Standard Care. DOTS.
9	Ereso, et al., (2021)	Ethiopia	Prospective Cohort Study Design. Public health facilities in Jimma Zone, Ethiopia	Directly Observed Therapy Short-Course (DOTS)	Newly diagnosed PTB cases	Treatment Outcome	Community-Based DOTS: TB treatment provided at a health post or patient's home by a Health Extension Worker (HEW) or a trained TB treatment supporter.	Facility-Based DOTS: TB treatment provided at governmental health centres or hospitals by a trained health worker.
10	Gashu, et al., (2021)	Ethiopia	Two-arm randomised controlled trial (RCT)	Directly Observed Therapy Short-Course (DOTS)	Newly diagnosed adult PTB cases.		Participants received weekly pill refilling and daily medication reminders using graphics-based and text messages in the local language (Amharic) in addition to standard of care.	Standard of Care.
11	Ge, et al., (2023)	China	Multicenter cohort study.	DOTS. Standard Regimen. (2HREZS/6HRZE or 3HREZ/6HREZ)		Treatment Outcome	Participants used the modified regimen. The modified regimen consist of 4 month of intensive phase & 4 month of continuation phase. (4H-Rt2-E-Z-w/orw/out S / 4 H-Rt2-E)	Standard of Care.
12	Potty, et al., (2023)	India	Retrospective cohort study. 46 tuberculosis units from urban select areas of Karnataka state and Telangana state.				Participants were included in patient peer support for tuberculosis. Attendance is voluntary. Family members and/or caregivers of the patients who had previously completed tuberculosis treatment were included in support groups Each patient would attend the support group meeting once a month until they completed their treatment course..	Standard of Care. Did not attend meeting.

Risk of Bias

Observational studies were appraised using the JBI Case Series Appraisal Checklist because none included a comparator group. Two studies (Paras et al., 2018; DesJardin et al., 2020) were rated as moderate risk of bias; the remainder were rated low risk. Among interventional studies, all three randomized controlled trials were rated moderate risk of bias; two of the nine cohort interventional studies were rated moderate risk, with the remainder rated low risk; the single quasi-experimental study was rated low risk.

Treatment Outcomes of Observational Studies

The overall weighted-average treatment success rate for drug-sensitive TB across observational studies was 87.6% (707,420 of 806,664 participants), exceeding the WHO benchmark of 85%. Only 33 of 71 studies (46%) reported success rates above the WHO threshold; 38 studies (54%) fell below it, including 10 studies (14%) below 75%. Zigong, China, reported the highest treatment success rate (96.60%, 4,373/4,527), while rural Chhattisgarh, India, reported the lowest (51.44%, 2,561/4,979). Success rates by subgroup were: children under 18, 90%; adults, 81%; seniors (cutoff varying by study, 55–65 years), 77.5%; males, 91.1%; females, 90.45%; HIV-positive, 71.3%; HIV-negative, 81%; new/first-treatment cases, 94% (416,511/444,696); retreatment cases, 75% (26,915/35,897); extrapulmonary TB, 85% (33,275/39,143); pulmonary TB, 83% (144,067/173,747); bacteriologically confirmed, 78% (56,064/71,619); clinically diagnosed, 88%; DOTS recipients, 96% (214,565/224,262); SAT recipients, 80% (22,847/28,637); urban residence, 78% (54,439/70,087); rural residence, 80% (19,009/23,778); alcohol drinkers, 67.4% (3,488/5,175); smokers, 74% (3,963/5,335); participants with diabetes, 83% (3,312/3,984); and participants with other comorbidities, 63.5% (3,495/5,504).

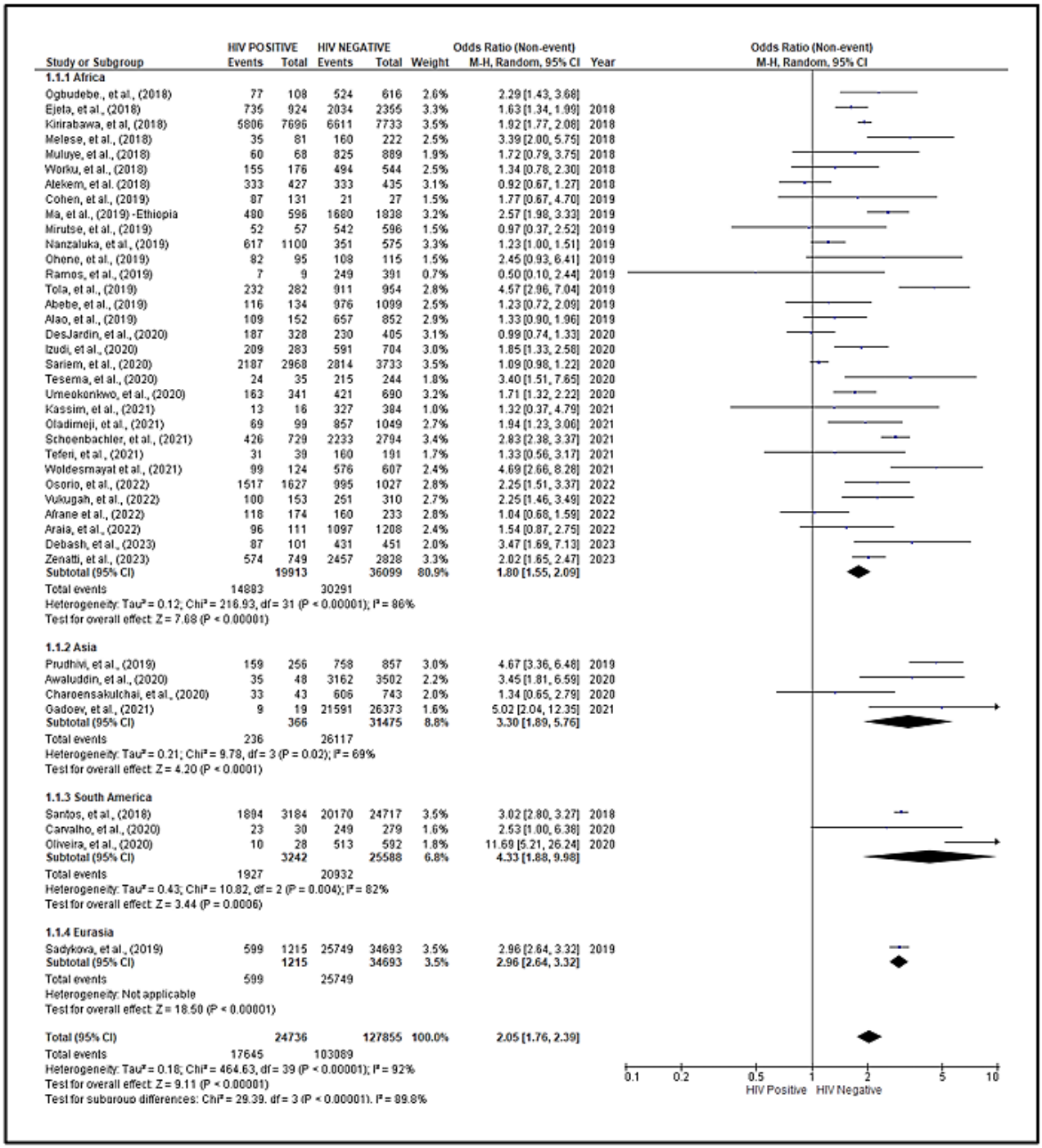
One data point in Table 1 warrants a note of caution: the child success rate entry for Afrane et al. (2022) is recorded as 146.40%, which is not a valid percentage. This has been retained as originally extracted, pending verification against the source publication. Readers should treat this specific cell with caution; it does not affect the pooled estimates reported below, which are derived from the event and total counts in the forest plot data rather than this summary table.

Association of Patient Factors with Treatment Success

HIV status was strongly linked to treatment success (see Figure 2): participants without HIV had notably higher odds of successful treatment compared to those with HIV (OR 2.05, 95% CI 1.76–2.39; I^2 = 92%; $p < 0.00001$). This pattern persisted across different regions, as revealed by subgroup analysis. These findings are consistent with Teferi et al. (2021), which reported that HIV co-infection significantly increased the risk of unsuccessful treatment outcomes relative to HIV-negative individuals. However, data on antiretroviral therapy (ART) among HIV-positive participants was inconsistently reported, making it difficult to analyze ART's specific impact.

Figure 2

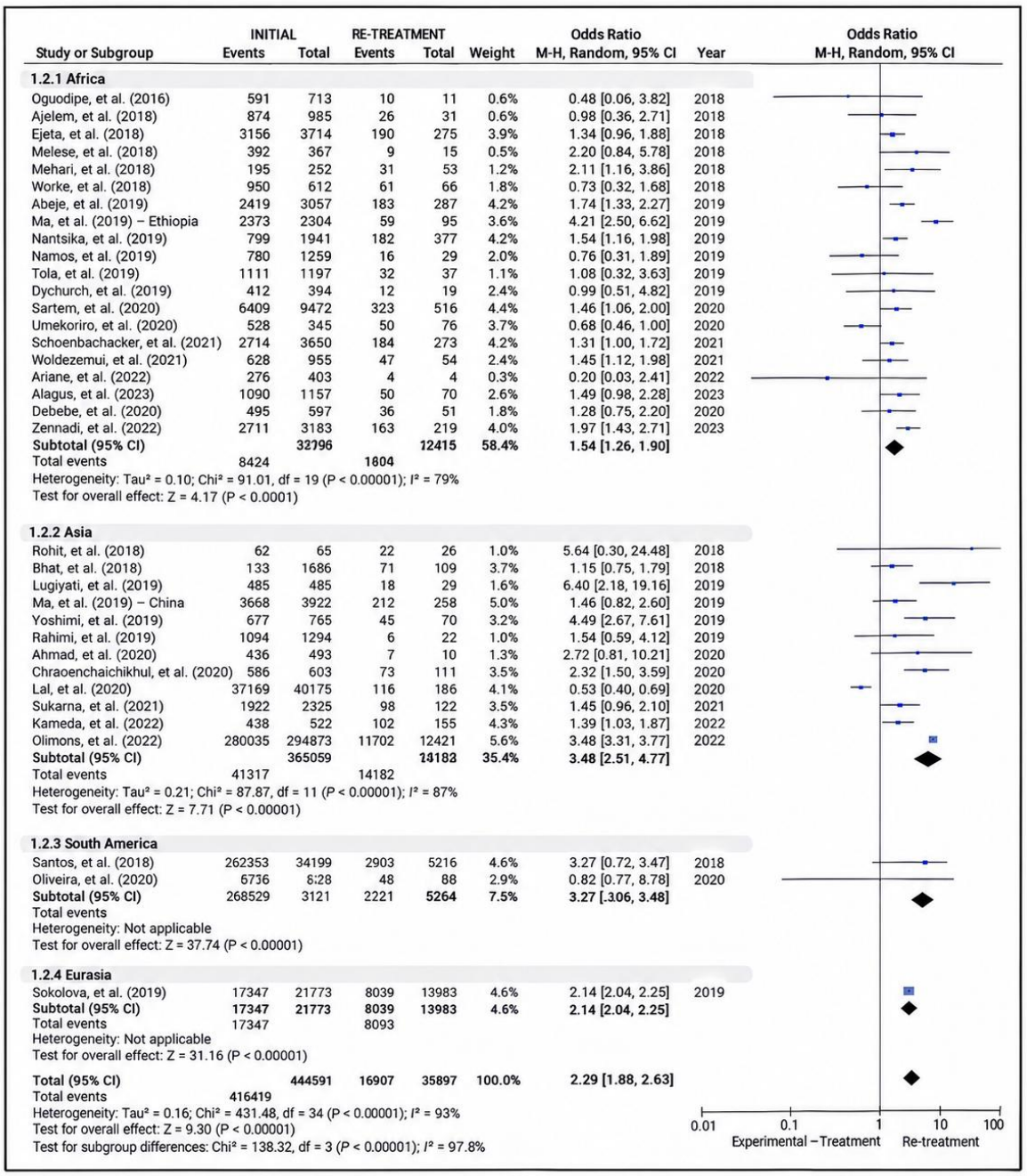
Pooled Estimate for HIV Status Associated with Treatment Success Rate



TB case type (new/initial versus retreatment) was strongly associated with treatment success (Figure 3): new or initial cases had significantly higher odds of success (OR 2.23, 95% CI 1.88–2.63; $I^2 = 93\%$; $p < 0.00001$), a pattern consistent across regional subgroups. This aligns with prior findings linking retreatment to worse outcomes, likely reflecting prior drug resistance, poorer adherence, and more advanced disease at presentation.14,15,16,17,18

Figure 3.

Pooled Estimate for TB Case Type (New/Initial Versus Retreatment) Associated With Treatment Success Rate



TB site (extrapulmonary versus pulmonary) was not significantly associated with treatment success (Figure 4) (OR 0.99, 95% CI 0.80–1.23; $I^2 = 97\%$; $p < 0.00001$), a finding consistent across regional subgroups.

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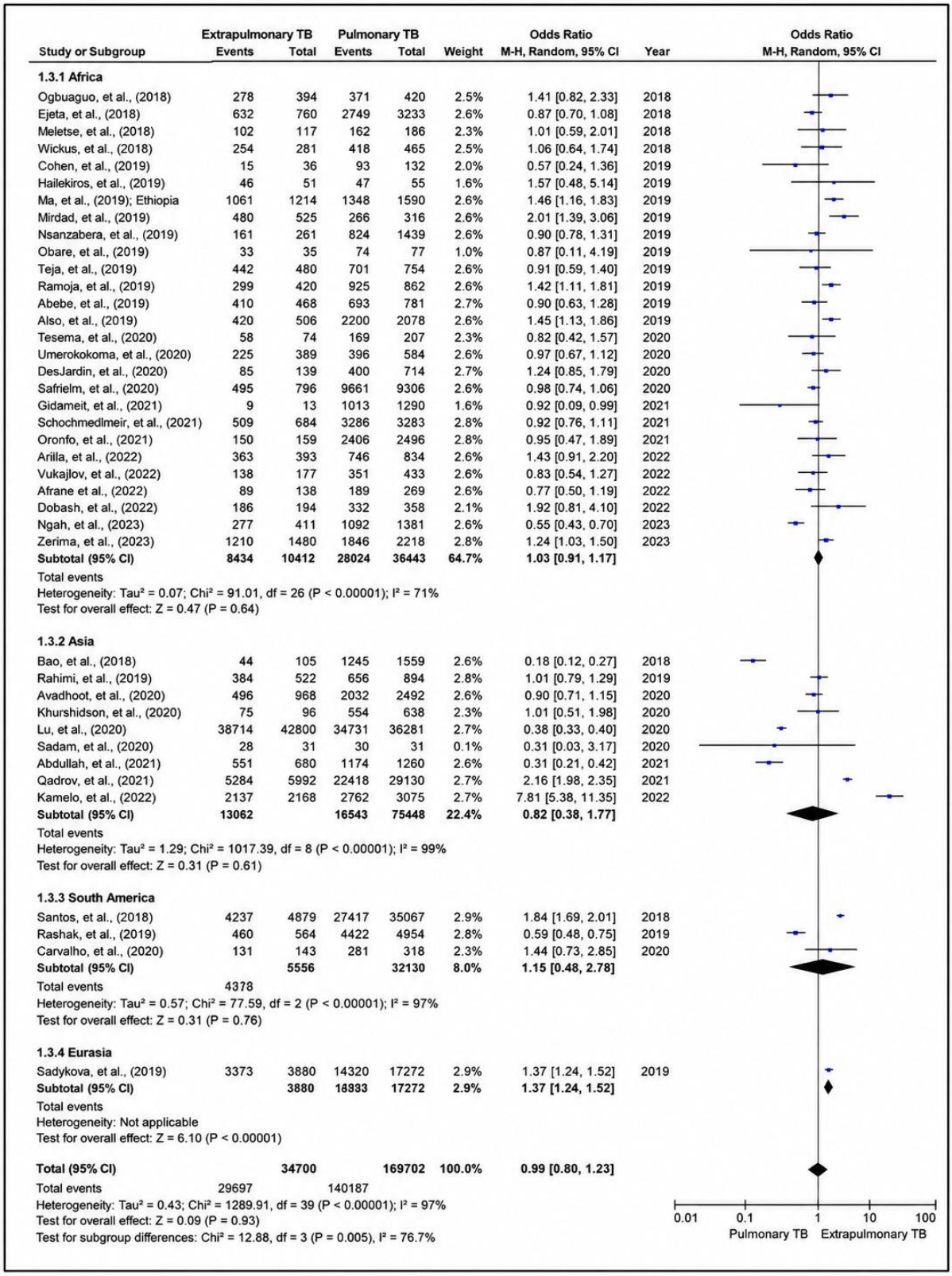
Figure 4.

Pooled Estimate for TB Site (Extrapulmonary Versus Pulmonary) Associated with Treatment Success Rate



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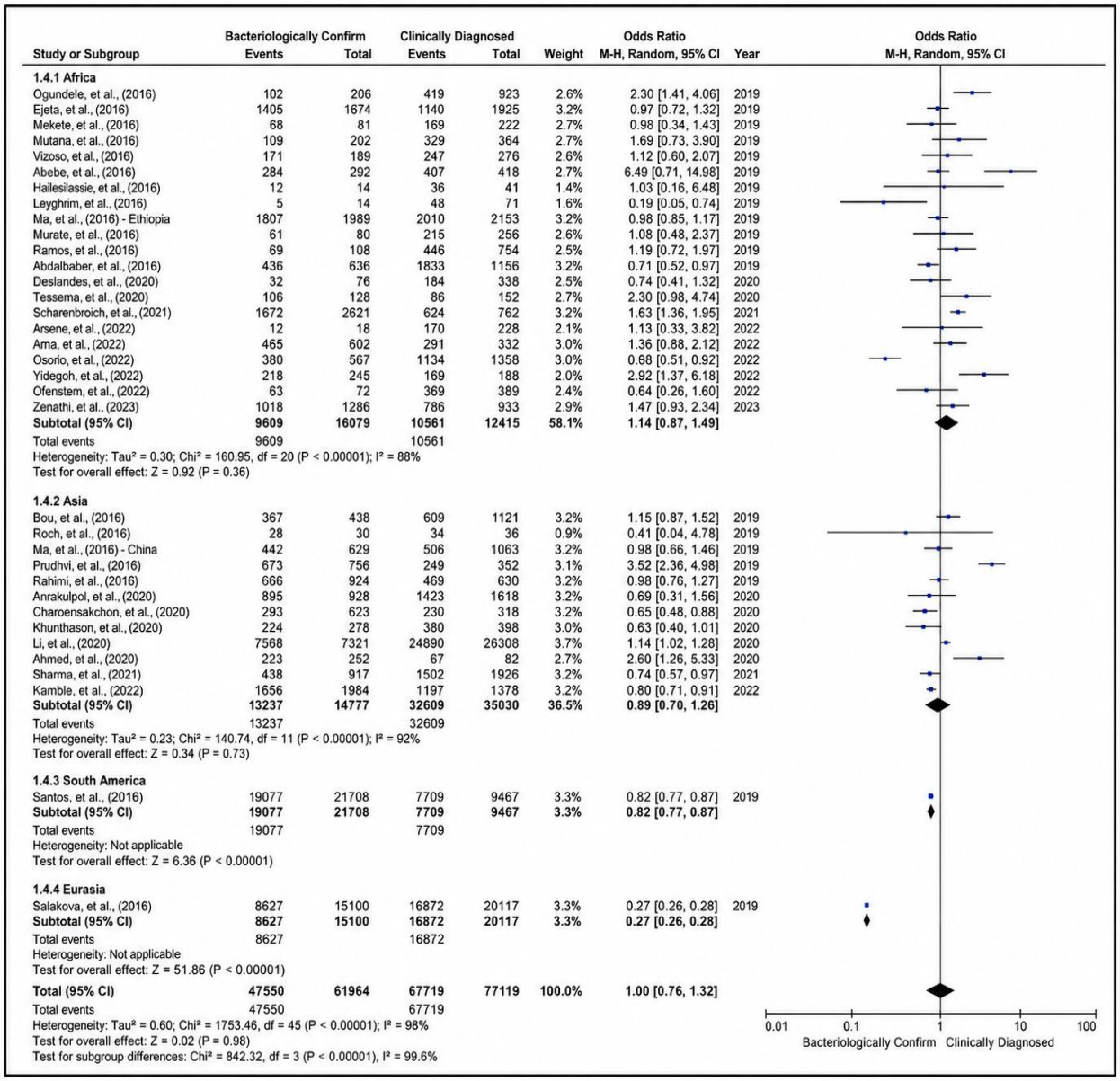
Bacteriological confirmation status (confirmed versus clinically diagnosed) was not significantly associated with treatment success (Figure 5) (OR 1.00, 95% CI 0.75–1.32; $I^2 = 98\%$; $p = 0.98$).

Figure 5.

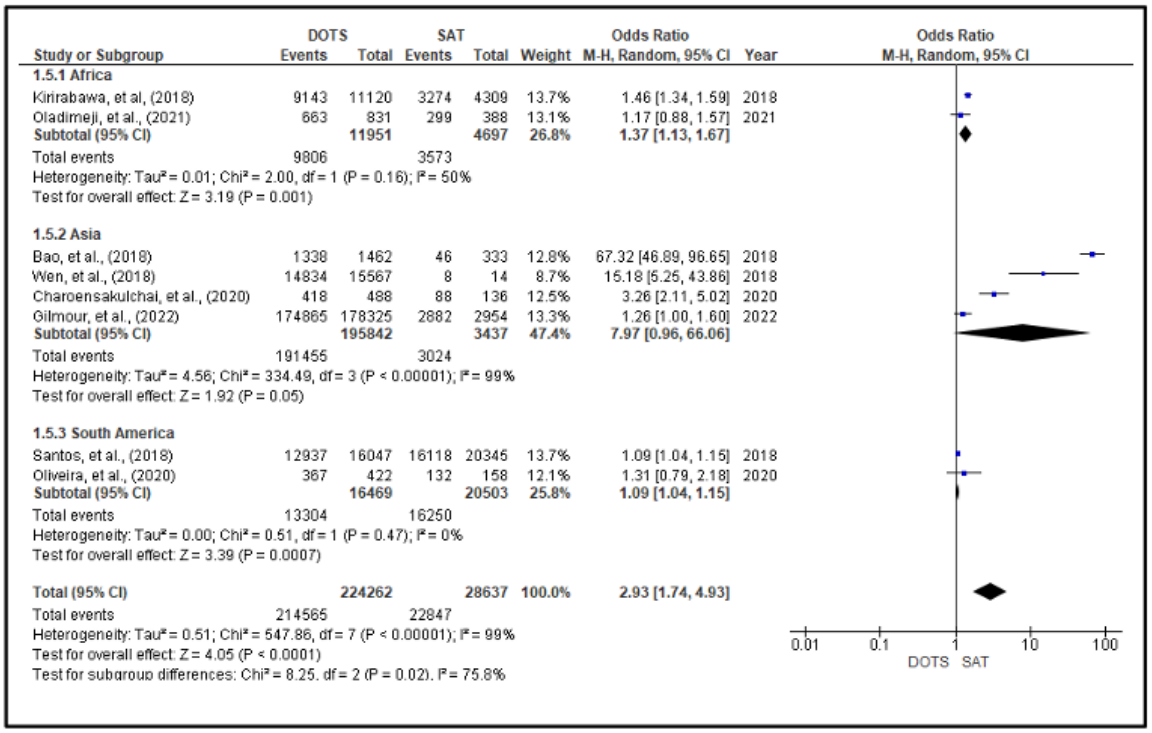
Pooled Estimate for Bacteriological Confirmation Status Associated with Treatment Success Rate



Treatment modality was strongly associated with treatment success (Figure 6): participants receiving DOTS had significantly higher odds of success than those receiving SAT (OR 2.93, 95% CI 1.74–4.93; $I^2 = 99\%$; $p < 0.00001$), a finding consistent across regions. This aligns with Alipanah et al.[9], which found SAT associated with lower treatment success, cure, and adherence than any form of directly observed therapy, though without a discernible difference in mortality, relapse, or drug resistance development.

Figure 6.

Pooled Estimate for Treatment Modality (DOTS Versus SAT) Associated With Treatment Success Rate



Patient residence (rural versus urban) was not significantly associated with treatment success (Figure 7) (OR 0.95, 95% CI 0.79–1.14; $I^2 = 83\%$; $p = 0.58$).

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Figure 7.

Pooled Estimate for Patient Residence (Rural Versus Urban) Associated with Treatment Success Rate

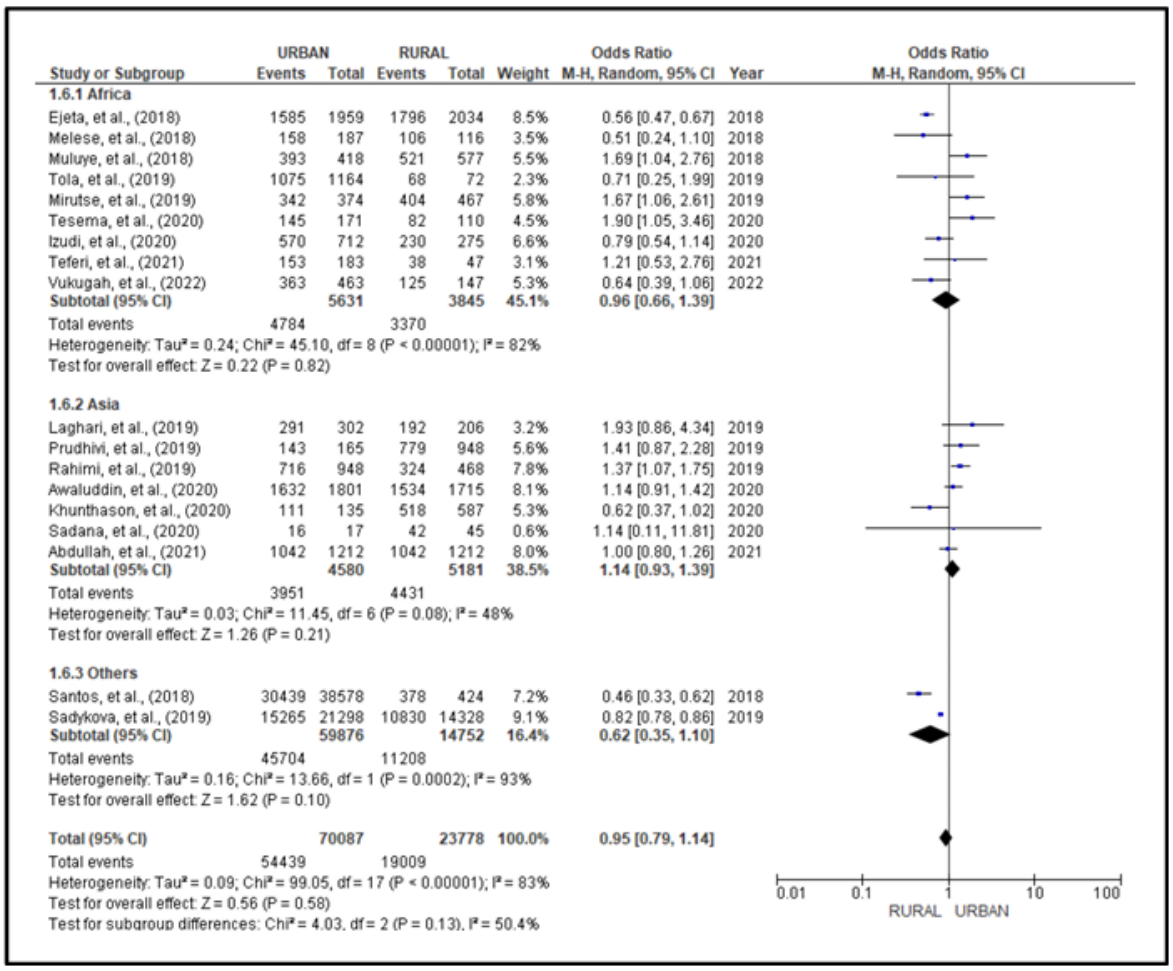
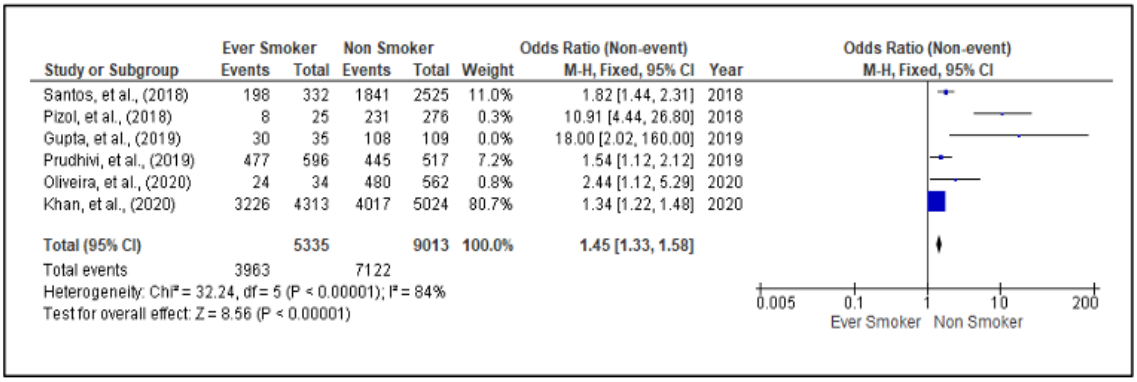


Figure 3.12 The Pooled Estimate for Patient residence set up (Rural VS Urban) (n=18)

Smoking history was significantly associated with treatment success (Figure 8): participants without a smoking history had significantly higher odds of success (OR 1.45, 95% CI 1.33–1.58; $I^2 = 84\%$; $p < 0.00001$). This pooled estimate was generated using a fixed-effects model in RevMan; an inconsistency with the random-effects approach used for other predictors is addressed in the Limitations.

Figure 8

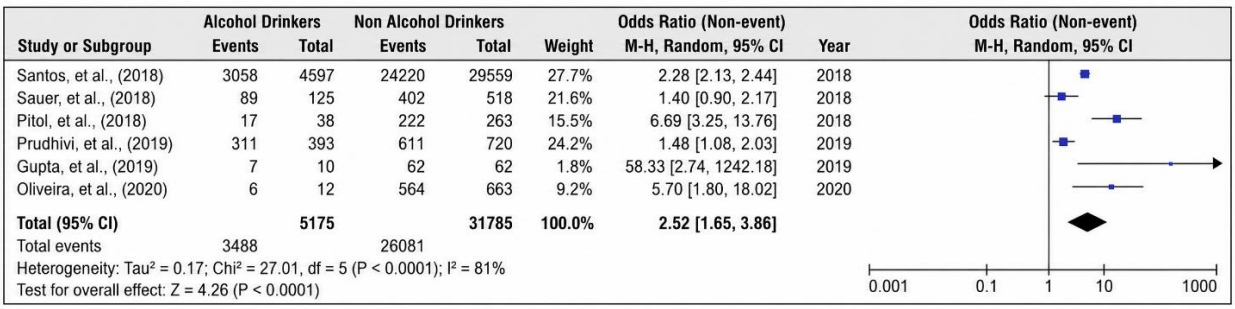
Pooled Estimate for Smoking History Associated with Treatment Success Rate



Alcohol use history was significantly associated with treatment success (Figure 9): participants without a history of alcohol use had significantly higher odds of success (OR 2.52, 95% CI 1.65–3.86; $I^2 = 81\%$; $p < 0.00001$). This is consistent with prior evidence linking alcohol use to poorer TB outcomes (Brecher, 2010; Ragan et al., 2020).

Figure 9.

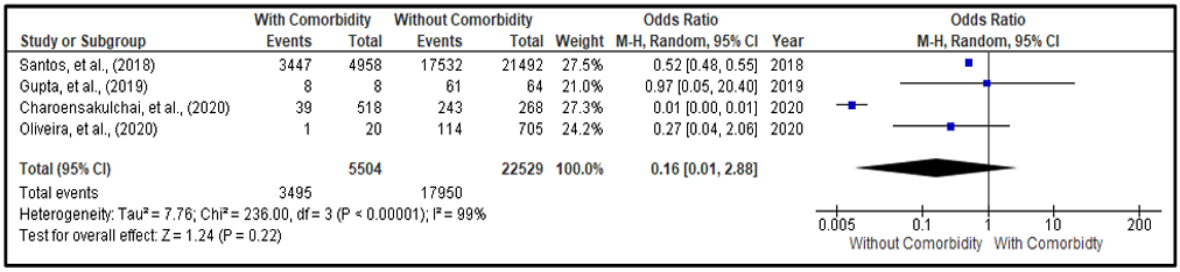
Pooled Estimate for Alcohol Use History Associated with Treatment Success Rate



Non-diabetic comorbidity was not significantly associated with treatment success (Figure 10) (OR 0.16, 95% CI 0.01–2.88; $I^2 = 99\%$; $p = 0.22$), based on only 4 studies.

Figure 10.

Pooled Estimate for Non-Diabetic Comorbidity Associated With Treatment Success Rate



Effects of Interventions

Across all 13 interventional studies, the overall pooled intervention effect size was 1.75 (95% CI 1.45–2.10; $I^2 = 60\%$; $p < 0.00001$), favoring intervention over standard care (Figure 11). Subgroup analysis separated randomized controlled trials from cohort studies; while the RCT subgroup's pooled effect favored intervention, individual RCTs did not reach statistical significance on their own. Five individual studies showed statistically significant, intervention-favoring effects: asynchronous video observed therapy (aVOT) (Doltu et al., ES 17.99, 95% CI 2.47–131.03; $p < 0.00001$), medication event monitoring systems (MEMS) (Park et al., ES 3.55, 95% CI 1.80–7.00; $p < 0.0008$), patient support groups (Potty et al., ES 2.15, 95% CI 1.86–2.48; $p < 0.0008$), pharmaceutical care (Tang et al., ES 2.09, 95% CI 1.01–4.34; $p < 0.0008$), and a modified drug regimen (Ge et al., ES 1.75, 95% CI 1.05–2.92).

aVOT allows patients to record their own medication-taking on a personal device for later clinician review, with non-conformance triggering a home visit or provider call; this approach produced better adherence at lower cost than directly observed therapy in a comparable low-income setting. MEMS uses a sensor-equipped smart pillbox (ePROMMS) that transmits real-time adherence data via a SIM-connected web application, prompting phone calls or home visits when a dose is missed; this was effective in rural Morocco but warrants a prospective cost-effectiveness evaluation before wider adoption. Patient support groups, structured around monthly meetings covering disclosure and stigma, treatment compliance, nutrition, and TB prevention among household members, produced adherence benefits consistent with earlier evidence on TB clubs as a social support model.

Pharmaceutical care involved structured pharmacist follow-up at one, two, and six months post-discharge, covering patient education, urinalysis for isoniazid metabolites, medication counts, laboratory monitoring, and pharmacist-physician review of regimen changes. Heterogeneity across the intervention studies ($I^2 = 60\%$) likely reflects differences in population, methodology, and intervention type and intensity. Funnel plot asymmetry was observed for the intervention synthesis (Figure 12), suggestive of possible publication bias; formal statistical testing (e.g., Egger's test) could not be performed, as this function is unavailable in RevMan, so this interpretation remains qualitative and is noted as a limitation.

Figure 11.

Pooled Effect of Intervention on TB Treatment Success Rate (N = 13)

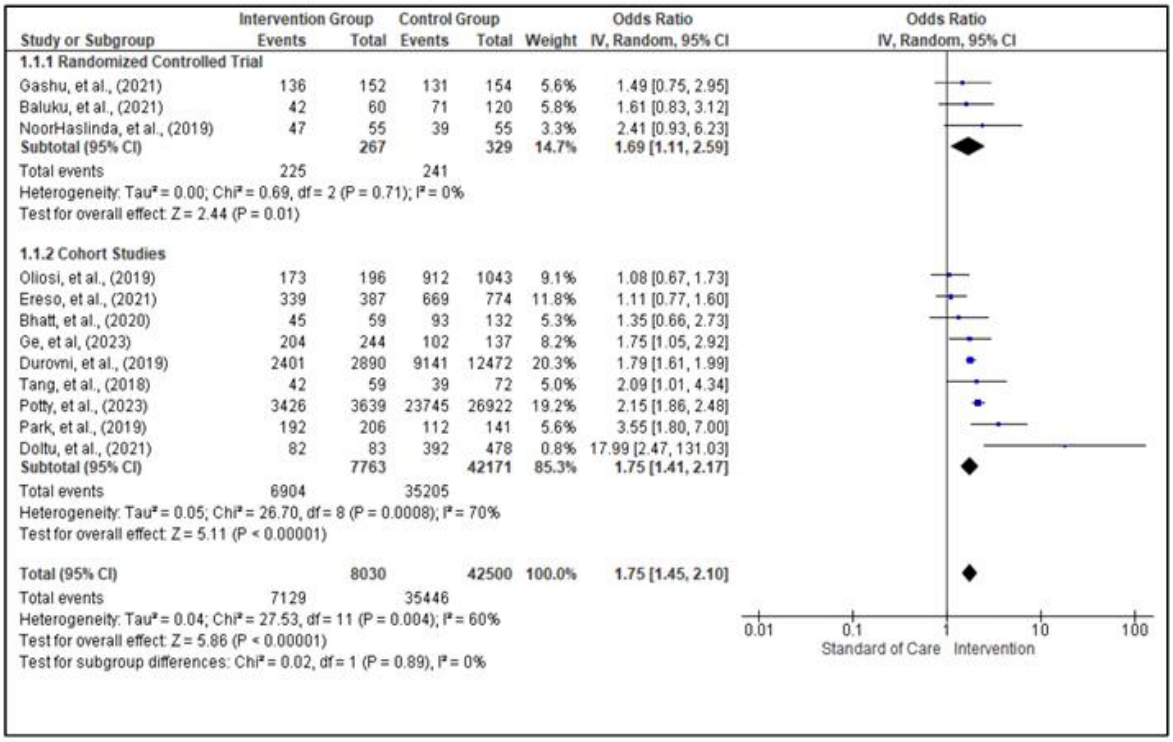
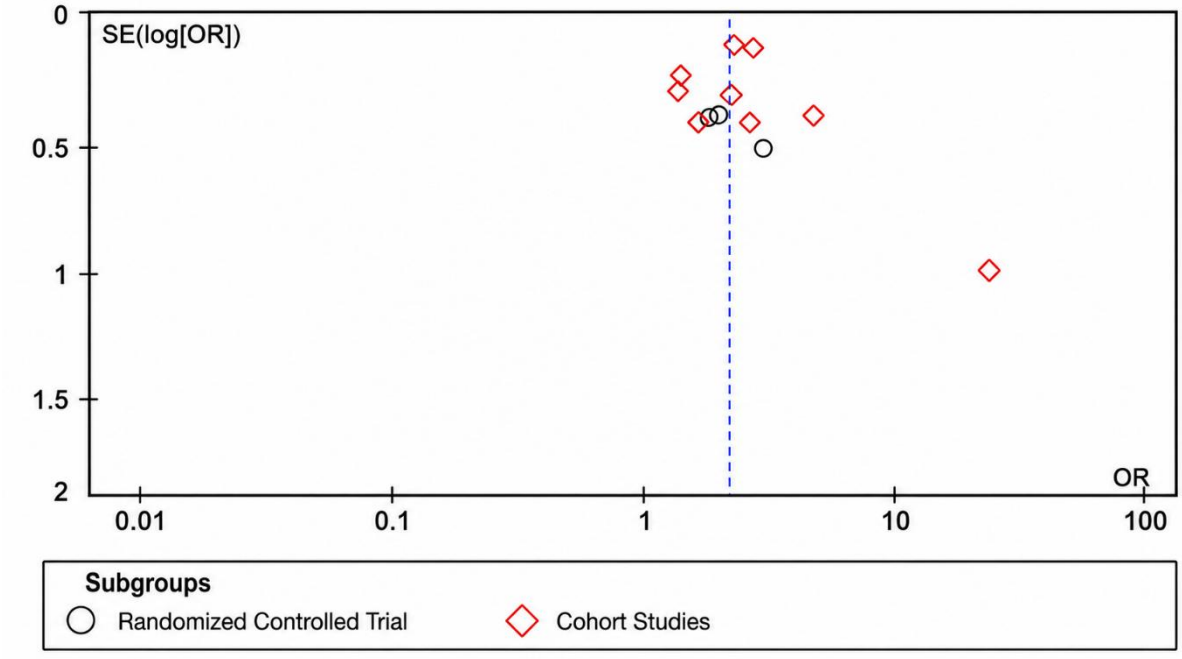


Figure 12.

Funnel Plot for the Pooled Effect of Intervention on TB Treatment Success Rate (N = 13)



DISCUSSION

Principal Findings

This systematic review and meta-analysis synthesized both predictors and interventions associated with drug-sensitive TB treatment success in LMICs using literature from 2018 to 2023. Consistent with earlier reviews, HIV-negative status, new case status, and receipt of DOTS were the strongest predictors of treatment success, while residence, TB site, and bacteriological confirmation were not significant. Beyond confirming these established predictors, this review's central contribution is the quantitative synthesis of intervention effectiveness, including two digital adherence tools, aVOT and MEMS, that were largely unavailable to earlier reviews of this literature.

What This Review Adds Beyond Existing Systematic Reviews

The pooled treatment success rate of 87.6% seen here exceeds the 79% reported by Teferi et al. (2021) in Africa and the 80.1% globally by Chaves Torres et al. (2019). Several reasons likely explain this variation. First, this review's timeframe of 2018–2023 includes newer interventions such as aVOT and MEMS, along with more recent patient-centered care strategies that were not widely available or utilized in earlier literature. Second, this review limited eligibility to LMICs, while previous reviews included broader or different regions. Third, excluding drug-resistant TB, HIV co-infection with advanced disease, and high-income country data removed populations with different baseline risks. Fourth, the high percentage of newly diagnosed, HIV-negative participants—who generally have better outcomes—probably contributed to the higher success rate. These differences emphasize that this review is not just a repeat of previous predictor analyses on a new population but also offers, for the first time in this field, a quantification of which adherence interventions have significant support specifically in LMICs.

Interpretation of Predictor Findings

Only 46% of included studies reported treatment success rates exceeding the WHO's 85% standard, underscoring persistent gaps despite the higher pooled estimate. The consistency of HIV status, case type, and treatment modality as predictors across this and earlier reviews strengthens confidence that these are genuine, generalizable risk factors rather than artifacts of any single review's inclusion criteria. Smoking and alcohol use history were also significantly associated with treatment success, consistent with known immunopathological mechanisms linking both exposures to impaired TB-relevant immune function. Conversely, the null findings for residence, TB site, and bacteriological confirmation suggest that, at the pooled level, these factors carry less independent predictive weight than clinical and treatment-history variables, though substantial heterogeneity (I^2 often exceeding 90%) across all predictor analyses means pooled point estimates should be read as general directional signals rather than precise, universally applicable values.

Interpretation of Intervention Findings

The five interventions with statistically significant effects, aVOT, MEMS, patient support groups, pharmaceutical care, and a modified drug regimen, share a common focus on medication adherence, reinforcing adherence support as the most actionable lever available to LMIC TB programs. The magnitude of aVOT's effect size (17.99) is notable but should be interpreted cautiously given it derives from a single cohort study with a wide confidence interval (2.47–131.03); this is a signal warranting further trials, not yet a settled effect size. Feasibility of aVOT and MEMS specifically depends on smartphone access, digital literacy, and network connectivity, all of which vary substantially across and within LMICs; claims about scalability should be interpreted within each setting's infrastructure constraints rather than generalized uniformly across the LMIC category.

Limitations

Several limitations should be acknowledged. This review was not prospectively registered in PROSPERO or another public registry. Some included studies lacked comprehensive demographic data, and reliance on observational studies with methodological variability may have introduced bias; the substantial heterogeneity observed (I^2 exceeding 90% for several predictors) reflects differences in study design, population characteristics, TB strain variability, and DOTS implementation models across settings, and pooled estimates should be interpreted as general trends rather than uniform effects. The pooled estimate for smoking history (Figure 8) was generated using a fixed-effect model in RevMan rather than the random-effects model used elsewhere in this review; given $I^2 = 84\%$ for this comparison, a random-effects re-analysis is recommended before this specific estimate is relied upon, and it is flagged here rather than silently presented as equivalent to the other predictor estimates. Funnel plot asymmetry suggested possible publication bias in the intervention synthesis, but formal testing (e.g., Egger's test) was not possible within RevMan, so this remains a qualitative impression. One data entry in the observational studies table (Afrane et al. 2022, child success rate) is not a plausible percentage and is flagged for verification against the original source rather than silently corrected. Finally, as with any pooled analysis drawing on studies with very different reporting completeness (from 7% to 56% of studies reporting a given subgroup variable), the predictor estimates carry different degrees of evidentiary weight, and this should inform how confidently each is applied in practice. Additionally, although risk of bias was assessed independently by two reviewers with disagreements resolved by discussion, a formal inter-rater agreement statistic (e.g., Cohen's kappa) was not computed and could be reported in future updates of this review.

CONCLUSIONS

The pooled treatment success rate for drug-sensitive TB across included studies was 87.6%, surpassing the World Health Organization's 85% treatment success benchmark and reflecting a favorable clinical shift in LMIC settings during the 2018–2023 review period. This systematic review and meta-analysis confirms that HIV-negative status, new case status, receipt of DOTS, and absence of smoking or alcohol use are significant predictors of drug-sensitive TB treatment success in LMICs, consistent with earlier reviews. Its principal contribution is the first quantitative synthesis, specific to LMICs, of adherence-focused intervention effectiveness using literature through 2023: asynchronous video observed therapy, medication event monitoring systems, patient support groups, pharmaceutical care, and a modified drug regimen all showed statistically significant improvements in treatment success. These findings support prioritizing adherence-focused interventions in TB programs, tailored to local digital infrastructure and resource constraints, while underscoring the need for further, adequately powered trials of digital adherence tools before large-scale implementation.

RECOMMENDATIONS

Practical. TB programs in LMICs should focus on adherence interventions that have proven effectiveness, especially patient support groups and pharmaceutical follow-up. These approaches need less digital infrastructure than aVOT or MEMS and are easier to scale across different resource settings. Additionally, programs should maintain a focus on case management based on key predictors such as HIV status, case type, and DOTS delivery, as these factors consistently influence treatment success.

Theoretical. This review reframes adherence support, rather than structural or demographic factors, as the most actionable lever for improving TB treatment success in LMICs, and extends the predictor literature by situating newer digital adherence tools within the same evidentiary framework as established interventions.

Policy. Before investing in scale-up of aVOT or MEMS, policymakers should assess local smartphone access, digital literacy, and network reliability, given that feasibility varies substantially across and within LMICs; national TB programs should also encourage prospective registration (e.g., PROSPERO) of future reviews in this area to support transparency.

Future Research. Adequately powered, multi-site trials of aVOT and MEMS are needed to confirm the wide-interval effect sizes reported here from single studies; a random-effects re-analysis of the smoking-history estimate, formal publication-bias testing (e.g., Egger's test) once more intervention studies are available, and more consistent subgroup-level reporting across primary studies would strengthen future syntheses.

List of Abbreviations

aVOT: asynchronous video observed therapy
CI: confidence interval
DOTS: directly observed treatment, short-course
DR/MDR-TB: drug-resistant / multidrug-resistant tuberculosis
EPTB: extrapulmonary tuberculosis
ePROMMS: electronic patient-reported outcome measures and monitoring system
ES: effect size
HIV: human immunodeficiency virus
JBI: Joanna Briggs Institute
LMIC: low- and middle-income country
MEMS: medication event monitoring system
OR: odds ratio
PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PTB: pulmonary tuberculosis
RCT: randomized controlled trial
RR: risk ratio
SAT: self-administered therapy
SP: smart pillbox
TB: tuberculosis
WHO: World Health Organization

Declarations

Ethics approval and consent to participate. Not applicable. This study used previously published, de-identified aggregate data and did not require ethics approval or participant consent.

Consent for publication. Not applicable.

Availability of data and materials. The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request. Data extraction templates and analytic scripts used for this review are likewise available from the corresponding author upon reasonable request.

Competing interests. The authors declare that they have no competing interests.

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Use of Artificial Intelligence Tools. No AI tools, including large language models, were involved in designing the study, extracting data, conducting statistical analysis, or interpreting results. During manuscript preparation, language editing or literature searches were aided by Grammarly and Perplexity AI tools.

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