

PREVALENCE AND DETERMINANTS OF DIABETES MELLITUS AMONGST PULMONARY TUBERCULOSIS PATIENTS A NARRATIVE REVIEW

Dr. Shilendra Kumar¹, Dr. Mallicka², Dr. Gulfam Ahmed Hashmi³, Dr. Syed Belal Hassan*

Junior Resident¹, Department of Community Medicine, Integral Institute of Medical Sciences and Research (IIMSR), Lucknow, Uttar Pradesh, India. ORCID ID- 0009-0005-1113-7437

Associate Professor², Department of Community Medicine, Integral Institute of Medical Sciences and Research (IIMSR), Lucknow, Uttar Pradesh, India. ORCID ID- 0000-0001-6082-9388

Professor and Head³, Department of Community Medicine, Integral Institute of Medical Sciences and Research (IIMSR), Lucknow, Uttar Pradesh, India. ORCID ID- 0009-0006-7478-0208

Professor⁴, Department of Community Medicine, Integral Institute of Medical Sciences and Research (IIMSR), Lucknow, Uttar Pradesh, India. ORCID ID- 0009-0002-9230-5532

Corresponding Author: Dr. Mallicka^{2*}

Email ID: drmallicka09@gmail.com

Postal Addresses:

Dr. Shilendra Kumar – H. No. 1, Gayatri Kunj, Kalindi Vihar, Agra – 282006, Uttar Pradesh, India.

Dr. Mallicka – Integral Institute of Medical Sciences and Research (IIMSR), Lucknow, Uttar Pradesh, India.

Dr. Gulfam Ahmed Hashmi – 508, SIHFW Campus, C Block, Indira Nagar, Lucknow, Uttar Pradesh, India.

Dr. Syed Belal Hassan – Office of Medical Superintendent, IIMSR, Lucknow, Uttar Pradesh, India.

Abstract

Tuberculosis and diabetes mellitus increasingly coexist in the same patients, particularly across South Asia, forming what many public health researchers now describe as a syndemic rather than two unrelated epidemics ^[1,2]. This narrative review synthesises recent, verifiable, open-access literature on the prevalence, determinants, pathophysiology, screening approaches and programmatic response to diabetes mellitus among patients with pulmonary tuberculosis, with particular attention to Indian and Lucknow-based evidence relevant. Individual Indian studies report considerably higher figures than the global pooled estimate: Rajaa et al. conducted a study in South India and found a prevalence of 39% ^[3], Bhatt et al. conducted a five-year tertiary hospital series in Lucknow and identified diabetes as the single most common comorbidity among elderly tuberculosis patients ^[4], Gupta et al. conducted a study in Delhi and found diabetes in 35.1% of geriatric patients ^[5], Sinha et al. conducted a five-site national cohort study and found a prevalence of 32.8% ^[6], and Kumar et al. conducted a study in Haryana and found a comparatively lower figure of 17.5% ^[7]. Diabetes impairs innate and adaptive immunity against Mycobacterium tuberculosis through disrupted macrophage function, altered cytokine signalling and impaired granuloma control ^[8,9], and this relationship appears bidirectional: bacterial genotype does not appear to differ substantially between diabetic and non-diabetic patients ^[10], while glycated haemoglobin tends to improve after treatment initiation, and a later rise in glycated haemoglobin predicts worse outcomes ^[11]. Diagnostic accuracy studies suggest that random and fasting plasma glucose combined with point-of-care glycated haemoglobin perform reasonably well as screening tools ^[12,13], though accuracy is reduced in populations with anaemia ^[14]. The World Health Organization's collaborative framework for bidirectional screening has been implemented in more than 30 countries with generally positive feasibility findings ^[15,16], though gaps in awareness, funding and service integration persist ^[17]. Economic analyses indicate that catastrophic health expenditure remains common among comorbid patients even where these services are nominally free ^[18,19]. Overall, the evidence supports systematic bidirectional screening in Indian tertiary care settings, while highlighting a continued need for locally generated data of the kind this review is intended to support.

How to cite this article: Dr. Shilendra Kumar¹, Dr. Mallicka², Dr. Gulfam Ahmed Hashmi³, Dr. Syed Belal Hassan. PREVALENCE AND DETERMINANTS OF DIABETES MELLITUS AMONGST PULMONARY TUBERCULOSIS PATIENTS A NARRATIVE REVIEW. Int J Drug Deliv Technol. 2026;16(83s):1488-1496. DOI: 10.25258/ijddt.16.83s.161.

Introduction

Tuberculosis remains one of the leading infectious causes of death worldwide, and India carries the largest absolute burden of any country. The convergence of these two epidemics in the same individuals is not coincidental: diabetes roughly triples the risk of developing active tuberculosis,

delays sputum culture conversion, and is associated with a higher risk of treatment failure, relapse and death, while tuberculosis itself can precipitate transient hyperglycaemia through the metabolic stress of chronic infection and inflammation ^[1,2,8]. The term syndemic has increasingly been applied to this relationship, capturing the idea that the two

PREVALENCE AND DETERMINANTS OF DIABETES MELLITUS AMONGST PULMONARY TUBERCULOSIS PATIENTS A NARRATIVE REVIEW

conditions interact biologically and socially in ways that amplify each other's burden, particularly in settings with limited integration between infectious disease and non-communicable disease services.

India's National Tuberculosis Elimination Programme has, in recent years, moved toward bidirectional screening of tuberculosis and diabetes patients, following the broader lead of the World Health Organization and International Union Against Tuberculosis and Lung Disease collaborative framework introduced in 2011 [15,16]. However, the prevalence and determinants of diabetes among tuberculosis patients vary considerably across Indian states and healthcare settings, and locally generated evidence remains comparatively limited outside a handful of well-studied sites such as Puducherry, Chennai and Delhi.

Most of the evidence synthesised here comes from India, other South and Southeast Asian countries, and a smaller number of multicountry studies from Africa, Latin America and Europe; the applicability of any single finding to the Lucknow setting should be treated as a working hypothesis to be tested locally rather than an assumption.

Methods

This is a narrative review rather than a systematic review, and no registered protocol or PRISMA methodology was followed. Relevant literature was identified through searches of PubMed, PubMed Central and connected literature-discovery tools, covering the period January 2016 to July 2026, using combinations of the terms tuberculosis, pulmonary tuberculosis, diabetes mellitus, prevalence, determinants, screening, bidirectional, glycaemic control and India. Reference lists of retrieved articles were hand-searched for additional sources.

Priority was given, where available, to studies conducted in India and specifically in Uttar Pradesh, given the intended local application of this review.

Selection and synthesis were narrative rather than systematic, with no formal risk-of-bias scoring or meta-analytic pooling attempted.

Epidemiology of the Tuberculosis-Diabetes Syndemic

Li et al. conducted a systematic review and meta-analysis pooling 153 studies across 51 countries and estimated the global prevalence of diabetes mellitus among pulmonary tuberculosis patients at 13.7%, with regional estimates ranging from 9.3% in the African region to 19.3% in the Americas and 14.6% in Southeast Asia [1]. Wu et al. conducted a separate meta-analysis approaching the relationship from the opposite direction and estimated the pooled incidence of pulmonary tuberculosis among patients with type 2 diabetes at approximately 130 per 100,000 person-years globally, rising to around 187 per 100,000

person-years in Asia and higher still in countries with a high tuberculosis burden [2].

Individual Indian studies generally report figures well above the global pooled estimate. Rajaa et al. conducted a study among a cohort in Puducherry, Cuddalore and Villupuram and found that 39% of newly diagnosed tuberculosis patients had coexisting diabetes, with only twelve patients needing to be screened to identify one new diabetes case [3]. Bhatt et al. conducted a five-year retrospective analysis of over 41,000 tuberculosis cases at a tertiary care hospital in Lucknow and found that diabetes mellitus was the single most common comorbidity among elderly patients, present in almost 30% of those with recorded comorbidity data, considerably higher than the proportion reporting alcohol or tobacco use [4]. Gupta et al. conducted a comparable retrospective cohort study at a tertiary hospital in Delhi and found diabetes in 35.1% of geriatric tuberculosis patients compared with 16.2% of non-geriatric patients [5]. Sinha et al. conducted a prospective, five-site cohort study across India and reported that 32.8% of adults with drug-sensitive pulmonary tuberculosis had diabetes at enrolment, alongside high rates of undernutrition and smoking [6]. Kumar et al. conducted a smaller prospective study in Haryana and found a comparatively lower figure of 17.5%, illustrating the extent of variation even within the same country [7]. Figure 1 places several of these estimates alongside the global pooled figure for context, and Table 1 summarises the same studies in more detail.

Study (first author, year)	Setting	Population / design	Reported prevalence of DM among PTB
Li et al., 2021 [1]	Global (51 countries, meta-analysis)	153 pooled studies	13.7% (95% CI 12.5-15.0), pooled global estimate
Rajaa et al., 2021 [3]	Puducherry, Cuddalore, Villupuram, South India	1188 newly diagnosed PTB patients, cross-sectional	39% (95% CI 36.2-41.8)
Bhatt et	Tertiary	41,751 TB	Diabetes

PREVALENCE AND DETERMINANTS OF DIABETES MELLITUS AMONGST PULMONARY TUBERCULOSIS PATIENTS A NARRATIVE REVIEW

al., 2026 [4]	hospital, Lucknow, India	cases, 5-year retrospective	most common comorbidity in geriatric cohort (~30% of those with comorbidity data)
Gupta et al., 2026 [5]	Tertiary hospital, New Delhi, India	951 adult TB patients, retrospective cohort	35.1% in geriatric patients vs 16.2% in non- geriatric patients
Sinha et al., 2025 [6]	5 clinical sites, India	2930 adults with drug- sensitive PTB, prospective cohort	32.8% at enrolment
Kumar et al., 2025 [7]	Ballabgarh, Haryana, India	412 adults with drug- sensitive PTB, prospective	17.5%

Table 1.

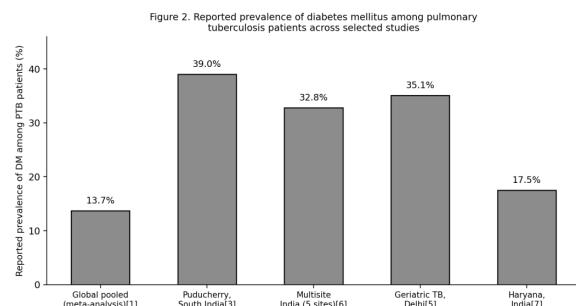


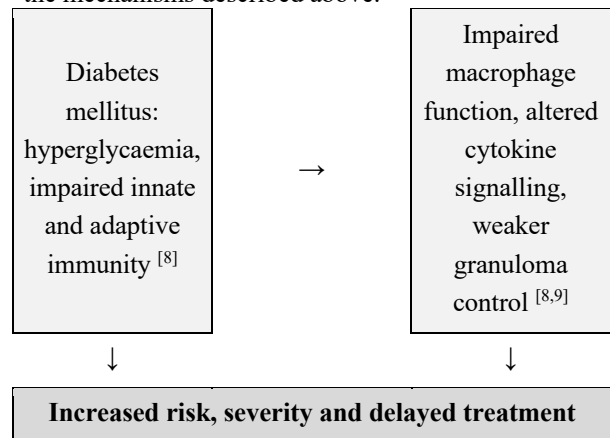
Figure 1. Reported prevalence of diabetes mellitus among pulmonary tuberculosis patients across selected studies, plotted from the figures in Table 1 [1,3,5,6,7].

Pathophysiological and Immunological Basis of the Association

The relationship between diabetes and tuberculosis is now understood to be genuinely bidirectional rather than a simple case of one condition predisposing to

the other. Saula et al. conducted a systematic review synthesising 81 studies published between 1974 and 2023 and concluded that diabetes broadly dysregulates both innate and adaptive immune responses against *Mycobacterium tuberculosis*, with altered cytokine signalling, impaired granuloma structure and reduced bacterial control reported across animal and human studies, and with emerging evidence that even pre-diabetes and intermediate hyperglycaemia may compromise tuberculosis immunity [8]. Consistent with this, Rajamanickam et al. conducted a South Indian study comparing cytokine and chemokine profiles and found that patients with pulmonary tuberculosis and pre-diabetes had elevated levels of several pro-inflammatory cytokines and chemokines compared with patients with tuberculosis alone, with some markers, including interleukin-18 and granulocyte-macrophage colony-stimulating factor, correlating with glycated haemoglobin levels, suggesting a direct link between glycaemic status and the immune response to infection [9].

Shankaregowda et al. conducted a genomic study that also examined whether the interaction reflects differences in the infecting organism rather than only the host [10]. On the metabolic side, Kornfeld et al. conducted a longitudinal cohort study from Chennai, following patients through and after tuberculosis treatment, and found that glycated haemoglobin tended to fall after treatment initiation across all glycaemic categories, that patients with normoglycaemia or prediabetes at baseline rarely progressed to diabetes by the end of the study, and that a rise in glycated haemoglobin after the intensive phase of treatment in patients with baseline diabetes was significantly associated with adverse tuberculosis outcomes, reinforcing the clinical importance of monitoring glycaemic trends throughout treatment rather than only at diagnosis [11]. Figure 2 sets out this bidirectional relationship schematically, drawing on the mechanisms described above.



PREVALENCE AND DETERMINANTS OF DIABETES MELLITUS AMONGST PULMONARY TUBERCULOSIS PATIENTS A NARRATIVE REVIEW

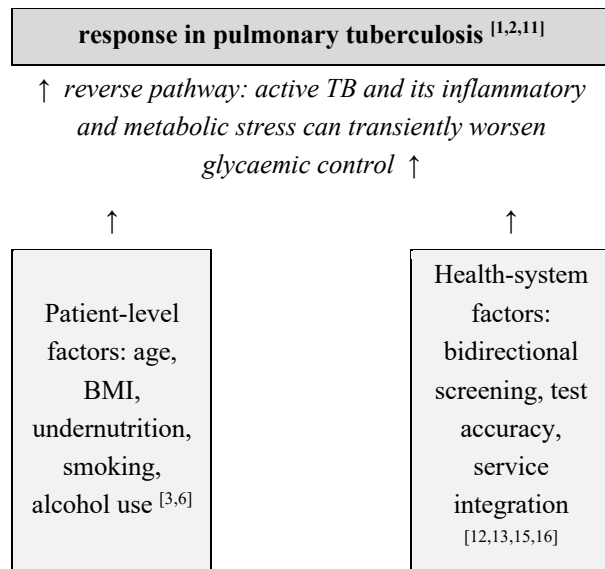


Figure 2. Adapted conceptual framework of the bidirectional relationship between diabetes mellitus and pulmonary tuberculosis. This is a conceptual diagram synthesised from the literature discussed above, not an empirically validated or tested causal pathway.

Determinants and Risk Factors for Diabetes Among Tuberculosis Patients

Determinants of diabetes among tuberculosis patients vary somewhat across settings, though several factors recur. Rajaa et al. conducted a cross-sectional study among 1188 newly diagnosed tuberculosis patients in Puducherry, Cuddalore and Villupuram and found that, in unadjusted analysis, age, marital status, caste, gender, education, household income and obesity were significantly associated with diabetes status. After adjustment, however, only marital status and body mass index category remained significant: currently married patients had an adjusted prevalence ratio (aPR) of 3.77 (95% CI 2.20-6.49) and widowed/separated/divorced patients an aPR of 3.66 (95% CI 1.96-6.83) for diabetes, compared with never-married patients, while, compared with underweight patients, the aPR for diabetes rose progressively with body mass index category-3.26 (95% CI 2.55-4.16) for normal weight, 3.86 (95% CI 2.69-5.52) for overweight and 4.08 (95% CI 2.81-5.94) for obese patients ^[3]. This finding is notable because it runs somewhat counter to the assumption that tuberculosis patients with diabetes are uniformly underweight; instead, it points to a more complex nutritional picture in which both undernutrition and excess adiposity can coexist with diabetes risk within the same tuberculosis-affected population.

Sinha et al. conducted a prospective cohort study across five clinical sites in India, enrolling 2930 adults with drug-sensitive pulmonary tuberculosis,

and took a different analytical approach, estimating the population-level contribution of several potentially modifiable risk factors to unfavourable tuberculosis treatment outcomes overall, rather than to diabetes specifically. In unadjusted analysis, 32.2% (95% CI 23.1-40.3) of unfavourable outcomes were attributable to undernutrition, 19.4% (95% CI 12.3-25.8) to ever-smoking and 8.5% (95% CI 4.3-12.6) to alcohol misuse; after adjusting for the simultaneous presence of multiple risk factors, undernutrition alone accounted for 29.0% (95% CI 17.6-38.8) of unfavourable outcomes, while ever-smoking and alcohol misuse accounted for 17.9% (95% CI 1.1-31.9) and 15.4% (95% CI 7.9-22.3) respectively, and diabetes itself was present in 32.8% of the cohort ^[6]. Read alongside the findings of Rajaa et al., this suggests that undernutrition, smoking, alcohol use and diabetes coexist and interact in Indian tuberculosis populations rather than operating as cleanly separable risk factors, which has implications for how a Lucknow-based study designs its determinant analysis. Age also emerges consistently as a determinant: Gupta et al. conducted a retrospective cohort study in New Delhi and found diabetes in 35.1% of geriatric tuberculosis patients compared with 16.2% of non-geriatric patients, and Bhatt et al. conducted a five-year retrospective study in Lucknow finding a substantially higher proportion of diabetes among geriatric patients than younger adults ^[4,5]. Table 2 summarises the determinants identified across these studies.

Determinant	Direction of association	Source study
Higher body mass index / obesity	Increased odds of diabetes among TB patients (adjusted PR 3.26-4.08 vs underweight, $p < 0.001$)	Rajaa et al., 2021 ^[3]
Marital status (currently married, or widowed/separated/divorced)	Increased adjusted prevalence ratio for diabetes (aPR 3.77, 95% CI 2.20-6.49 currently married; aPR 3.66, 95% CI 1.96-6.83 widowed/separated/divorced)	Rajaa et al., 2021 ^[3]

PREVALENCE AND DETERMINANTS OF DIABETES MELLITUS AMONGST PULMONARY TUBERCULOSIS PATIENTS A NARRATIVE REVIEW

	vorced)	
Older / geriatric age	Higher prevalence of diabetes comorbidity (35.1% geriatric vs 16.2% non-geriatric)	Bhat et al., 2026 [4]; Gupta et al., 2026 [5]
Undernutrition	Largest attributable fraction of unfavourable TB outcomes overall (adjusted AF 29.0%, 95% CI 17.6-38.8)	Sinha et al., 2025 [6]
Smoking and alcohol misuse	Significant contributors to unfavourable TB outcomes (adjusted AF: ever-smoking 17.9%, alcohol misuse 15.4%); commonly co-occur with diabetes	Sinha et al., 2025 [6]

Table 2. Determinants of diabetes mellitus among tuberculosis patients identified in selected studies.

Screening and Diagnostic Approaches

Because a substantial proportion of diabetes among tuberculosis patients is previously undiagnosed, the choice of screening test matters considerably for programme design. Grint et al. conducted a study across Indonesia, Peru, Romania and South Africa comparing random plasma glucose, point-of-care glycated haemoglobin, fasting blood glucose, urine dipstick testing and clinical risk scores against laboratory glycated haemoglobin as the reference standard, finding that point-of-care glycated haemoglobin performed best on its own, and that a two-step approach using random plasma glucose to identify patients for follow-up point-of-care glycated haemoglobin testing performed well in two of the four countries while reducing the number of more expensive confirmatory tests required [12]. Kibirige et al. conducted a related evaluation in Uganda and found that fasting blood glucose modestly

outperformed laboratory-measured glycated haemoglobin against an oral glucose tolerance test reference standard in confirming diabetes among recently diagnosed tuberculosis patients, though both tests had important limitations in a small sample [13]. Calderon et al. conducted a prospective cohort study from Lima, Peru that illustrates an important caveat for glycated haemoglobin-based screening in tuberculosis populations specifically: patients with tuberculosis and diabetes in that cohort had substantially lower haemoglobin levels than other groups, and this anaemia was associated with reduced accuracy of glycated haemoglobin as a diagnostic test, since glycated haemoglobin values can be distorted by altered red blood cell turnover [14]. Given that anaemia is itself common among tuberculosis patients in India, this finding is directly relevant to test selection for a Lucknow-based screening protocol and suggests that plasma glucose-based tests, rather than glycated haemoglobin alone, may be the more dependable first-line screening option in similar settings. Table 3 summarises the screening approaches evaluated across these three studies.

Study (first author, year)	Setting	Tests compared	Key finding
Grint et al., 2018 [12]	Indonesia, Peru, Romania, South Africa	Random plasma glucose, point-of-care HbA1c, fasting glucose, urine dipstick, risk scores vs laboratory HbA1c	Point-of-care HbA1c alone performed best; two-step RPG-then-HbA1c approach reduced testing burden
Kibirige et al., 2023 [13]	Kampala, Uganda	Fasting blood glucose and laboratory HbA1c vs oral glucose	Fasting blood glucose modestly outperformed HbA1c; both had

PREVALENCE AND DETERMINANTS OF DIABETES MELLITUS AMONGST PULMONARY TUBERCULOSIS PATIENTS A NARRATIVE REVIEW

		tolerance test	important accuracy limitations
Calderon et al., 2019 [14]	Lima, Peru	Fasting plasma glucose, HbA1c, oral glucose tolerance test	Anaemia in TB-DM patients reduced diagnostic accuracy of HbA1c specifically

Table 3. Diagnostic tools evaluated for screening diabetes mellitus among tuberculosis patients.

Clinical and Programmatic Implications

Salifu et al. conducted a scoping review and found evidence of the framework's implementation in 35 countries, with bidirectional screening identified in both rural and urban settings, though the review also found limited evidence describing the specific mechanisms of collaboration between tuberculosis and diabetes services on the ground [16]. Milice et al. conducted a related rapid review that reached a similar conclusion, describing bidirectional activities as valuable, feasible and broadly effective where implemented, while noting that limited awareness of the comorbidity among healthcare workers and patients remained a persistent barrier to fuller integration [15]. Salifu et al. conducted a qualitative study of healthcare workers implementing bidirectional screening in Ghana and identified increased staff capacity and institutionalisation of screening as facilitators, against barriers that included delays in screening, stigma associated with tuberculosis, poor collaboration between the separate tuberculosis and diabetes units, and skewed funding that favoured one programme over the other [17]; similar structural barriers plausibly apply within India's own separately administered National Tuberculosis Elimination Programme and National Programme for Prevention and Control of Non-Communicable Diseases.

Beyond screening feasibility, comorbidity carries a measurable economic cost even in health systems that formally provide free tuberculosis care. Rupani et al. conducted a cohort study from Bhavnagar, Gujarat and found that catastrophic costs, defined as health-related expenditure exceeding 20% of annual household income, affected 5% of tuberculosis-diabetes patients compared with 4% of tuberculosis-only patients, with being below the poverty line and requiring initial hospitalisation identified as significant predictors of catastrophic expenditure,

although catastrophic costs themselves were not directly associated with unfavourable tuberculosis treatment outcomes in that particular cohort [18]. Skordis-Worrall et al. conducted a qualitative and survey-based study from Kyrgyzstan that similarly found very high levels of catastrophic health spending among patients with tuberculosis, diabetes or both, despite both conditions being nominally covered within the state benefit package, and noted that health workers often viewed comorbid patients as too complex for routine primary care management, a perception that itself may drive additional referral costs and delays [19].

Discussion and Future Directions

Taken together, the literature reviewed here supports three broad conclusions relevant to a tertiary-care hospital study in Lucknow. First, the prevalence of diabetes among pulmonary tuberculosis patients in India appears consistently higher than the global pooled estimate, though it varies considerably between Indian sites, from around 17.5% in Haryana to 39% in Puducherry [1,3,7], which means locally generated prevalence data cannot simply be extrapolated from other Indian states and should be established directly. Second, the determinants of this comorbidity in Indian settings extend well beyond the classical picture of an underweight tuberculosis patient, encompassing higher body mass index, marital status, older age and, at a population level, undernutrition, smoking and alcohol use, suggesting that a comprehensive determinant analysis in Lucknow should collect data across this full range rather than assuming which factors will prove significant in advance [3,6]. Third, screening test selection is not a neutral methodological detail: the accuracy of glycated haemoglobin appears to be reduced in tuberculosis populations with a high burden of anaemia, a consideration directly relevant to protocol design in a north Indian tertiary care setting where anaemia among tuberculosis patients is common [14].

Several limitations of the underlying evidence base should be kept in mind:

- Limited Uttar Pradesh-specific data: while Bhatt et al.'s five-year retrospective study from a tertiary hospital in Lucknow provides valuable local context, it was not designed primarily to examine diabetes determinants among tuberculosis patients, leaving a gap that a dedicated cross-sectional study can address [4].
- Screening test accuracy varies by population: diagnostic accuracy studies conducted in Uganda, Peru and four other countries may not generalise directly to a north Indian tertiary care population with its

PREVALENCE AND DETERMINANTS OF DIABETES MELLITUS AMONGST PULMONARY TUBERCULOSIS PATIENTS A NARRATIVE REVIEW

own patterns of anaemia, body composition and glycaemic distribution^[12,13,14].

- Limited evidence on service integration mechanisms: existing reviews of the WHO bidirectional framework describe feasibility and barriers at a general level but provide little operational detail on how tuberculosis and diabetes services can be practically integrated within a single Indian tertiary care hospital^[15,16].

Conclusion

Diabetes mellitus and pulmonary tuberculosis interact through overlapping immunological, nutritional and social pathways, and this comorbidity is more common in India than the global average, though its precise scale and determinants differ meaningfully even between Indian states. The evidence reviewed here indicates that bidirectional screening is feasible and clinically meaningful, that test selection should account for local factors such as anaemia, and that determinants extend beyond simple undernutrition to include obesity, age and marital status. A dedicated study among pulmonary tuberculosis patients at a tertiary care hospital in Lucknow is well justified by these gaps, and stands to contribute meaningfully to the still-limited evidence base on this syndemic from Uttar Pradesh specifically.

Declarations

Funding: NA

Competing Interests: The authors declare that they have no competing interests or conflicts of interest related to this study.

Ethical Approval: Not applicable (review article).

Consent for publication: There is consent for the publication of this paper.

Authors' contributions: All authors contributed equally.

Acknowledgements

The authors are grateful to the Dean, Head of the Department of Community Medicine, and our guide and co-guide at Integral Institute of Medical Sciences & Research, Faculty of Medicine and Health Sciences, Integral University, Lucknow. **MCN No. IU/R&D/2026-MCN0004976**

PREVALENCE AND DETERMINANTS OF DIABETES MELLITUS AMONGST PULMONARY TUBERCULOSIS PATIENTS A NARRATIVE REVIEW

References

1. Li M, Chen T, Hua Z, Yan H, Wang D, Li Z, et al. Global, regional, and national prevalence of diabetes mellitus in patients with pulmonary tuberculosis: a systematic review and meta-analysis. *DiabetolMetab Syndr*. 2021;13:127. doi:10.1186/s13098-021-00743-3. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC8557479/>
2. Wu Q, Liu Y, Ma YB, Liu K, Chen SH. Incidence and prevalence of pulmonary tuberculosis among patients with type 2 diabetes mellitus: a systematic review and meta-analysis. *Ann Med*. 2022;54(1):1657-1666. doi:10.1080/07853890.2022.2085318. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC9225779/>
3. Rajaa S, Krishnamoorthy Y, Knudsen S, Roy G, Ellner J, Horsburgh CR, et al. Prevalence and factors associated with diabetes mellitus among tuberculosis patients in South India-a cross-sectional analytical study. *BMJ Open*. 2021;11(10):e050542. doi:10.1136/bmjopen-2021-050542. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC8543642/>
4. Bhatt D, Ratnam R, Abbas F, Singh M, Singh U, Jain P. Epidemiology of geriatric tuberculosis: a five-year retrospective study from a tertiary care hospital in India. *BMC Geriatr*. 2026;26(1). doi:10.1186/s12877-026-07451-5. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC13214118/>
5. Gupta S, Rastogi V, Sharma D, Singh M, Sharawat V, Nandini R, et al. A comparative analysis of comorbidities, clinical profiles, and treatment outcomes among geriatric and non-geriatric tuberculosis patients in New Delhi, India: a retrospective cohort study. *Cureus*. 2026;18(3):e105771. doi:10.7759/cureus.105771. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC13108069/>
6. Sinha P, Karoly M, Padmapriyadarsini C, Paradkar M, Mave V, Gupte N, et al. Contribution of key comorbidities to unfavorable treatment outcomes among adults with drug-sensitive pulmonary TB in India: a prospective cohort analysis. *Chest*. 2026;169(1):64-72. doi:10.1016/j.chest.2025.05.055. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC13169425/>
7. Kumar R, Singh UB, Chandra A, Kandasamy D, Krishnan A. Association of diabetes mellitus with presentation and treatment outcomes among adult patients with pulmonary tuberculosis. *Am J Trop Med Hyg*. 2025;112(5):1065-1071. doi:10.4269/ajtmh.24-0390. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC12062685/>
8. Saula AY, Cevik M, Cliff JM, Ronacher K, Bowness R. Immune dysregulation in tuberculosis-diabetes comorbidity: mechanistic and translational insights. *Front Immunol*. 2026;17:1803046. doi:10.3389/fimmu.2026.1803046. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC13149154/>
9. Rajamanickam A, Kothandaraman SP, Kumar NP, Viswanathan V, Shanmugam S, Hissar S, et al. Cytokine and chemokine profiles in pulmonary tuberculosis with pre-diabetes. *Front Immunol*. 2024;15:1447161. doi:10.3389/fimmu.2024.1447161. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC11390597/>
10. Shankaregowda R, Allegritti YH, Sumana MN, Rao MR, Raphael E, Mahesh PA, et al. Whole-genome sequencing of Mycobacterium tuberculosis isolates from diabetic and non-diabetic patients with pulmonary tuberculosis. *Microorganisms*. 2023;11(8):1881. doi:10.3390/microorganisms11081881. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC10457832/>
11. Kornfeld H, Procter-Gray E, Kumpatla S, Kane K, Li W, Magee MJ, et al. Longitudinal trends in glycated hemoglobin during and after tuberculosis treatment. *Diabetes Res Clin Pract*. 2023;196:110242. doi:10.1016/j.diabres.2023.110242. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC13282844/>
12. Grint D, Alisjhabana B, Ugarte-Gil C, Riza AL, Walzl G, Pearson F, et al. Accuracy of diabetes screening methods used for people with tuberculosis, Indonesia, Peru, Romania, South Africa. *Bull World Health Organ*. 2018;96(11):738-749. doi:10.2471/BLT.17.206227. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC6239004/>
13. Kibirige D, Zawedde-Muyanja S, Andia-Biraro I, Olum R, Adakun S, Sekaggya-Wiltshire C, et al.

PREVALENCE AND DETERMINANTS OF DIABETES MELLITUS AMONGST PULMONARY TUBERCULOSIS PATIENTS A NARRATIVE REVIEW

- Diagnostic accuracy of two confirmatory tests for diabetes mellitus in adult Ugandans with recently diagnosed tuberculosis. *Ther Adv Infect Dis.* 2023;10:20499361231216799. doi:10.1177/20499361231216799. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC10748612/>
- 0239-3. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC5353796/>
14. Calderon RI, Arriaga MB, Lopez K, Barreda NN, Sanabria OM, Froes Neto JF, et al. High prevalence and heterogeneity of dysglycemia in patients with tuberculosis from Peru: a prospective cohort study. *BMC Infect Dis.* 2019;19(1):799. doi:10.1186/s12879-019-4416-2. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC6737721/>
 15. Milice DM, Macicame I, L Peñalvo J. The collaborative framework for the management of tuberculosis and type 2 diabetes syndemic in low- and middle-income countries: a rapid review. *BMC Public Health.* 2024;24(1):738. doi:10.1186/s12889-024-18256-9. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC10921776/>
 16. Salifu RS, Hlongwa M, Hlongwana K. Implementation of the WHO's collaborative framework for the management of tuberculosis and diabetes: a scoping review. *BMJ Open.* 2021;11(11):e047342. doi:10.1136/bmjopen-2020-047342. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC8601079/>
 17. Salifu RS, Hlongwana KW. Barriers and facilitators to bidirectional screening of TB-DM in Ghana: healthcare workers' perspectives. *PLoS One.* 2020;15(7):e0235914. doi:10.1371/journal.pone.0235914. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC7360027/>
 18. Rupani MP, Vyas S, Shah IA. Cohort study on association between catastrophic costs and unfavorable tuberculosis treatment outcomes among TB-HIV and TB-diabetes comorbid patients in India. *BMC Public Health.* 2024;24(1):2028. doi:10.1186/s12889-024-19609-0. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC11285260/>
 19. Skordis-Worrall J, Round J, Arnold M, Abdraimova A, Akkazieva B, Beran D. Addressing the double-burden of diabetes and tuberculosis: lessons from Kyrgyzstan. *Global Health.* 2017;13(1):16. doi:10.1186/s12992-017-