



Prevalence of Documented Diabetes Mellitus and Associated Factors among Adult Tuberculosis Patients Registered At Selected Tuberculosis Units of Jhansi District, Uttar Pradesh: A Retrospective Cohort Study

Krishna Kumar Singh¹ , Shobha Chaturvedi² , Mehar Bano³ 

¹Junior Resident (Post-graduate), Department of Community Medicine, Maharani Laxmi Bai Medical College, Jhansi, Uttar Pradesh, India

²Associate Professor and Head, Department of Community Medicine, Maharani Laxmi Bai Medical College, Jhansi, Uttar Pradesh, India

³Associate Professor, Department of Community Medicine, Maharani Laxmi Bai Medical College, Jhansi, Uttar Pradesh, India

Corresponding Author: Dr. Krishna Kumar Singh

DOI: <https://doi.org/10.5281/zenodo.23539890>

Article Received 18-09-2026 / Accepted 15-10-2026 / Published 22-10-2026

ABSTRACT:

Background: India has the highest tuberculosis (TB) burden and a growing burden of diabetes mellitus (DM), which worsens TB outcomes. Sub-district TB-DM data from Bundelkhand are scarce.

Aims and Objective: To estimate the prevalence of documented DM among adult TB patients at two tuberculosis units (TUs) of Jhansi district and to identify associated factors and treatment outcomes.

Materials and Methods: This record-based retrospective cohort study included 259 eligible adult TB patients notified on the Nikshay portal at Badagaon (n=121) and Chirgaon (n=138) TUs between March 2023 and May 2024. Data were analysed using chi-square/Fisher's exact tests and Firth penalised logistic regression.

Results: Mean age was 40.8±15.1 years; 68.3% were males, 86.1% rural and 54.1% underweight. The prevalence of documented DM was 6.9% (18/259; 95% CI 4.4–10.7); all cases were previously known type 2 DM. On bivariate analysis, DM was associated with age (15.5% at 40–59 years; p<0.001), lower education and unskilled occupation; in the Firth model, only age ≥40 years remained associated (adjusted OR 10.38; 95% CI 2.29–99.69). Treatment success was 97.7%. Crude case fatality was higher with documented DM (22.2% vs 0.4%), but was based on only five deaths and not adjusted for confounding.

Conclusion: About one in fourteen adult TB patients had documented DM, concentrated among those aged ≥40 years; the true prevalence may be higher because undiagnosed DM may have been missed. Bidirectional screening with confirmatory glycaemic testing should be strengthened.

Key words: Tuberculosis, Diabetes Mellitus, Type 2, Comorbidity, Risk Factors, Treatment Outcome.



This is an Open Access article distributed under the terms of the [Creative Commons Attribution 4.0 International License](https://creativecommons.org/licenses/by/4.0/).

© 2026 The Author(s). Published by [Scientific Publications](https://www.scientificpublications.in/).

How to Cite

Krishna Kumar Singh, Shobha Chaturvedi, & Mehar Bano. (2026). Prevalence of Documented Diabetes Mellitus and Associated Factors among Adult Tuberculosis Patients Registered At Selected Tuberculosis Units of Jhansi District, Uttar Pradesh: A Retrospective Cohort Study. *International Journal of Medical Sciences and Academic Research*, 7(05), 270-277. <https://doi.org/10.5281/zenodo.23539890>

INTRODUCTION:

Tuberculosis (TB) remains the leading infectious cause of death worldwide; an estimated 10.8 million people developed TB in 2023, and India accounts for about a quarter of this burden.[1,2] India also has a rapidly rising burden of diabetes mellitus (DM), with an estimated 74.2 million adults with diabetes in 2021, about half of them undiagnosed, and a national prevalence of 11.4%.[3,4]

DM increases the risk of active TB about three-fold by impairing cell-mediated immunity, and is associated with delayed sputum conversion, treatment failure, relapse and death.[5–8] The prevalence of DM among TB patients is estimated at 15.3% worldwide and 21% in South Asia, with Indian estimates ranging from 5% to 66%.[9,10] India's National Framework for Joint TB-Diabetes Collaborative Activities therefore recommends screening every notified TB patient for DM, recorded on the Ni-kshay portal under the National Tuberculosis Elimination Programme (NTEP).[11]

Most Indian TB-DM evidence comes from tertiary-care centres and southern states; programme-based studies from northern and central India are few,[12–15] and no sub-district data were found for the largely rural and socioeconomically disadvantaged Bundelkhand region of Uttar Pradesh.

Aim and Objectives:

Aim:

- This study aimed to find out how common documented DM is among adult TB patients under routine programme conditions at the tuberculosis unit level in Jhansi district, Uttar Pradesh.

Objective:

- To estimate the prevalence of documented DM among adult TB patients at the Badagaon and Chirgaon tuberculosis units.
- To identify the sociodemographic and clinical factors associated with DM.
- To compare treatment outcomes, including case fatality, between TB patients with and without DM.

MATERIALS AND METHODS:

Study design and setting:

This was a record-based retrospective cohort study, with cross-sectional assessment of baseline DM prevalence and retrospective ascertainment of end-of-treatment outcomes, reported according to the STROBE guidelines. It was conducted at the Badagaon and Chirgaon tuberculosis units (TUs) of Jhansi district, located at Community Health Centres serving predominantly rural populations of 194,296 and 177,000, respectively. The TUs were selected purposively for their patient load and feasibility of record access.

Study population and sampling:

All TB patients aged ≥ 18 years diagnosed and notified at the two TUs between March 2023 and May 2024 were eligible, irrespective of sex, site of disease or treatment history. After excluding eight patients aged < 18 years, 279 adult records were extracted; a further 20 were excluded on verification (notification date outside the study period, 18; recorded age 17 years, 2), leaving 259 patients (Badagaon 121; Chirgaon 138). All eligible patients were included; the achieved sample was smaller than the initially estimated 366 (expected DM prevalence 39%,[12] 5% absolute precision, 95% confidence), which reduced precision.

Data sources and variables:

With permission from the District Tuberculosis Officer, Jhansi, data were extracted from the Ni-kshay portal and TB notification, treatment and laboratory register using a pretested semi-structured proforma. Variables included sociodemographic characteristics, alcohol use, body mass index (BMI) at diagnosis, TB category, site, drug-resistance pattern, comorbidities, Ni-kshay Mitra support, treatment outcome and recorded cause of death. The latest recorded outcome date was January 2025, so all participants could reach a final outcome. Records were cross-checked between the portal and registers, double-entered and de-identified before analysis.

Operational definitions:

Under NTEP, notified TB patients are screened for DM by capillary blood glucose. DM status was ascertained only from records; no glucose testing was performed by the investigators. Documented DM (TB-DM) was defined as previously diagnosed DM recorded in the Ni-kshay portal or facility records (a recorded diagnosis or anti-diabetic medication). Individual glucose values were not recorded, so prevalence refers to documented, not necessarily true, DM. BMI was categorised using Asian cut-offs.[16] TB category, site, drug resistance and treatment outcomes followed NTEP definitions; cured and treatment completed were combined as treatment success.

Statistical analysis:

Data were analysed using IBM SPSS Statistics version 26.0. Prevalence was reported with a Wilson 95% confidence interval (CI). Associations were assessed using Pearson's chi-square, likelihood-ratio chi-square or Fisher's exact test, and mean age using Welch's t-test. Variables with bivariate $p < 0.1$ and estimable odds ratios were entered into an exploratory Firth penalised logistic regression model. A p -value < 0.05 was considered significant.

RESULTS:

Characteristics of the study participants

The mean age was 40.8 ± 15.1 years; 68.3% were males, 86.1% rural, 81.5% married and 46.3% unskilled workers. Most had new TB (94.6%) and bacteriologically confirmed pulmonary TB (86.5%); abdominal (42.9%) and pleural (20.0%) TB were the commonest of 35 extrapulmonary cases. Drug-resistant TB was found in 14 (5.4%) patients, 13 of them at Chirgaon. Over half (54.1%) were underweight, 22.8% used alcohol and 18.1% had COPD/asthma (Table 1). Only nine (3.5%) received Ni-kshay Mitra support. According to aggregate TU records, 287 of 1,430 presumptive TB patients of all ages examined (20.1%) were diagnosed with TB (Table 2).

Prevalence of documented diabetes mellitus:

Documented DM was recorded in 18 of 259 patients (6.9%; 95% CI 4.4–10.7); 6.6% at Badagaon and 7.2% at Chirgaon. DM status was recorded for all patients, but screening test results were not, so screening completeness could not be verified. All 18 had previously known type 2 DM and new, bacteriologically confirmed, drug-sensitive pulmonary TB; no newly diagnosed DM was documented. TB-DM patients were older than those without DM (48.9 ± 7.6 vs 40.2 ± 15.3 years; $p < 0.001$).

Factors associated with TB-DM:

DM prevalence was 0% below 20 years, 0.9% at 20–39 years, 15.5% at 40–59 years and 6.3% at 60–79 years ($p < 0.001$). DM was more common among patients educated below intermediate level (cOR 3.90, 95% CI 1.25–12.19) and unskilled workers (cOR 4.46, 95% CI 1.43–13.94). All TB-DM patients were married ($p = 0.030$), a crude difference likely reflecting age. Sex, residence, caste, religion, BMI, alcohol use, COPD/asthma and hypertension were not associated with DM, and no extrapulmonary or previously treated patient had DM. In the Firth model, only age ≥ 40 years remained associated with DM (aOR 10.38, 95% CI 2.29–99.69), although imprecisely; the conventional model gave similar conclusions (Table 1). In a sensitivity analysis of all 279 extracted records, prevalence was 7.2% (95% CI 4.7–10.8) and age ≥ 40 years remained associated (Firth aOR 9.93).

Treatment outcomes:

Treatment success was 97.7% (253/259); five patients (1.9%) died and one was not evaluated. Crude case fatality was 22.2% (4/18) with TB-DM versus 0.4% (1/241) without DM ($p < 0.001$; unadjusted risk ratio 53.6, 95% CI 6.3–454.5). The four deceased TB-DM patients were men aged 40–66 years with new, smear-positive pulmonary TB; two had COPD/asthma, one hypertension and two used alcohol. Recorded causes of death were respiratory failure (three) and coronary artery disease (one) (Table 3).

Table 1: Characteristics of adult tuberculosis patients and factors associated with documented diabetes mellitus (n=259)

Variable / category	Total n (%)	TB-DM n (%)*	p-value	cOR (95% CI)	Firth aOR (95% CI)†
Age group (years)					
18–19	15 (5.8)	0 (0.0)	<0.001‡	NE	–
20–39	113 (43.6)	1 (0.9)		1 (Ref)	–
40–59	97 (37.5)	15 (15.5)		20.49 (2.65–158.22)	–
60–79	32 (12.4)	2 (6.3)		7.47 (0.65–85.16)	–
≥80	2 (0.8)	0 (0.0)		NE	–
Age (dichotomised)					
<40 years	128 (49.4)	1 (0.8)	<0.001	1 (Ref)	1 (Ref)
≥40 years	131 (50.6)	17 (13.0)		18.94 (2.48–144.57)	10.38 (2.29–99.69)
Sex					
Male	177 (68.3)	11 (6.2)	0.494	1 (Ref)	–
Female	82 (31.7)	7 (8.5)		1.41 (0.53–3.78)	–
Residence					
Rural	223 (86.1)	14 (6.3)	0.290§	1 (Ref)	–
Urban	36 (13.9)	4 (11.1)		1.87 (0.58–6.02)	–
Marital status					
Married	211 (81.5)	18 (8.5)	0.030§	1 (Ref)	–
Unmarried	48 (18.5)	0 (0.0)		NE	–
Religion					
Hindu	253 (97.7)	17 (6.7)	0.354§	1 (Ref)	–
Muslim	6 (2.3)	1 (16.7)		2.78 (0.31–25.13)	–
Caste category					
General/OBC	140 (54.1)	10 (7.1)	0.895	1 (Ref)	–
SC/ST	119 (45.9)	8 (6.7)		0.94 (0.36–2.46)	–
Education					
Intermediate/graduate	131 (50.6)	4 (3.1)	0.013	1 (Ref)	1 (Ref)
Below intermediate	128 (49.4)	14 (10.9)		3.90 (1.25–12.19)	0.85 (0.22–3.63)
Occupation					
Others (skilled/semi-professional/not working)	139 (53.7)	4 (2.9)	0.006	1 (Ref)	1 (Ref)
Unskilled	120 (46.3)	14 (11.7)		4.46 (1.43–13.94)	2.57 (0.73–10.78)
Body mass index (kg/m²)					
Normal (18.5–22.9)	104 (40.2)	10 (9.6)	0.426‡	1 (Ref)	–
Underweight (<18.5)	140 (54.1)	7 (5.0)		0.49 (0.18–1.35)	–
Overweight (23.0–24.9)	5 (1.9)	0 (0.0)		NE	–
Obese (≥25.0)	10 (3.9)	1 (10.0)		1.04 (0.12–9.11)	–
Alcohol use					
No	200 (77.2)	13 (6.5)	0.569§	1 (Ref)	–
Yes	59 (22.8)	5 (8.5)		1.33 (0.45–3.90)	–
COPD/asthma					
No	212 (81.9)	13 (6.1)	0.337§	1 (Ref)	–
Yes	47 (18.1)	5 (10.6)		1.82 (0.62–5.39)	–
Hypertension					
No	250 (96.5)	17 (6.8)	0.483§	1 (Ref)	–
Yes	9 (3.5)	1 (11.1)		1.71 (0.20–14.51)	–
Site of TB					
Pulmonary	224 (86.5)	18 (8.0)	0.144§	1 (Ref)	–

Variable / category	Total n (%)	TB-DM n (%)*	p-value	cOR (95% CI)	Firth aOR (95% CI)†
Extrapulmonary	35 (13.5)	0 (0.0)		NE	—
TB category					
New	245 (94.6)	18 (7.3)	0.608§	1 (Ref)	—
Previously treated	14 (5.4)	0 (0.0)		NE	—
Total	259 (100)	18 (6.9)			

TB-DM: Tuberculosis with diabetes mellitus; cOR/aOR: Crude/adjusted odds ratio; CI: Confidence interval; Ref: Reference; NE: Not estimable (zero cell); OBC: Other backward class; SC/ST: Scheduled caste/scheduled tribe; COPD: Chronic obstructive pulmonary disease. p-values by Pearson's chi-square test unless indicated.

*Row percentage; †Firth penalised logistic regression including age, education and occupation (18 events; estimates imprecise); conventional aORs were 14.99 (1.83–122.64), 0.88 (0.21–3.65) and 2.80 (0.71–11.06), respectively; ‡Likelihood-ratio chi-square test; §Fisher's exact test.

Table 2: Programmatic indicators at the two tuberculosis units over the 15-month study period

Indicator	Badagaon TU	Chirgaon TU	Total
Catchment and staffing			
Population served	194,296	177,000	371,296
TB care staff: MO / LT / X-ray technician / pharmacist / STS	2 / 2 / 1 / 2 / 0	1 / 1 / 0 / 0 / 1	3 / 3 / 1 / 2 / 1
Case finding			
Presumptive TB patients examined, n	675	755	1,430
Eligible adult TB patients included, n	121	138	259
Presumptive TB patients diagnosed with TB (all ages), n (%)*	—	—	287 (20.1)
Annualised presumptive TB examination rate (per 100,000/year)	277.9	341.2	308.1
Case mix, n (% of included patients)			
Extrapulmonary TB	15 (12.4)	20 (14.5)	35 (13.5)
Previously treated TB	1 (0.8)	13 (9.4)	14 (5.4)
Drug-resistant TB	1 (0.8)	13 (9.4)	14 (5.4)
TB with documented diabetes mellitus	8 (6.6)	10 (7.2)	18 (6.9)
Patient support and outcome, n (% of included patients)			
Supported by a Ni-kshay Mitra	2 (1.7)	7 (5.1)	9 (3.5)
Treatment success (cured/completed)	118 (97.5)	135 (97.8)	253 (97.7)

TU: Tuberculosis unit; TB: Tuberculosis; MO: Medical officer; LT: Laboratory technician; STS: Senior treatment supervisor. Annualised rate = (number in 15 months ÷ population) × 100,000 × 12/15. *Aggregate all-age TU counts, not reconcilable record-by-record with the eligibility-verified line list.

Table 3: Treatment outcomes by diabetes status, and profile of the deceased TB-DM patients**A. Treatment outcomes by diabetes status**

Treatment outcome	TB-DM (n=18) n (%)	TB without DM (n=241) n (%)	Total (n=259) n (%)
Treatment success (cured/completed)	14 (77.8)	239 (99.2)	253 (97.7)
Died	4 (22.2)	1 (0.4)	5 (1.9)
Not evaluated	0 (0.0)	1 (0.4)	1 (0.4)
Crude case fatality: $p < 0.001^*$; unadjusted risk ratio 53.6 (95% CI 6.3–454.5)			

B. Profile of the deceased TB-DM patients (n=4)

Case	TU	Age (years)/ sex	Education/ occupation	Alcohol use	BMI category	Other comorbidity	Cause of death (as recorded)
1	Badagaon	40/M	High school/ auto driver	Yes	Underweight	Hypertension	Respiratory failure
2	Badagaon	47/M	High school/ farmer	No	Normal	COPD/asthma	Coronary artery disease
3	Chirgaon	61/M	Intermediate/ labourer	No	Normal	COPD/asthma	Respiratory failure
4	Chirgaon	66/M	Primary/ farmer	Yes	Normal	None	Respiratory failure

TB-DM: Tuberculosis with diabetes mellitus; TU: Tuberculosis unit; BMI: Body mass index; COPD: Chronic obstructive pulmonary disease; M: Male; CI: Confidence interval.

*Fisher's exact test (died vs not died). Causes of death as recorded in programme records, not independently verified; unadjusted comparison based on five deaths. The single death without DM was a 50-year-old woman with new pulmonary TB and no recorded comorbidity.

DISCUSSION:

In this study from two TUs of the Bundelkhand region, about one in fourteen adult TB patients (6.9%) had documented DM, concentrated among those aged ≥ 40 years, and TB-DM patients had a markedly higher crude case fatality.

This prevalence is lower than the pooled estimates of 15.3% worldwide and 21% in South Asia [9, 10] and then reports from southern India,[12,15] but comparable to the 8.5%–11% reported from a south Indian secondary-care hospital.[13] Several factors may explain this. First, all cases were previously known DM and screening results were not recorded; because about half of Indians with diabetes are undiagnosed,[3] undiagnosed DM may have been missed through capillary-only screening, lack of confirmatory fasting glucose or glycated haemoglobin (HbA1c) testing, or incomplete documentation. Second, our population was young, largely rural and undernourished; diabetes is less prevalent in rural India,[4] and undernutrition is a competing TB risk factor. Third, record-based designs under-report comorbidities. The true TB-DM burden is therefore probably higher, which argues for improving the quality, not merely the coverage, of bidirectional screening.

Age was the strongest correlate of DM, consistent with studies from India, Bangladesh and Brunei and with systematic reviews.[12,17–19] The adjusted estimate was unstable, as only one DM case occurred below 40 years. The crude associations with lower education and unskilled occupation disappeared after adjustment, suggesting confounding by age, as older patients were less educated and more often in agricultural or unskilled work; the marital-status difference likewise reflects age. The non-significant urban excess agrees with India's urban–rural diabetes gradient.[4] The lack of association with BMI should be interpreted cautiously, because weight loss in TB means BMI at diagnosis may not reflect pre-morbid adiposity.

All TB-DM patients had pulmonary TB, consistent with DM predisposing to pulmonary, often cavitary, disease.[6] The higher crude case fatality with DM agrees in direction with meta-analyses (OR 1.88 and 1.74)[8,10] and Indian cohort data,[20] but its magnitude and very wide confidence interval reflect only five deaths. TB-DM patients were older, and several of the deceased had COPD/asthma, hypertension or alcohol use; residual confounding by age, comorbidity and unmeasured factors such as HIV status cannot be excluded, so

this finding is exploratory. None of the deceased had Ni-kshay Mitra support, but overall coverage was only 3.5%, so no inference can be drawn. Closer follow-up of TB-DM patients, including glycaemic monitoring, screening for cardiovascular and respiratory comorbidity and linkage to community support, is consistent with the national framework.[11]

About one-fifth of presumptive TB patients examined were diagnosed with TB. The proportion of extrapulmonary TB (13.5%) was lower than the approximately 29% reported from a south Indian secondary-care hospital,[13] possibly reflecting limited extrapulmonary diagnostic facilities at the sub-district level.

CONCLUSION:

Documented DM was present in 6.9% of adult TB patients at two TUs of Jhansi district; all cases were previously known, suggesting that undiagnosed DM may be missed. Age ≥ 40 years remained associated with documented DM after adjustment, although imprecisely. The higher crude case fatality with DM was based on five deaths and was unadjusted. Bidirectional TB-DM screening under NTEP should be strengthened with confirmatory glycaemic testing, particularly for patients aged ≥ 40 years, and prospective studies with standardised glycaemic assessment are needed.

DECLARATIONS:

Ethical Approval: The Institute Ethics Committee (Human Studies) approved the study (Certificate No. 764/IEC/I/2024-2025; 09 April 2024). Data were extracted only after approval, from existing routine records without patient contact, in accordance with the Helsinki Declaration as revised in 2013. No patient identifiers are reported.

Informed Consent: Informed consent was obtained from all participants prior to their inclusion in the study. Participants were informed that their data would be kept confidential and used solely for research purposes.

Funding Information: There was no financial support concerning this work.

Conflict of Interest: The authors declare that there is no conflict of interest.

Data availability statement: The dataset presented in this study is available on request from the corresponding author.

AI Use Disclosure: No generative AI tools were used in the writing or data analysis. AI tools were limited to language assistance. The authors remain fully responsible for the content.

Acknowledgement: The authors thank the District Tuberculosis Officer, Jhansi, and the medical officers,

laboratory technicians and treatment supervisors of the Badagaon and Chirgaon tuberculosis units for access to programme records.

REFERENCES:

1. World Health Organization. Global tuberculosis report 2024. Geneva: World Health Organization; 2024 [cited 2026 Sep 28]. <https://www.who.int/publications/i/item/9789240101531>
2. Central TB Division, Ministry of Health and Family Welfare. India TB report 2024. New Delhi: Ministry of Health and Family Welfare, Government of India; 2024 [cited 2026 Sep 28]. https://tbcindia.mohfw.gov.in/wp-content/uploads/2024/10/TB-Report_for-Web_08_10-2024-1.pdf
3. Magliano DJ, Boyko EJ; IDF Diabetes Atlas 10th edition scientific committee. IDF Diabetes Atlas. 10th ed. Brussels: International Diabetes Federation; 2021 [cited 2026 Sep 28]. <https://www.ncbi.nlm.nih.gov/books/NBK581934/>
4. Anjana R, Unnikrishnan R, Deepa M et al. Metabolic non-communicable disease health report of India: the ICMR-INDIAB national cross-sectional study (ICMR-INDIAB-17) The Lancet Diabetes & Endocrinology, 2023; 11, 474-489. [https://doi.org/10.1016/S2213-8587\(23\)00119-5](https://doi.org/10.1016/S2213-8587(23)00119-5)
5. Jeon CY, Murray MB (2008) Diabetes Mellitus Increases the Risk of Active Tuberculosis: A Systematic Review of 13 Observational Studies. PLoS Med 5(7): e152. <https://doi.org/10.1371/journal.pmed.0050152>
6. Dooley KE, Chaisson RE. Tuberculosis and diabetes mellitus: convergence of two epidemics. Lancet Infect Dis. 2009;9(12):737-746. [https://doi.org/10.1016/S1473-3099\(09\)70282-8](https://doi.org/10.1016/S1473-3099(09)70282-8)
7. Baker, M.A., Harries, A.D., Jeon, C.Y. et al. The impact of diabetes on tuberculosis treatment outcomes: A systematic review. BMC Med 9, 81 (2011). <https://doi.org/10.1186/1741-7015-9-81>
8. Huangfu P, Ugarte-Gil C, Golub J, Pearson F, Critchley J. The effects of diabetes on tuberculosis treatment outcomes: an updated systematic review and meta-analysis. Int J Tuberc Lung Dis. 2019;23(7):783-96. <https://doi.org/10.5588/ijtld.18.0433>
9. Noubiap JJ, Nansseu JR, Nyaga UF, Nkeck JR, Endomba FT, Kaze AD, et al. Global prevalence of diabetes in active tuberculosis: a systematic review and meta-analysis of data from 2.3 million patients with tuberculosis. Lancet Glob Health.

- 2019;7(4):e448-60. [https://doi.org/10.1016/S2214-109X\(18\)30487-X](https://doi.org/10.1016/S2214-109X(18)30487-X)
10. Gautam, S., Shrestha, N., Mahato, S. *et al.* Diabetes among tuberculosis patients and its impact on tuberculosis treatment in South Asia: a systematic review and meta-analysis. *Sci Rep* **11**, 2113 (2021). <https://doi.org/10.1038/s41598-021-81057-2>
 11. Revised National Tuberculosis Control Programme; National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases and Stroke. National framework for joint TB-diabetes collaborative activities. New Delhi: Directorate General of Health Services, Ministry of Health and Family Welfare; 2017 [cited 2026 Sep 28]. <https://tbcindia.gov.in/WriteReadData/National%20framework%20for%20joint%20TB%20diabetes%2023%20Aug%202017.pdf>
 12. Rajaa S, Krishnamoorthy Y, Knudsen S, Roy G, Ellner J, Horsburgh CR, Hochberg NS, Salgame P, S G, Prakash Babu S, Sarkar S. Prevalence and factors associated with diabetes mellitus among tuberculosis patients in South India-a cross-sectional analytical study. *BMJ Open*. 2021 Oct 22;11(10):e050542. doi: 10.1136/bmjopen-2021-050542. PMID: 34686553; PMCID: PMC8543642. <https://doi.org/10.1136/bmjopen-2021-050542>
 13. Ragouraman D, Priyadharsini RP, Venkatesh C. Prevalence of tuberculosis and diabetes comorbidity in patients attending secondary healthcare hospital in south India: A retrospective study. *J Family Med Prim Care*. 2021 Mar;10(3):1241-1245. doi: 10.4103/jfmprc.jfmprc_1984_20. Epub 2021 Apr 8. PMID: 34041158; PMCID: PMC8140231. https://doi.org/10.4103/jfmprc.jfmprc_1984_20
 14. Nagar V, Gour D, Pal DK, Singh AR, Joshi A, Dave L. A study on prevalence of diabetes and associated risk factors among diagnosed tuberculosis patients registered under Revised National Tuberculosis Control Programme in Bhopal District. *J Family Med Prim Care*. 2018;7(1):130-6. https://doi.org/10.4103/jfmprc.jfmprc_289_17
 15. Balakrishnan S, Vijayan S, Nair S, Subramoniapillai J, Mrithyunjayan S, Wilson N, et al. High diabetes prevalence among tuberculosis cases in Kerala, India. *PLoS One*. 2012;7(10):e46502. <https://doi.org/10.1371/journal.pone.0046502>
 16. WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet*. 2004;363(9403):157-63. [https://doi.org/10.1016/S0140-6736\(03\)15268-3](https://doi.org/10.1016/S0140-6736(03)15268-3)
 17. Omar N, Wong J, Thu K, Alikhan MF, Chaw L. Prevalence and associated factors of diabetes mellitus among tuberculosis patients in Brunei Darussalam: a 6-year retrospective cohort study. *Int J Infect Dis*. 2021;105:267-73. <https://doi.org/10.1016/j.ijid.2021.02.064>
 18. Sarker M, Barua M, Guerra F, Saha A, Aftab A, Latif AHM, et al. Double trouble: prevalence and factors associated with tuberculosis and diabetes comorbidity in Bangladesh. *PLoS One*. 2016;11(10):e0165396. <https://doi.org/10.1371/journal.pone.0165396>
 19. Workneh MH, Bjune GA, Yimer SA. Prevalence and associated factors of tuberculosis and diabetes mellitus comorbidity: a systematic review. *PLoS One*. 2017;12(4):e0175925. <https://doi.org/10.1371/journal.pone.0175925>
 20. Mave V, Gaikwad S, Barthwal M, Chandanwale A, Lokhande R, Kadam D, et al. Diabetes mellitus and tuberculosis treatment outcomes in Pune, India. *Open Forum Infect Dis*. 2021;8(4):ofab097. <https://doi.org/10.1093/ofid/ofab097>