

Diabetes screening among people with tuberculosis: a systematic review and meta analysis



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Summary

Background Tuberculosis (TB) remains a major public health challenge, with 10.8 million people developing TB in 2023. Diabetes mellitus (DM) is associated with an increased risk of TB and adverse TB outcomes. The prevalence of DM is rising, especially in regions of the world where TB is endemic. Early detection and proper management of DM in those with TB may improve outcomes.

Methods We performed a systematic review and meta-analysis of the yield of screening and the prevalence of DM among people with TB. Databases searched included PubMed, Cochrane CENTRAL, CINAHL, Embase, Global Health, LILACS, and Web of Science between January 2000 and September 2025. We included studies on the yield and prevalence of DM determined through DM screening among people with TB, where TB was identified microbiologically. All records were independently screened by two reviewers and discrepancies resolved by discussion. Risk of bias (RoB) was assessed using the Hoy tool for prevalence studies. Studies were pooled using random-effects meta-analysis with inverse variance weighting and stratified by World Health Organization (WHO) region and age (over and under 40 years). This systematic review and meta-analysis is registered online on PROSPERO CRD42023425596.

Findings Our search retrieved 7530 studies. After full-text screening we included 33 studies involving 19,581 individuals with TB from 21 countries. The overall pooled yield of DM screening in people with TB was 7.8% (95% CI: 5.1–11.1), ranging from 2.6% (95% CI: 1.5–4.0) in the Western Pacific region (3 studies from 1 country) to 31.6% (95% CI: 12.4–54.3) in the Eastern Mediterranean region (3 studies from 2 countries).

Interpretation DM is common among people with TB. The yield of DM screening was greater in the Eastern Mediterranean and South-East Asia regions which had a higher prevalence of DM. Findings were limited by substantial heterogeneity across studies and lack of comparison groups without TB in included studies. Future studies are needed to optimize approaches to detect DM among people with TB.

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Research in context

Evidence before this study

Data on the yield and prevalence of diabetes mellitus (DM) in people with tuberculosis (TB) disease is important for assessment of the burden of comorbid TB and DM disease, and is also useful for resource allocation and planning. However, to our knowledge, there are limited estimations of the yield of DM screening in TB patients using rigorous diagnostic criteria from various countries and regions worldwide. We searched PubMed (National Library of Medicine), Cochrane CENTRAL (Cochrane Library), CINAHL (EBSCOhost), Embase (Elsevier), Global Health (CABI direct) LILACS (Pan American Health Organization) and Web of Science (via Clarivate) databases, between January 2000 and September 2025 for papers published in English Spanish, French, Mandarin, Cantonese, and Portuguese. We used the terms “tuberculosis” (including “TB,” “*Mycobacterium tuberculosis*”), “diabetes mellitus” (including “diabetes,” “DM,” “hyperglycemia,” “dysglycemia”), “screening” (including “diagnosis,” “detection”), and “prevalence” (including “epidemiology,” “incidence”), along with their Medical Subject Heading (MeSH) terms and synonyms to systematically search the databases. After removal of duplicates, our search yielded 7530 results.

Added value of this study

We provide estimates of the yield of DM screening among people with TB based on rigorous World Health Organization diagnostic criteria from various regions worldwide. We analyzed 33 studies involving 19,546 individuals with TB from 21 countries. The overall yield of diabetes screening was 7.8% (95% CI: 5.1–11.1), with substantial regional variation ranging from 2.6% in the Western Pacific Region to 31.6% in the Eastern Mediterranean Region. The yield was substantially higher in populations with mean age 40 years and older (12.6%) compared with younger populations (4.5%). The overall prevalence of diabetes among tuberculosis patients was 16.2% (95% CI: 12.2–20.7).

Implications of all the available evidence

DM is common among people with TB globally, with substantial numbers of undiagnosed cases that can be identified through screening. The considerable regional and age-related variation in screening yield suggests that screening programs should be adapted to local epidemiological contexts.

Introduction

Tuberculosis (TB) remains a major global public health challenge. In 2023 an estimated 10.8 million people developed TB disease, and approximately 1.25 million people died from TB.¹ Diabetes mellitus (DM) is a key health related risk factor for TB,¹ and is associated with a twofold increased risk of TB disease² as well as worse TB outcomes including an increased risk of treatment failure, death, and relapse.³ As of 2022, an estimated 828 million adults aged 18 and older were living with DM, which is more than four times that of 1990.⁴ In addition, low- and middle-income countries (LMICs) have experienced the largest increases in DM, however treatment access remains persistently low.⁴ Many LMICs with a growing DM burden also have a high burden of TB.⁵

In 2011 the World Health Organization (WHO) published the Collaborative Framework for Care and Control of Tuberculosis and Diabetes. This framework recommended DM screening among people with TB at the start of TB treatment in order to detect undiagnosed DM and offer co-management for both conditions.⁶ Given this recommendation, data on the yield and prevalence of DM in people with TB disease is important for assessment of the burden of comorbid TB and

DM and is also useful for resource allocation and planning. A previous systematic review including data from 200 studies spanning 50 countries provided estimates of the prevalence of DM among people with TB at global, regional, and country levels.⁷ In this review the prevalence of DM among people with TB was 15.3%, with results varying substantially by age, sex, regions, level of country income, and development.⁷ However, this review did not report on the yield of screening for DM among people with TB, and there have been numerous additional studies reporting the yield of DM screening in people with TB published since.^{8–15} Furthermore, as this review primarily explored the prevalence of DM in people with TB, the identification of new episodes of DM was not the main focus. DM was identified by physician records, or by measured fasting plasma glucose, or an oral glucose tolerance test (OGTT) according to WHO criteria, and in some cases, it was self-reported. Confirmatory tests of DM were not conducted to ensure accuracy of the DM diagnosis. Therefore, we conducted a systematic review and meta-analysis to determine the yield of screening (defined as a strategy for identifying diabetes in an at-risk population, using an initial test followed by a subsequent confirmatory test) and prevalence of DM

among people with confirmed TB disease using WHO diabetes diagnostic criteria.¹⁶

Methods

Search strategy and selection criteria

We performed a systematic review and meta-analysis reporting on the yield and prevalence of DM determined through DM screening among people with TB, specifically, those diagnosed with TB disease or receiving TB treatment. We considered yield of screening for newly diagnosed DM as the number of new DM cases detected divided by the number of people with TB who were screened for DM (excluding those with a prior DM diagnosis).

We included studies where TB was identified microbiologically (i.e. by sputum smear microscopy, culture, or with a molecular WHO-recommended rapid diagnostic test (mWRD)) (Supplementary Text 1). We excluded studies where TB was diagnosed solely by clinical and/or radiological methods. As our primary outcome was yield of screening for DM, individuals with previously diagnosed/known DM were not included in the numerator or denominator. A case of DM identified through screening was considered newly diagnosed only if it met the WHO criteria for diagnosing DM¹⁷ (Supplementary Text 1). Screening was defined as the entire two-stage process of identifying a person who is more at risk of DM using an initial glycemic test and then confirming DM with a subsequent confirmatory glycemic test. Therefore, for a study to be included, the initial test and confirmatory test for DM must have been conducted at the start of TB treatment to confirm a DM diagnosis, or by a single glycemic test supported by classic diabetes symptoms (e.g., frequent urination, thirst) (Supplementary Text 1). Studies with DM identified by self-report or medical records only were excluded.

We included cross-sectional or longitudinal studies that had either an initial and confirmatory test for DM, or a single glycemic test supported by classic diabetes symptoms. We excluded retrospective studies, case series, systematic reviews, narrative reviews and studies that did not report a numerator and denominator for DM and TB. In addition, we excluded studies that did not report on the age distribution of participants as we aimed to analyze the yield of screening by age group given that DM prevalence is age dependent.

A comprehensive search strategy was developed using search terms from previously published systematic reviews related to TB and DM^{18–21} and with support from an information specialist (MSW). Key words, Medical Subject Heading (MeSH) terms and synonyms for TB, diabetes and screening were included in the search strings. The search strategy (adapted for use in all databases) is available in Supplementary Text 2. Databases searched included PubMed (National Library of Medicine), Cochrane CENTRAL (Cochrane Library),

CINAHL (EBSCOhost), Embase (Elsevier), Global Health (CABI direct) LILACS (Pan American Health Organization) and Web of Science (via Clarivate), between January 2000 and September 2025.

Retrieved studies were imported into Covidence. After de-duplication, titles and abstracts were independently screened by two reviewers. Data extraction of summary estimates from eligible full-texts articles was independently conducted by two reviewers. Any discrepancies were resolved by discussion or by consulting with a third team member. Articles in Spanish, French, Mandarin, Cantonese, and Portuguese were reviewed by a native speaker at the title and abstract, full text, and data extraction phases. Texts in all other languages besides English and the languages previously mentioned were excluded. We noted reasons for exclusion and followed Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines for reporting the study selection process (Fig. 1).^{22,23} A protocol for this systematic review was published in advance in PROSPERO (2023; CRD42023425596; https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42023425596).

Data analysis

A standardized extraction form was developed in Excel and was piloted using five studies. Information extracted included study period, design, setting, inclusion and exclusion criteria of study participants, total sample size, sex and age distributions, weight, body mass index, the presence of human immunodeficiency virus (HIV) and other comorbidities, type of glycemic tests for DM screening and confirmation (i.e. fasting blood glucose, oral glucose tolerance tests, glycated hemoglobin), existing and new DM diagnoses, timepoints of DM testing, diagnostic tests used for TB, type of TB (pulmonary/extrapulmonary), drug-resistant/drug susceptible TB, TB treatment regimen, potential confounders, and length of follow-up.

Native language speakers assisted with extracting data from studies not published in English. Double data extraction was carried out on all studies. In case of missing data or unclear information, study authors were contacted for clarification.

We performed random-effects meta-analyses using the DerSimonian-Laird method²⁴ to estimate pooled diabetes prevalence and yield of screening in TB patients. We used random-effects models as epidemiological measures such as diabetes prevalence and screening yield vary substantially between populations. Therefore, the fixed-effect assumption of one true prevalence across all studies is implausible given the diversity of settings in our analysis.²⁵ Meta-analysis of proportions was performed using Stata's `metan` command with the `proportion` option. Proportions were stabilized using the Freeman-Tukey double arcsine transformation²⁶ prior to pooling, with pooled estimates back-transformed to the original scale. Individual

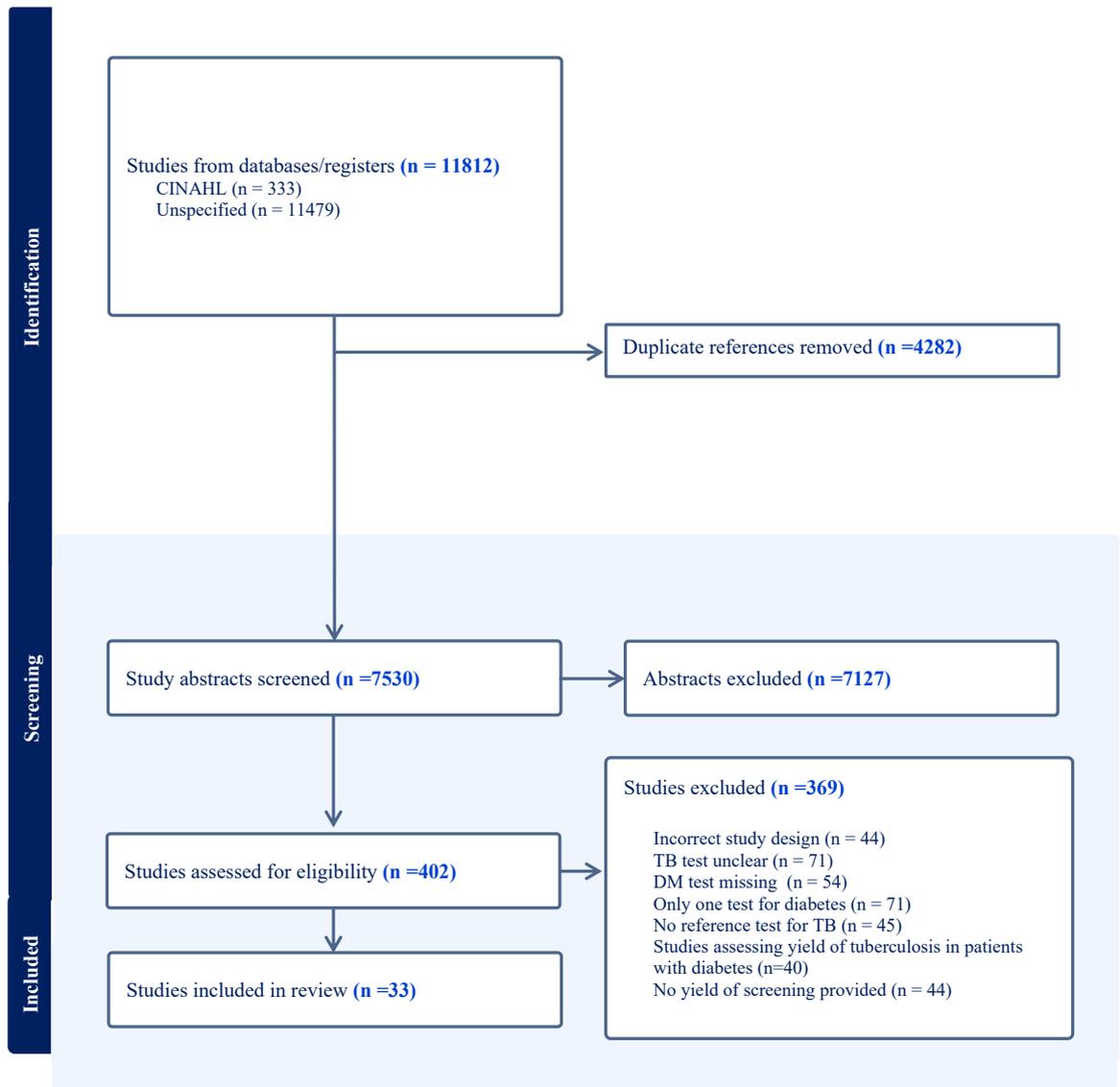


Fig. 1: Review flow diagram.

studies were weighted using the inverse-variance method, with greater weight given to larger, more precise studies. Pooled estimates were calculated as the inverse-variance weighted mean of the transformed proportions, where weights incorporate both within-study variance and between-study variance (τ^2). Confidence intervals for individual studies were calculated using the exact method (Clopper-Pearson), as several studies were small with few events, making this method more reliable than asymptotic approximations. Confidence intervals for pooled estimates were calculated using the Wald method on the transformed scale, then back-transformed to the proportion scale to provide 95% confidence intervals.²⁷

Heterogeneity across studies was quantified using Cochran’s Q test, the I^2 statistic with 95% confidence intervals based on the Gamma distribution, and between-study variance (τ^2) estimated using the DerSimonian-Laird method.²⁴ Meta-regression was performed to examine study-level characteristics that might explain heterogeneity in screening yield and diabetes prevalence. We used inverse-variance weighted linear regression with robust standard errors, where the dependent variable was each study’s proportion estimate (transformed using the Freeman-Tukey transformation²⁶) and analytic weights were equal to the inverse of the squared standard error of each study’s transformed proportion. We examined three categorical

predictors: (1) WHO region (Africa, South-East Asia, Americas, Eastern Mediterranean, Western Pacific, Europe), (2) age category of study population (mean/median age <40 years vs \geq 40 years), and (3) (no use of OGTT vs use of OGTT). We fitted both unadjusted models and an adjusted model including all three predictors simultaneously. The proportion of heterogeneity explained by each model was quantified using the adjusted R^2 statistic. Meta-regression was performed separately for screening yield and diabetes prevalence. Publication bias was assessed using the Luis Furuya-Kanamori (LFK) index, which is specifically designed for meta-analyses of proportions.²⁸ All statistical analyses were performed using Stata version 18.0 (Stata-Corp LLC, College Station, TX, USA). The metan command was used for meta-analysis and the regress command for meta-regression.²⁷

The yield of screening for newly diagnosed DM was calculated as the number of new DM cases detected divided by the number of people with TB who were screened for DM (excluding those with a prior DM diagnosis). The prevalence of DM was calculated as the number of DM cases (new and previously diagnosed) divided by the number of people with TB who were screened for DM. Ninety-five percent confidence intervals (CIs) were calculated using the Freeman-Tukey double arcsine transformation to stabilize the variance of proportions reported from each study.²⁹ The number needed to screen to identify one new DM case was estimated as the inverse of the yield of screening. We also calculated the prevalence of DM which included people with newly diagnosed DM and previously diagnosed DM. For those previously diagnosed with DM, we used the authors' definition of DM since it was not always possible to determine how DM was identified. We also assessed trends in glycemia over time when data were available and when tests were conducted at least 2 months apart.

Descriptive statistics were reported from the studies or calculated, where possible. Meta-analyses and forest plots were used to examine the results for both yield and prevalence and were stratified by 1) WHO region, and 2) mean/median age of study participants. Finally, we carried out meta-regression analyses to examine heterogeneity in the yield and prevalence estimates. Outputs from our meta-regression are included in [Supplementary Text 3](#). All analyses were performed in STATA (version 18).³⁰

Risk of bias (RoB) was assessed using the Hoy tool for prevalence studies,³¹ and visualized using the Robvis software.³² Two domains, "Were data collected directly from the subjects (as opposed to a proxy)?" and "Was an acceptable case definition used in the study?" were excluded as they were inclusion criteria in our study.

Ethics statement

This study is a systematic review and meta-analysis of previously published literature and did not involve

primary data collection from human participants. As such, ethical approval and informed consent were not required. All included studies had obtained appropriate ethical approvals from their respective institutions as reported in the original publications.

Role of funding source

This study was funded by the World Health Organization (WHO). The funder of the study had no role in data collection, or data analysis. However, WHO staff co-authored the study and were involved in aspects of design, data interpretation and editing of the report. The authors alone are responsible for the views expressed in this publication and they do not necessarily represent the views, decisions or policies of the institutions with which they are affiliated.

Results

After removal of duplicates, 7530 records were identified for title and abstract screening. In total, 402 studies were selected for full-text review ([Fig. 1](#)). The main reasons for exclusion were: diagnostic test to confirm DM was not repeated where necessary ($n = 71$), or tests used for TB screening not reported ($n = 71$). There were no studies excluded due to language restrictions. We contacted six authors with queries concerning study details that influenced inclusion in the review; four responded.

Study characteristics

In total, 33 studies met our inclusion criteria. All 33 studies used a cross-sectional study design. These studies included 19,581 individuals with TB who were screened for DM from 21 countries across 6 WHO regions; 11 studies from 8 countries in the African region (Democratic Republic of Congo, Ethiopia, Gabon, Mali, Mozambique, South Africa, Uganda, United Republic of Tanzania), 8 studies from 5 countries in South-East Asia (Bangladesh, India, Indonesia, Myanmar, Nepal), 7 studies from countries in the Americas (Brazil, Colombia, Mexico, Peru), 3 studies from 2 countries in the Eastern Mediterranean region (Islamic Republic of Iran, Pakistan), 3 studies from 1 country in the Western Pacific region (China), and 1 study from Europe (Romania).

Study sample sizes ranged from 70³³ to 3009¹⁵ participants. One study,³⁴ had a minority (39.9%) of male participants. In all other studies, the majority of participants were male, with proportions ranging from 54.0%³³ to 80.7%.¹¹ The median age of participants ranged from 30³⁵ to 50³⁴ years and the mean age ranged from 34¹³ to 58 years.³⁶ The weighted mean age of study participants varied by region, and was 34.6 years in the Africa region, 38.1 years in the Americas, 43.0 years in Europe, 43.2 years in the Eastern Mediterranean region, 43.9 years in the Western Pacific, and 44.9 in the South East Asia region.

Among the 19,581 individuals, a total of 1494 (7.6%) people already had a diagnosis of DM. Therefore 18,087 (92.3%) did not have previously known DM (Table 1).

In total, 17 studies (51.5%) included only people with pulmonary TB, while 12 studies (36.4%) included individuals with both pulmonary and extrapulmonary TB; 4 studies (12.1%) did not report on the type of TB present. Strategies for DM screening varied. The majority of studies (n = 22) reported screening for DM at the beginning of TB treatment, while 11 studies conducted DM screening at treatment initiation and then conducted additional tests more than 1 month after.

Screening yield

Among 18,087 people without a prior history of DM, 1837 new diagnoses of DM were found, equating to a pooled screening yield across 33 studies of 7.7% (95% CI: 5.0–11.0), ranging from 0.0% to 57.0% (Table 1 and Fig. 2). The yield varied by WHO region: in the African region (11 studies) the yield was 4.0% (95% CI: 2.6–5.8), in South-East Asia (8 studies) 12.3% (95% CI: 7.5–18.2), in the Americas (7 studies) 4.9% (95% CI: 2.0–8.9), in the Eastern Mediterranean (3 studies) 31.6% (95% CI: 12.5–54.3), in the Western Pacific (3 studies all from China) 2.6% (95% CI: 1.5–4.0) and in one study from Europe it was 6.6% (95% CI: 4.5–9.2).

For the 18 studies where the mean/median age was <40 years, the overall yield was 4.5% (95% CI: 3.3–5.9). In the 15 studies with a mean/median age of 40 years and above, the yield was 12.6% (95% CI: 6.9–19.8). In four of these studies a yield of greater than 20% was reported (Supplementary Figure S1). There was considerable heterogeneity in the yield of DM amongst the included studies (Fig. 2). This likely reflects the diverse study populations, methodological differences, and varying DM prevalence across the multiple studies represented. Assessment of publication bias using the LFK index (Supplementary Figure S3) revealed no evidence of asymmetry for screening yield (LFK = 0.78), suggesting that publication bias is unlikely to have substantially affected our pooled estimates.

Diabetes prevalence

A total of 1494 people already had a diagnosis of DM. This meant that there were 3331 individuals with DM amongst 19,581 individuals with TB. The pooled overall prevalence of DM in TB was 16.0% (95% CI: 12.0–20.5) (Table 1 and Fig. 3). As with yield, the prevalence of DM varied in the included studies by WHO region: in the African region (11 studies) it was 6.8% (95% CI: 4.7–9.1), in South-East Asia (8 studies) 24.5% (95% CI: 15.6–34.7), in the Americas (7 studies) 16.1% (95% CI: 10.4–22.7), in the Eastern Mediterranean (3 studies) 41.0% (95% CI: 13.0–72.2), in the Western Pacific (3 studies) 13.3% (95% CI: 6.8–21.3) and in the one study from Europe it was 13.0% (95% CI: 10.2–16.3).

In 19 studies which included participants with a mean or median age less than 40 years, the DM prevalence was 10.0% (95% CI: 7.8–12.4) compared with a prevalence of 25.8% (95% CI: 17.2–35.4) among 14 studies which included participants with a mean/median age 40 years or higher. In 8 studies with a mean/median age of 40 years or higher the prevalence was greater than 20% (Supplementary Figure S2).

Glycemic trends during TB treatment

We identified n = 11 studies where DM screening was carried out at the start of TB treatment, and repeat glycemic measurements were performed during TB treatment using the same tests at baseline and follow-up.^{11,12,14,15,36,37,46,49–51,55} These studies reported a downward trend in glucose levels over time. In one study, amongst people with newly diagnosed DM at the time of TB treatment initiation HbA1c dropped by 2.5 percentage points within the first three months of TB treatment without any glucose-lowering therapy.¹¹ Another study reported that among those with newly diagnosed DM, 46% and 62% no longer had hyperglycemia after three months and six months of TB treatment, respectively.⁵⁰

Assessment of heterogeneity

Substantial heterogeneity was observed across studies for both screening yield ($I^2 = 98.2\%$, 95% CI: 95.6%–99.0%; Cochran's Q = 1739.52, df = 32, $p < 0.001$; $\tau^2 = 0.102$) and diabetes prevalence ($I^2 = 98.5\%$, 95% CI: 96.4%–99.1%; Cochran's Q = 2071.64, df = 32, $p < 0.001$; $\tau^2 = 0.112$). This heterogeneity likely reflects diverse study populations, methodological differences, and varying diabetes prevalence across settings. Meta-regression analyses demonstrated that WHO region alone explained 73.7% of heterogeneity in screening yield ($R^2 = 0.737$) and 54.4% of heterogeneity in diabetes prevalence ($R^2 = 0.544$).

Meta-regression analysis of screening yield confirmed statistically significant differences between regions. The Eastern Mediterranean region had a statistically higher yield than all other regions while Africa had a significantly lower yield than the Southeast Asian, Eastern Mediterranean and European regions, but not the Americas or the Western Pacific (Fig. 2). For prevalence, all regions except the Western Pacific were statistically significantly higher than Africa. This remained the case after adjusting for age.

Assessment of publication bias

Assessment of publication bias using the LFK index revealed no evidence of asymmetry for screening yield (LFK = 0.78) or diabetes prevalence (LFK = 0.31), (Supplementary Figure S3) suggesting that publication bias was unlikely to have influenced the results of our pooled estimates.

Study Author, year	Country	Number in study	Number screened for DM	DM tests	% Female	Age Distribution (Median, IQR or *Mean, SD)	Total with DM (known and new)		Number of new DM identified by screening		Number needed to screen to detect 1 new DM case (95% CI)
							N	Prevalence ^a (%, 95% CI)	n (N)	Yield ^a (%, 95% CI)	
All regions, all studies^b		23,594	19,581				3331	16.0 (1.0, 20.5)	1837 (18,087)	7.7 (5.0, 11.0)	11 (10-11)
Africa region		6515	6474				479	6.8 (4.7, 9.1)	274 (6269)	4.0 (2.6, 5.8)	
Adegbite, 2022 ⁸	Gabon	227	227	FBG, HbA1c	45.8	39 (29, 51)	29	12.8 (8.7, 17.8)	12 (210)	5.7 (3.0, 9.8)	18 (10, 33)
Byashalira, 2022 ^{9,c}	United Republic of Tanzania	649	649	RBG, POC HbA1c	35.3	*41 (17)	17	2.6 (1.5, 4.2)	17 (649)	2.6 (1.5, 4.2)	38 (24, 65)
Jerene, 2022 ¹⁰	Ethiopia	2381	2381	RBG, FBG	47.4	31 (24, 42)	197	8.3 (7.2, 9.5)	98 (2282)	4.3 (3.5, 5.2)	23 (19, 29)
Ugarte-Gil, 2020 ³⁵	South Africa	331	331	FBG, HbA1c, RBG	38.1	35 (28, 48)	20	6.0 (3.7, 9.2)	3 (314)	1.0 (0.2, 2.8)	104 (36, 506)
Diarra, 2019 ³⁷	Mali	201	201	FBG	24.4	31 (25,40)	11	5.5 (2.8, 9.6)	5 (195)	2.6 (0.8, 5.9)	39 (17, 119)
Mcebula, 2017 ³⁸	South Africa	325	325	POC HbA1c, HbA1c	39.7	*39.5 (7.9)	10	3.1 (1.5, 5.6)	2 (317)	0.6 (0.1, 2.3)	159 (44, 1307)
Pizzol, 2017 ³⁹	Mozambique	301	299	OGTT	32.6	*36.7 (range 18-83)	3	1.0 (0.2, 2.9)	3 (299)	1.0 (0.2, 2.9)	100 (34, 482)
Workneh, 2016 ⁴⁰	Ethiopia	1353	1314	RBG, FBG	47.3	*35.7 (15.3)	109	8.3 (6.9, 9.9)	64 (1269)	5.0 (3.9, 6.4)	20 (16, 26)
Kibirige, 2013 ⁴¹	Uganda	260	260	RBG	43.8	*34.5 (9.5)	22	8.5 (5.4, 12.5)	17 (255)	6.7 (3.9, 10.5)	15 (10, 25)
Kibirige, 2024 ⁴²	Uganda	232	232	RBG, FBG, OGTT, HbA1c	69.0	35 (27-42)	32	13.8 (9.8, 18.7)	29 (229)	12.7 (8.8, 17.5)	8 (6, 12)
Kakisingi, 2024 ⁴³	Democratic Republic of Congo	255	255	FBG	33	35 (25-47)	29	11.4 (7.9, 15.7)	24 (250)	9.6 (6.4, 13.7)	10 (8,17)
South-East Asia Region		5507	4271				1039	24.5 (15.6, 34.7)	412 (3803)	12.3 (7.5, 18.2)	
Kornfeld, 2023	India	428	428	HbA1c	19.3	*43.6 (SD: NR)	244	57.0 (52.2, 61.8)	68 (252)	27.0 (21.6, 32.9)	4 (3, 5)
Alkabab, 2021 ¹²	Bangladesh	429	429	HbA1c	35.9	*45 (15)	158	36.8 (32.3, 41.6)	58 (329)	17.6 (13.7, 22.2)	6 (5, 7)
Hirayama, 2021 ¹³	Nepal	281	267	FBG, OGTT	NR	*34 (range: 18-64)	28	10.5 (7.1, 14.8)	14 (253)	5.5 (3.1, 9.1)	18 (11, 33)
Jayashankar, 2021 ⁴⁴	India	93	93	FBG, HbA1c, OGTT	21.6	*42 (15)	31	33.3 (23.9, 43.9)	31 (93)	33.3 (23.9, 43.9)	3 (2, 4)
Soe, 2020 ⁴⁵	Myanmar	2502	1280	RBG, FBG	33.0	*56.5 (11.3)	298	23.3 (21.0, 25.7)	139 (1280)	12.4 (10.5, 14.5)	8 (7, 9)
Ugarte-Gil, 2020 ³⁵	Indonesia	748	748	FBG, HbA1c, RBG	43.0	37 (27, 49)	128	17.1 (14.5, 20.0)	32 (652)	4.9 (3.4, 6.9)	20 (15, 30)
Gupte, 2018 ⁴⁶	India	392	392	FBG, RBG, HbA1c	37.2	31 (23, 44)	58	14.8 (11.4, 18.7)	13 (347)	3.7 (2.0, 6.3)	27 (16, 50)
Alisjahbana, 2007	Indonesia	634	634	FBG	44.7	45 (39.8, 52)	94	14.8 (12.2, 17.8)	57 (597)	9.5 (7.3, 12.2)	10 (8, 14)
Americas region		2401	1870				261	16.1 (10.4, 22.7)	95 (1704)	4.9 (2.0, 8.9)	
Bezerra, 2022 ¹⁴	Brazil	140	140	HbA1c	33.0	36 (IQR: NR)	20	14.3 (9.0, 21.2)	7 (127)	5.5 (2.2, 11.0)	18 (9, 45)
Ugarte-Gil, 2020 ³⁵	Peru	600	600	FBG, HbA1c, RBG	42.0	30 (22, 43)	47	7.8 (5.8, 10.3)	12 (565)	2.1 (1.1, 3.7)	47 (27, 91)
Moreira, 2017 ⁴⁷	Brazil	473	473	FBG, HbA1c	31.5	*37.5 (10.3)	59	12.5 (9.6-15.8)	49 (463)	10.6 (7.9-13.7)	9 (7, 12)
Restrepo, 2013 ⁴⁸	Mexico	90	90	HbA1c	37.8	*41.3 (14.5)	38	42.2 (31.9, 53.1)	6 (58)	10.3 (3.9, 21.2)	10 (5, 21)
Calderon, 2019 ⁴⁹	Peru	143	136	FBG, HbA1c, OGTT	38.9	*33.3 (16)	19	14 (8.6, 21.0)	0 (117)	0.0 (0.0, 3.1)	
Castellanos-Joya, 2014 ³⁴	Mexico	885	361	FBG, HbA1c	60.1	45 (57, 66)	70	19.4 (15.4, 23.9)	16 (307)	5.0 (3.0, 8.3)	19 (21, 32)
Yaneth-Giovanetti, 2019 ³³	Colombia	70	70	FBG	46	35.8	8	11.4 (5.1, 21.3)	5 (67)	7.5 (2.5, 16.6)	13 (6, 31)
Eastern Mediterranean Region		5787	3764				1132	41.0 (13.0, 72.2)	956 (3588)	31.6 (12.4, 54.3)	
Habib, 2020 ¹⁵	Pakistan	5,032	3009	HbA1c	46.6	*41.5 (23)	716	23.8 (22.3, 25.4)	716 (3009)	23.8 (22.3, 25.4)	4 (3, 5)
Aftab, 2017 ⁵⁰	Pakistan	462	462	FBG	24.5	*44 (13)	315	68.2 (63.7, 72.4)	195 (342)	57.0 (51.6, 62.3)	2 (1.6, 1.9)
Baghaei, 2015 ³⁶	Iran	293	293	FBG, HbA1c	44.0	60 (37, 44)	101	34.5 (29.3, 40.1)	45 (237)	19.0 (14.5, 24.5)	5 (4, 7)
Western Pacific Region		2878	2696				354	13.2 (6.3, 21.9)	69 (2575)	2.6 (1.6, 3.9)	
Liu, 2021 ⁵¹	China	500	500	FBG	34.8	42 (27, 59)	75	15.0 (12.0, 18.4)	7 (432)	1.6 (0.7, 3.3)	62 (30, 127)

(Table 1 continues on next page)

Study Author, year	Country	Number in study	Number screened for DM	DM tests	% Female	Age Distribution (Median, IQR or *Mean, SD)	Total with DM (known and new)		Number of new DM identified by screening		Number needed to screen to detect 1 new DM case (95% CI)
							N	Prevalence ^a (%; 95% CI)	n (N)	Yield ^b (%; 95% CI)	
(Continued from previous page)											
Zhao, 2016 ³²	China	1252	1252	FBG, HbA1c	24.2	50 (19)	97	7.8 (6.4, 9.4)	44 (1199)	3.7 (2.7, 4.9)	27 (21, 36)
Chen, 2014 ³³	China	1126	944	FBG, HbA1c	33.3	37.2*	182	19.3 (16.8, 21.9)	18 (944)	2.3 (1.4, 3.6)	53.4 (34.0, 84.3)
Europe Region		506	506				66	13.0 (10.2, 16.3)	31 (471)	6.6 (4.5, 9.2)	
Ugarte-Gil, 2020 ³⁵	Romania	506	506	FBG, HbA1c, RBG	29.2	43 (30.0, 54.0)	66	13.0 (10.2, 16.3)	31 (471)	6.6 (4.5, 9.2)	15 (11, 21)

^aDM, Diabetes Mellitus; IQR, Interquartile Range; SD, Standard Deviation; CI, Confidence Interval; FBG, Fasting Blood Glucose; HbA1c, Hemoglobin A1c (glycated hemoglobin); OGTT, Oral Glucose Tolerance Test; RBG, Random Blood Glucose; POC HbA1c, Point-of-Care Hemoglobin A1c. ^bPrevalence and yield estimates by World Health Organization region⁵⁴ and for all regions combined are from the results of the meta-analysis. ^cNumbers for Byalashira⁹ study were provided via personal communication.

Table 1: Summary of included studies.

Risk of bias assessment

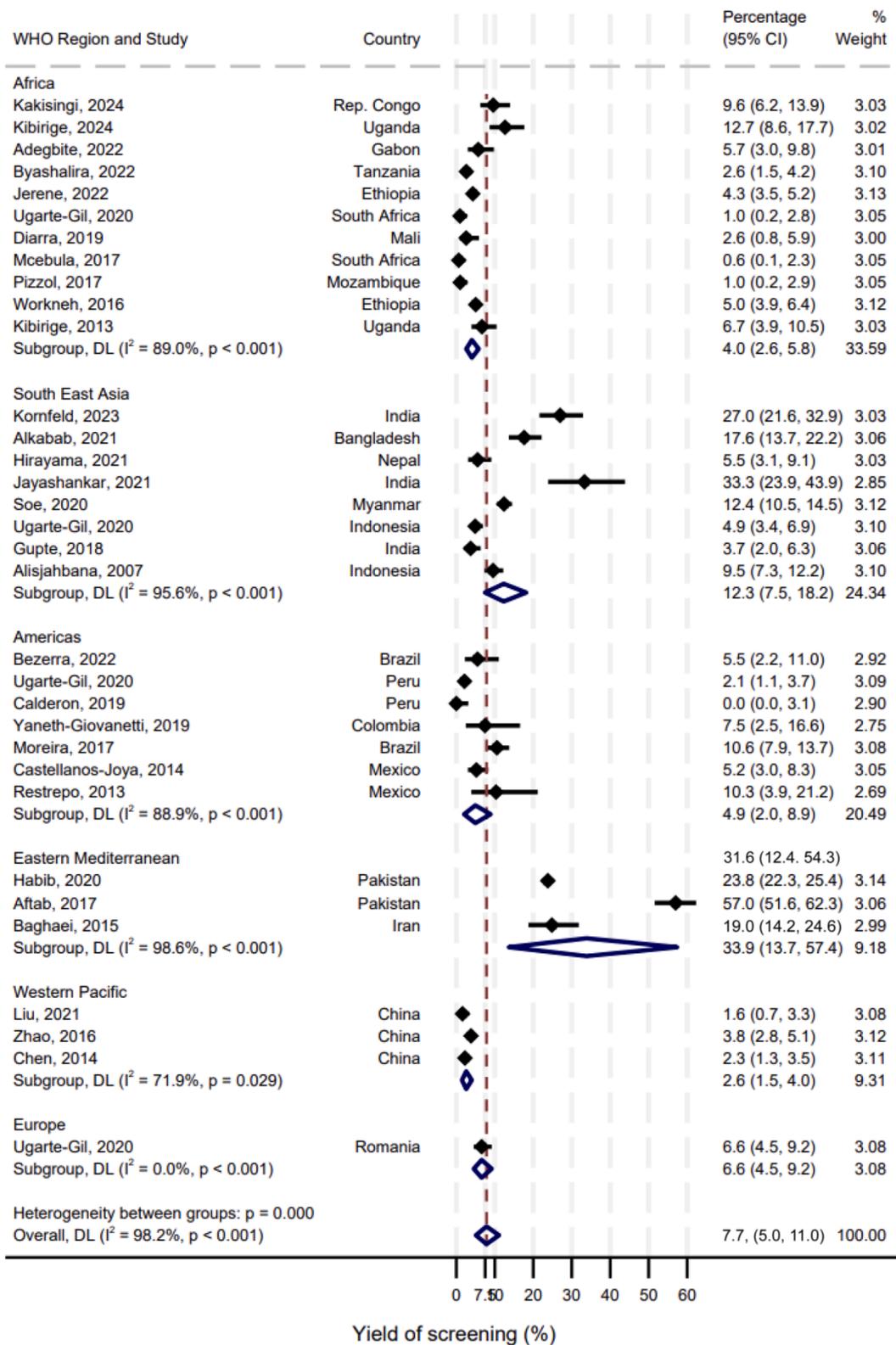
Overall, there was a low risk of bias (15/30 low risk vs 3/28 high risk) in the included studies. Most included studies (26/30, 86%) selected consecutive patients attending TB clinics, therefore there was low risk of bias due to the population sampling frame (D2).

However, 9 studies had a high risk of bias due to a high likelihood of non-response bias (D4), while 8 studies had high likelihood of bias as to the form of selection of the study sample (D3). We only included studies that met specific criteria for TB diagnosis and for DM diagnosis, and therefore there was also generally a low risk of bias for these criteria (D6 and D7) (Fig. 4).

Discussion

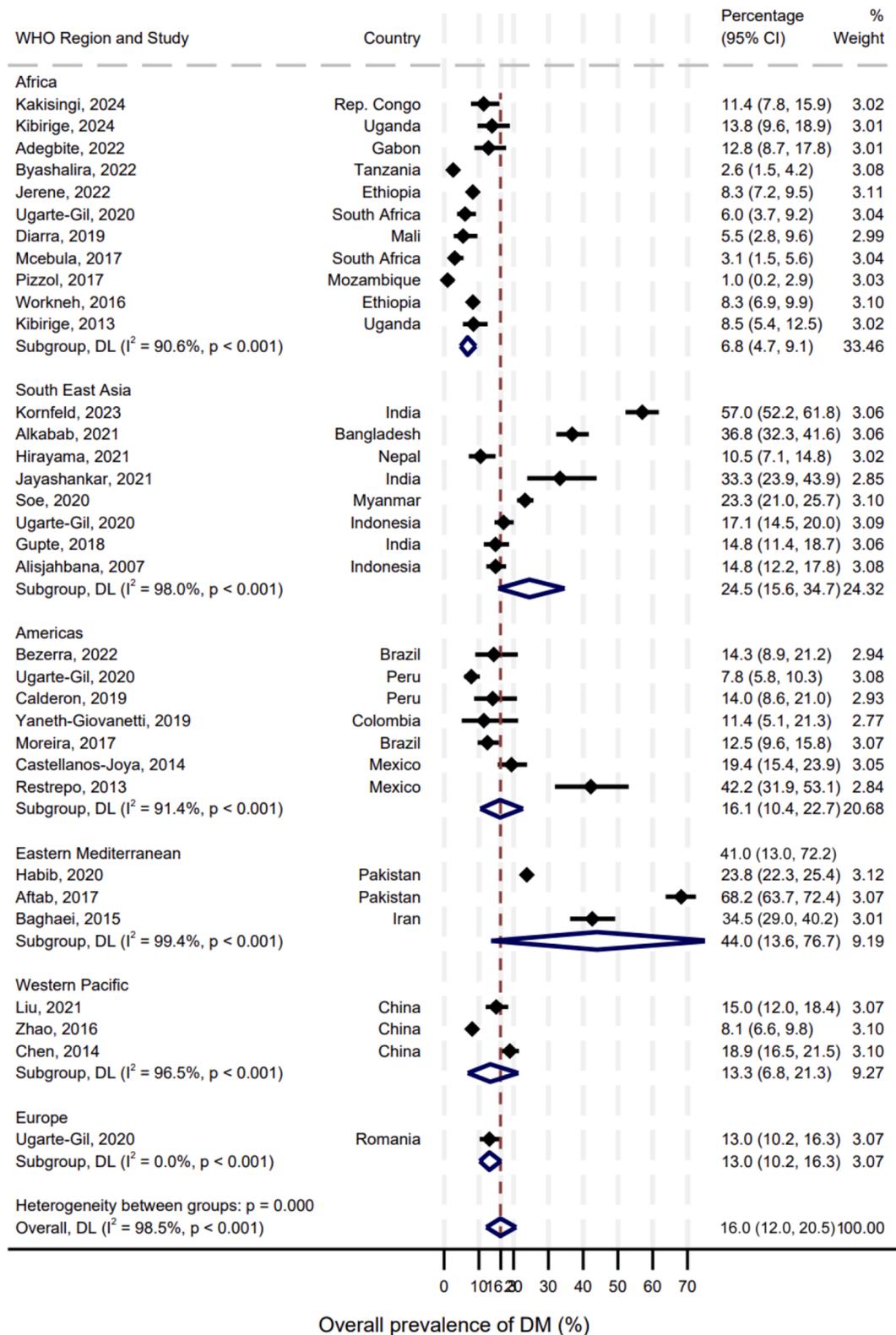
We compiled data on DM screening among 19,581 people with TB and summarized the yield and prevalence of DM. Overall, we found a 16.0% prevalence of DM in people with TB which is slightly higher than previously estimated.⁷ We observed wide variability in the yield, ranging from 0% in Peru⁴⁹ to 57% in Pakistan.⁵⁰ The highest yield was in the Eastern Mediterranean region (31.6%) followed by the South-East Asia region (12.3%), while the 3 studies from China (Western Pacific Region) and the African region had the lowest yields at 2.6% and 4.0%, respectively. This heterogeneity could be explained by the diverse study populations and the underlying DM prevalence in each particular region and time period.⁵⁶ In addition, DM is associated with aging, which was reflected in the evidence with higher yields reported amongst studies whose mean age was greater than 40 years. The low yield and prevalence found in the African region is likely a result of the lower background prevalence of DM in the Africa Region compared to South-East Asia and the relatively low mean age of study participants from the Africa region (mean 34 years), compared to South-East Asia region (where there was a higher prevalence of diabetes and a mean age of 45 years).⁵⁶ In addition, some countries such as China⁵⁷ have implemented national DM screening programs, which may explain a high proportion of previously diagnosed DM, and therefore a lower yield, in some settings.

The number of adults with DM is rising steeply worldwide, increasing to 828 million in 2022, a more than fourfold increase since 1990,⁴ and this rise is expected to continue. In addition, globally, 45% of DM is undiagnosed.⁵⁸ In LMIC this figure is 87.5%.⁵⁸ Many LMIC countries also have a high TB burden.⁵⁹ This is of note as DM increases the risk of poor TB outcomes such a treatment failure, relapse, and mortality,³ and plays a potential role in the increasing the risk of developing multi-drug resistant TB.⁶⁰ Therefore, optimal co-management of both conditions, along with close monitoring and follow-up, is required for people



NOTE: Weights and between-subgroup heterogeneity test are from random-effects model

Fig. 2: Forest plot of yield of diabetes mellitus screening in people with tuberculosis by World Health Organization Region. WHO, World Health Organization; CI, confidence interval; DL, DerSimonian-Laird; I^2 , measure of heterogeneity.



NOTE: Weights and between-subgroup heterogeneity test are from random-effects model

Fig. 3: Forest plot of prevalence of diabetes mellitus in people with tuberculosis by World Health Organization Region. WHO, World Health Organization; CI, confidence interval; DL, DerSimonian-Laird; I^2 , measure of heterogeneity.

Study	Risk of bias									Overall
	D1	D2	D3	D4	D5	D6	D7	D8	D9	
Adegbite, 2022	+	+	+	+	+	+	+	+	+	-
Byashalira, 2022	+	+	×	+	+	+	×	+	+	-
Jerene, 2022	+	+	+	×	+	+	+	+	+	+
Ugarte-Gil, 2020	+	+	+	+	+	+	+	+	+	+
Diarra, 2019	+	+	+	+	+	+	+	+	+	+
Mcebula, 2017	×	+	+	+	+	+	+	+	+	-
Pizzol, 2017	+	+	+	×	+	+	+	+	+	-
Workneh, 2016	+	+	+	+	+	+	+	+	+	+
Kibirige, 2013	+	+	×	+	+	+	×	+	+	-
Kornfeld, 2023	+	+	+	×	+	+	+	+	+	+
Alkabab, 2021	+	+	+	+	+	+	+	+	+	+
Hirayama, 2021	+	+	+	+	+	+	×	+	+	-
Jayashankar, 2021	+	+	+	×	+	+	+	+	+	-
Soe, 2020	+	+	+	+	+	+	+	+	+	+
Gupte, 2018	+	+	×	×	+	+	+	+	+	-
Alisjahbana, 2007	+	+	+	+	+	+	+	+	+	+
Bezerra, 2022	+	+	×	+	+	+	+	+	+	+
Calderon, 2019	+	×	×	×	+	+	+	+	+	-
Yaneth-Giovanetti, 2019	×	×	×	×	+	+	+	×	+	×
Moreira, 2017	+	+	+	+	+	+	+	+	+	+
Castellanos-Joya, 2014	+	×	×	×	+	+	+	+	+	×
Restrepo, 2013	+	+	+	+	+	+	+	+	+	+
Habib, 2020	×	+	+	×	+	+	+	+	+	×
Aftab, 2017	+	×	×	+	+	+	×	+	+	-
Baghaei, 2015	×	+	+	+	+	+	+	+	+	-
Liu, 2021	+	+	+	+	+	+	+	+	+	+
Zhao, 2016	+	+	+	+	+	+	+	×	+	-
Chen, 2014	+	+	+	+	+	+	+	+	+	+
Kakisingi, 2024	+	+	+	+	+	+	+	+	+	+
Kibirige, 2024	+	+	+	+	+	+	+	+	+	+

D1: Was the study's target population a close representation of the national population in relation to relevant variables, e.g age, sex, occupation?
D2: Was the sampling frame a true or close representation of the target population?
D3: Was some form of random selection used to select the sample, OR, was a census undertaken?
D4: Was the likelihood of non-response bias minimal?
D5: Were data collected directly from the subjects (as opposed to a proxy)?
D6: Was an acceptable case definition used in the study?
D7: Was the study instrument that measured the parameter of interest (e.g prevalence of low back pain) shown to have reliability and validity (if necessary)?
D8: Was the same mode of data collection used for all subjects?
D9: Were the numerator(s) and denominator(s) for the parameter of interest appropriate?

Judgement
● High
● Unclear
● Low
● Not applicable

Fig. 4: Risk of bias assessment. Ugarte-Gil, 2020 was listed only once in this table, hence accounting for the lower number of studies presented here compared to overall. Risk of bias assessment for included studies across nine domains: D1 (representativeness of study population), D2 (sampling frame), D3 (random selection), D4 (likelihood of non-response bias), D5 (data collection method), D6 (case definition reliability and validity), D7 (instrument reliability and validity), D8 (mode of data collection), D9 (appropriateness of numerator and denominator). Each study was rated as low risk (green), unclear risk (yellow), or high risk (red) for each domain, with an overall risk assessment provided. Studies are listed chronologically by first author and publication year.

with TB and DM.⁶¹ In addition, early detection of previously undiagnosed DM among people with TB provides an opportunity for timely DM management which may help reduce the risk of future DM related complications.⁶²

The World Health Organization recommends that people with TB be screened for DM at the start of TB treatment.⁶³ In some settings, there may be concerns about screening all individuals with TB for DM. DM screening for all individuals with TB may carry a risk of

false positive results which may lead to negative outcomes such as unnecessary treatment and psychological stress. In addition, some studies in our review showed that people with initial elevated glucose levels experience a decline over time during TB treatment without specific diabetes therapies. Whilst diabetes management should be provided to anyone diagnosed with diabetes, in line with recommendations, this finding supports the need for reassessment of glycemic levels in people newly diagnosed with diabetes after 1–3 months, which is already a part of WHO diabetes glucose control protocols.¹⁷ Screening large numbers of individuals for DM will also incur costs. Therefore, further research as to cost-effectiveness evaluations would be useful. Lastly, there were no studies in our review that reported on referral to DM services for people newly diagnosed with DM and it is unclear what services individuals received after their DM diagnosis. This is of note as an important principle of screening is linkage to services for diagnosis, treatment and management.⁶⁴ Ensuring access to DM care in the context of Universal Health Coverage is a high priority.⁶⁵

Our review has several strengths. First, we included a broad search strategy that drew on studies from several different databases. We retrieved 7530 records, and few exclusion criteria were applied. Studies were excluded only if they had unclear case definitions of either TB or DM. Additionally, we only included studies with robust diagnostic criteria for both TB and DM to ensure an accurate diagnosis. There were no studies excluded due to language restrictions and the risk of bias was low amongst the included studies. The findings from this review have informed the development of the World Health Organization's Operational Handbook on Tuberculosis.⁶³

Our review also has limitations, often reflecting limitations in the included studies. All included studies were observational in design and did not include a control group of people without TB. Therefore, it was not possible to determine whether the yield of screening for DM or the prevalence of DM in people with TB differs from people without TB. Second, the included studies used a range of tests to screen for DM. This might reflect locally available policies and diagnostic infrastructure. The majority of studies did not compare the results of different glycemic tests, which limited the possibility of drawing any conclusions about the yield of different tests. Third, no studies reviewed provided any information on clinical outcomes and follow-up, nor cost effectiveness of screening, which is an important knowledge gap.

Our review identified several gaps in the literature. Namely, the sensitivity, specificity, cost-effectiveness and uptake of different DM screening modalities was not identified in the publications and future research should include these measures. Assessment for DM symptoms and other risk factors could potentially offer

new ways to enhance early DM detection. While evidence for such an approach was not included in this review, such evidence could provide a more targeted path to DM diagnosis, particularly in resource-limited settings. This raises interesting questions about how assessment of DM symptoms could complement existing strategies and whether it might facilitate timely access to care. Additionally, while we reviewed data from 21 countries, the majority of studies in our review came from the regions of Africa, South-East Asia, and the Americas. All studies in the Western Pacific region were from China and no other countries in that region were represented. It is possible that the results would differ had there been more data available from a broader range of countries.

In conclusion, we found a yield of DM screening among people with TB of 7.8% and a prevalence of 16.2%. However, study results were highly heterogeneous and prevalence and yield varied considerably across studies and regions. While the yield was highest in the Eastern Mediterranean (33.9%) and South-East Asia regions (12.1%), all of the studies from the Eastern Mediterranean region had a yield greater than 20%, while only half of the studies from the South-East Asia region had a yield greater than 10%. A higher yield of DM screening is likely to be related to the background prevalence of DM, which is in turn shaped by the region and time-period in which the study was conducted as well as the demographic composition of the population and access to health care.

Our findings highlight the potential for targeted, age-specific DM screening strategies as countries scale up DM screening for people with TB. However, additional studies including comparison groups free of TB are needed to truly understand whether the yield and prevalence of DM in people with TB would have been different in those without TB. In addition for people with TB and DM there is a need to effectively link people to comprehensive care, enhance disease management, monitor the implementation of DM screening and TB-DM care, and ultimately aim to improve patient outcomes.

Contributors

AB, BH, FM, KV, SS, JM, JAC, MJM, UPG conceptualized the study. AB, BH, KV, JM, UPG, JAC, MJM, KGC participated in the study design, and UPG, JAC, MJM, KGC participated in the funding acquisition. MSW, JAC, PH and MJM developed the search strategies. DKQ, PH and JAC provided project administration. JAC, MJM, UPG, and AK screened studies for inclusion. FH, DKQ, KO, PH, NS, AK and JAC performed data extraction. JAC, ESL, UG, FH, and PH performed the analyses. UPG wrote the first draft of the manuscript with input from JAC, PH and MJM and ESL. UPG, MJM, and JAC accessed and verified the data. All authors assisted with interpretation, provided critical revision and approved the final manuscript.

Data sharing statement

This systematic review and meta-analysis did not collect individual participant data. Extracted study-level data will be made available along with a data dictionary defining each field. The study protocol is publicly

available through PROSPERO (registration CRD42023425596: https://www.crd.york.ac.uk/prospERO/display_record.php?ID=CRD42023425596). Additional materials including the standardized data extraction form, statistical analysis code (Stata.do files), complete search strategies, and a list of excluded studies with reasons for exclusion will be made available upon reasonable request to the corresponding author. Researchers may request access to data by contacting the corresponding author.

Declaration of interests

Jennifer Manne-Goehler receives grant support from the National Institutes of Health, including the National Institute of Diabetes and Digestive and Kidney Diseases, National Institute on Aging, and National Institute of Allergy and Infectious Diseases. She serves as Institutional Site Principal Investigator for HIV clinical trials of treatment sponsored by Gilead and ViiV Healthcare. Dr. Manne-Goehler has provided consulting services to the World Health Organization (WHO). Dr. Manne-Goehler has received honoraria for lectures and presentations from the University of Nebraska and the University of Massachusetts.

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All other authors declare no competing interests.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.eclinm.2026.103803>.

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