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Original Research Article

Comorbid Tuberculosis and Diabetes Mellitus: Assessing Health Status and Therapeutic Responses in Patients from Gujarat

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Abstract:

Background: Tuberculosis (TB) and diabetes mellitus (DM) are two major global health challenges, with their coexistence increasingly recognized as a serious public health concern, particularly in low- and middle-income countries like India. The dual burden of TB and DM complicates disease management and adversely affects treatment outcomes. This study aimed to assess the socio-demographic profile, glycemic control, and treatment outcomes in newly diagnosed pulmonary TB patients with coexisting diabetes in Gujarat, India.

Methods: A longitudinal observational study was conducted for six months across five Tuberculosis Units (TUs) in Gujarat. Eighty newly diagnosed pulmonary TB patients with diabetes were enrolled and followed through three stages: at diagnosis, after the intensive phase of TB treatment, and at the end of therapy. Socio-demographic data, glycemic parameters (FBG, PPBG, HbA1c), and treatment outcomes were assessed using pre-tested questionnaires and laboratory investigations. Data were analyzed using SPSS version 25.0.

Results: The majority of participants were middle-aged males (61.25%), with laborers constituting the largest occupational group (42.5%). Significant improvement in glycemic control was observed during treatment: mean FBG reduced from 162.8 mg/dL to 139.5 mg/dL ($p<0.001$) and PPBG declined from 247.3 mg/dL to 210.9 mg/dL ($p<0.001$). Treatment success was achieved in 90.2% of patients, while 6.9% were lost to follow-up and 2.8% died.

Conclusion: Integrated management of TB and diabetes significantly improved glycemic control and resulted in favorable treatment outcomes. Comprehensive bidirectional screening and collaborative management are essential for improving the prognosis of TB-DM comorbid patients.

Keywords: Tuberculosis, Diabetes Mellitus, Comorbidity, Treatment Outcome, Glycemic Control.

Introduction

Tuberculosis (TB) and diabetes mellitus (DM) are two major public health concerns "that exert a significant global burden, particularly in low- and middle-income countries. The convergence of these two diseases presents a unique and increasingly recognized challenge to global health systems. TB remains among the leading causes of mortality globally, ranking as the 13th leading cause of death and the second deadliest infectious disease after COVID-19 [1]. Despite substantial progress in the diagnosis, treatment, and prevention of TB, the disease continues to disproportionately affect vulnerable populations such as the impoverished, the malnourished, and the elderly. The global epidemiology of TB reveals a highly uneven distribution, with approximately 87% of all cases reported in sub-Saharan Africa, Asia, and South America, highlighting the persistent geographical inequity in disease burden [2].

The epidemiological profile of diseases in India has also undergone a significant transition over recent decades, characterized by a steady decline in communicable diseases (CDs) and a concurrent rise in non-communicable diseases (NCDs) [3,4]. This epidemiological shift has generated competition for healthcare resources and policy attention between CDs, such as TB, and NCDs, such as diabetes mellitus and cardiovascular diseases. DM, particularly type 2 diabetes, has emerged as a substantial risk factor for TB, complicating disease control efforts. Globally, an estimated 9.6 million new TB cases occur annually, with approximately 1 million of these cases occurring in individuals with coexisting diabetes. Notably, there are now more TB patients living with diabetes than with human immunodeficiency virus (HIV) infection, underscoring the urgent need to address this comorbidity within TB control programs.

The association between TB and DM is bidirectional and synergistic, with each condition influencing the course and prognosis of the other. Diabetes is a recognized independent risk factor for the development of active TB, increasing the risk by two- to threefold compared to non-diabetic individuals. Conversely, TB itself may contribute to glucose dysregulation, leading to impaired glucose tolerance (IGT) and new-onset diabetes in previously euglycemic individuals [5]. This complex interplay poses significant challenges to both diagnosis and management. Furthermore, evidence indicates that diabetes alters the clinical presentation of TB, influencing symptomatology, radiographic manifestations, treatment response, and final outcomes. Individuals with diabetes and TB are more likely to present with atypical radiological findings, slower sputum conversion rates, higher rates of treatment failure, and increased risk of relapse and mortality. These observations highlight the need for tailored clinical and therapeutic strategies for individuals with dual TB-DM burden.

The co-occurrence of TB and DM also imposes a substantial burden on patients' quality of life (QoL), encompassing physical, psychological, and social dimensions [6]. The chronic nature of diabetes, compounded by the infectious and often stigmatized nature of TB, amplifies psychological distress and social isolation, further complicating adherence to long treatment regimens. This dual disease burden requires a comprehensive, patient-centered approach that integrates medical, psychological, and social interventions. Effective management of TB-DM comorbidity demands a coordinated, multidisciplinary approach encompassing early screening, timely diagnosis, optimized treatment regimens, and robust follow-up mechanisms.

Recognizing this challenge, India's National TB Elimination Program (NTEP), formerly known as the Revised National TB Control Programme (RNTCP), in collaboration with the National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Diseases, and Stroke (NPCDCS), developed the "National Framework for Joint TB Diabetes Collaborative Activities" in 2017 [7,8]. This framework aims to reduce morbidity and mortality related to TB-DM comorbidity through systematic bidirectional screening, early diagnosis, and integrated management. Such collaborative initiatives are critical not only for improving individual patient outcomes but also for achieving population-level disease control targets.

Furthermore, the Sustainable Development Goals (SDGs) and the WHO Global Action Plan for the Prevention and Control of NCDs aim to reduce premature mortality from NCDs, including diabetes, by 30% by 2030. Achieving this target necessitates focused attention on comorbid conditions such as TB-DM, which present unique challenges and require innovative programmatic responses [9]. Against this backdrop, the present study was conceived to evaluate the progression of health status among individuals with TB and DM during anti-TB treatment and to assess treatment outcomes after therapy. By generating" evidence on the clinical course and outcomes of this vulnerable group, the study aims to inform future policies and programmatic strategies for managing TB-DM comorbidity in resource-constrained settings.

Materials and Methods

Study Design: This was a longitudinal observational study conducted to assess newly registered pulmonary tuberculosis (PTB) patients with diabetes mellitus (DM). The study was carried out at the Department of Community Medicine, Parul Institute of Medical Sciences & Research, Parul University, Vadodara, Gujarat, between six months.

Study Location: The study population was selected from five tuberculosis units (TUs) under the government health system in Gujarat. These TUs function under the Revised National Tuberculosis Control Program (RNTCP), ensuring standardized diagnosis, treatment, and follow-up of tuberculosis patients.

Sample Size: The study included a sample size of 80 patients, comprising newly diagnosed pulmonary TB patients with coexisting diabetes mellitus. This sample was derived from the total registered pulmonary TB cases across the five TUs during the study period. These 80 patients were followed longitudinally at the time of diagnosis, during treatment, and at the end of treatment.

Inclusion and Exclusion Criteria: Patients were included if they were newly diagnosed pulmonary TB cases with diabetes mellitus, aged 18 years or above, and willing to participate in the study after providing informed consent. Patients with extrapulmonary TB, multidrug-resistant TB (MDR-TB), extensively drug-resistant TB (XDR-TB), or those with serious co-morbid conditions preventing follow-up were excluded.

Data Collection: Data were collected using preformed, pre-tested, and semi-structured questionnaire through face-to-face interviews conducted by trained investigators. Information collected included socio-demographic characteristics, clinical history of tuberculosis and diabetes mellitus, quality of life (QoL) indicators, and treatment outcomes.

Procedure: All newly diagnosed TB patients were screened for diabetes mellitus at the time of TB diagnosis using random blood sugar (RBS) testing. Blood samples were collected by a trained laboratory technician at the Distinct Tuberculosis Center and analyzed at the same facility. Those with elevated RBS suggestive of diabetes underwent fasting blood glucose (FBG) and post-prandial plasma glucose (PPBG) testing for confirmation. These

samples were collected at the TUs and analyzed at the same location. Additionally, HbA1c testing was performed at the Parul Institute of Medical Science & Research to assess long-term glycemic control. However, due to the COVID-19 pandemic and associated lockdowns, several patients did not complete HbA1c testing, resulting in its exclusion from final analysis.

Patients followed at three points:

1. At the time of diagnosis and initiation of anti-tuberculosis treatment (baseline visit)
2. At the end of the intensive phase of treatment (first follow-up)
3. At the end of the full treatment duration (second follow-up)

During these follow-ups, patients were reassessed for their diabetic status, quality of life, and treatment outcomes. Loss to follow-up and mortality were recorded at each stage.

Examination Parameters: All patients underwent anthropometric assessment, including measurement of height, weight, and calculation of body mass index (BMI). BMI was categorized using the Asian Classification. Laboratory parameters included random blood sugar (RBS), fasting blood glucose (FBG), post-prandial plasma glucose (PPBG), and HbA1c (where available).

The diagnosis of pulmonary tuberculosis was confirmed by:

- Detection of *Mycobacterium tuberculosis* in sputum smear microscopy or GeneXpert testing,
- Clinical diagnosis based on persistent symptoms and chest radiographic findings suggestive of TB disease.

Diabetes mellitus was diagnosed according to the following criteria:

- Fasting plasma glucose ≥126 mg/dL or post-prandial plasma glucose ≥200 mg/dL in symptomatic individuals
- Fasting plasma glucose ≥126 mg/dL or post-prandial plasma glucose ≥200 mg/dL on two separate occasions in asymptomatic individuals
- Known cases of diabetes mellitus already receiving anti-diabetic treatment

Statistical Analysis: Data were entered into Microsoft Office Excel 2016 and analyzed using SPSS (Statistical Package for the Social Sciences), version 25.0 (IBM, Chicago, USA). Descriptive statistics were applied to summarize demographic and clinical data. Chi-square Test and "T-test were used to analyze changes over time for categorical and continuous variables, as appropriate. A p-value <0.05 was considered statistically significant.

Results

The socio-demographic and clinical profile of the 80 study participants revealed that the majority (47.5%) were aged between 31-50 years, followed by 33.75% who were above 50 years. Males comprised 61.25% of the sample, indicating a higher prevalence of pulmonary tuberculosis (PTB) with diabetes mellitus (DM) among men. In terms of occupation, laborers constituted the largest group (42.5%), highlighting the socio-economic vulnerability of these patients. Nutritional status, assessed using the Asian BMI classification, showed that 22.5% of participants were underweight, while 48.75% had normal BMI, and only 10% were obese. Smoking history revealed that 37.5% of the participants were current smokers, underscoring smoking as a notable risk factor in this population. This profile highlights that PTB-DM co-morbidity disproportionately affects economically vulnerable, middle-aged males with a significant proportion having suboptimal nutritional status and smoking exposure.

Table 1: Socio-demographic and Clinical Profile of Study Participants (n=80)

Variable	Frequency (%)
Age Group (in years)	
18-30	15 (18.75%)
31-50	38 (47.5%)
>50	27 (33.75%)
Gender	
Male	49 (61.25%)
Female	31 (38.75%)
Occupation	
Unemployed	21 (26.25%)
Laborer	34 (42.5%)
Skilled Worker	15 (18.75%)
Others	10 (12.5%)
BMI (Asian Classification)	
Underweight (<18.5)	18 (22.5%)
Normal (18.5-22.9)	39 (48.75%)
Overweight (23-24.9)	15 (18.75%)

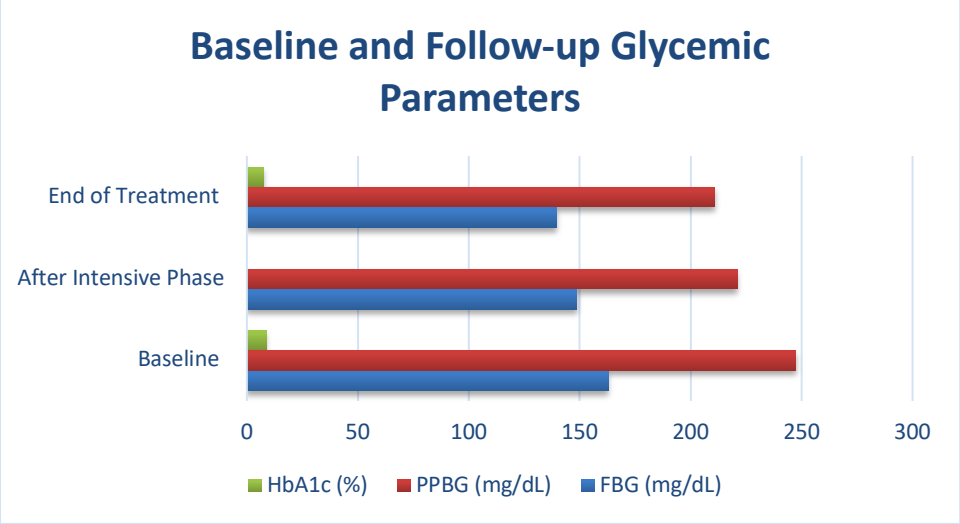
Obese (≥25)	8 (10%)
Smoking History	
Current smoker	30 (37.5%)
Non-smoker	50 (62.5%)

The glycemic parameters of 72 participants demonstrated a significant improvement over the course of tuberculosis treatment. Mean fasting blood glucose (FBG) reduced from 162.8 mg/dL at baseline to 139.5 mg/dL at the end of treatment ($p<0.001$). Similarly, post-prandial blood glucose (PPBG) showed a significant decline from 247.3 mg/dL to 210.9 mg/dL ($p<0.001$). HbA1c, which was measured only at baseline and at the end of treatment, also showed marked improvement from 8.7% to 7.5% ($p<0.001$), reflecting better long-term glycemic control after initiation of tuberculosis treatment and diabetes management. These findings suggest that integrated care, including anti-tuberculosis therapy alongside diabetes management, significantly enhances glycemic control in co-morbid PTB-DM patients.

Table 2: Baseline and Follow-up Glycemic Parameters (n=72)

Parameter	Baseline (Mean ± SD)	After Intensive Phase (Mean ± SD)	End of Treatment (Mean ± SD)	p-value (Baseline vs End)
FBG (mg/dL)	162.8 ± 23.4	148.7 ± 22.1	139.5 ± 19.8	<0.001
PPBG (mg/dL)	247.3 ± 29.5	221.1 ± 27.6	210.9 ± 26.5	<0.001
HbA1c (%)	8.7 ± 1.1	- (Not repeated)	7.5 ± 0.9	<0.001

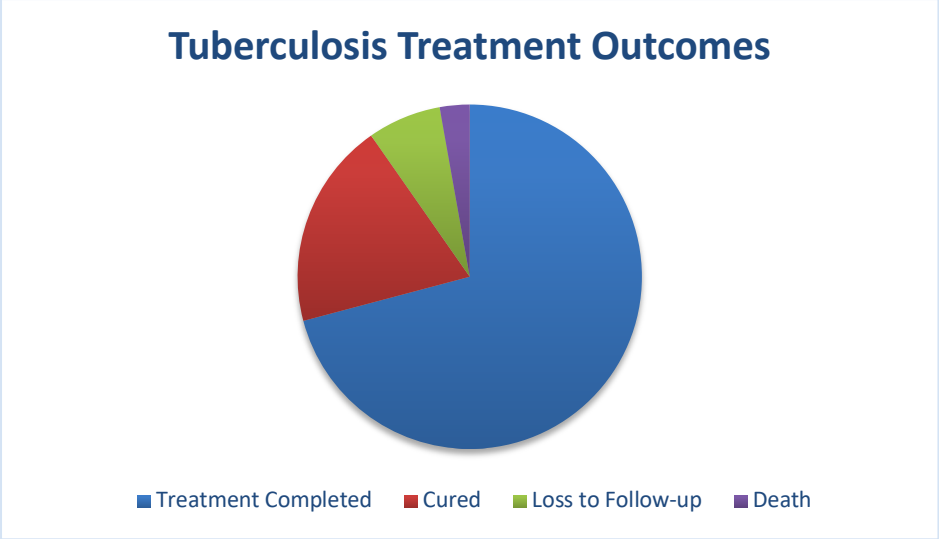
Note: HbA1c was assessed only at baseline and end of treatment.



Among the 72 participants who completed follow-up, the treatment success rate (including both cured and treatment completed) was 90.2%, with 70.8% completing treatment and 19.4% being microbiologically confirmed as cured. However, 6.9% were lost to follow-up and 2.8% died during the study period. These outcomes indicate a relatively high success rate compared to general TB treatment, but the presence of diabetes may have contributed to the small proportion of unfavorable outcomes such as loss to follow-up and mortality. The study underscores the importance of close follow-up and integrated management to improve retention and survival in this high-risk group.

Table 3: Tuberculosis Treatment Outcomes (n=72)

Outcome	Frequency (%)
Treatment Completed	51 (70.8%)
Cured	14 (19.4%)
Loss to Follow-up	5 (6.9%)
Death	2 (2.8%)
Total	72 (100%)



Quality of life (QoL), assessed using the WHOQOL-BREF, showed statistically significant improvements across all four domains from baseline to the end of treatment ($p<0.001$ for all). Physical health scores improved from 39.5 to 61.2, reflecting better functional capacity and symptom relief. Psychological well-being improved from 42.3 to 63.7, suggesting enhanced mental health as patients progressed through treatment. Social relationship scores also rose from 44.8 to 63.1, indicating better interpersonal interactions and support systems. Environmental domain scores increased from 46.2 to 61.9, possibly reflecting improved access to healthcare, nutrition, and treatment support over time. Overall, these findings highlight the positive impact of successful tuberculosis and diabetes co-management on patients' holistic well-being.

Table 4: Quality of Life (QoL) Score Assessment Over Time (WHOQOL-BREF, n=72)

Domain	Baseline (Mean ± SD)	End of Intensive Phase (Mean ± SD)	End of Treatment (Mean ± SD)	p-value (Baseline vs End)
Physical Health	39.5 ± 8.7	52.4 ± 7.9	61.2 ± 8.5	<0.001
Psychological	42.3 ± 9.1	54.1 ± 8.2	63.7 ± 7.6	<0.001
Social Relationships	44.8 ± 7.8	55.9 ± 6.9	63.1 ± 7.3	<0.001
Environment	46.2 ± 8.3	55.3 ± 7.5	61.9 ± 7.7	<0.001

Nutritional status, assessed using BMI, demonstrated improvement for treatment. The proportion of underweight participants reduced from 25% at baseline to 16.7% at the end of treatment, indicating nutritional recovery. Simultaneously, the proportion of participants with normal BMI increased from 50% to 55.6%, while the proportion of overweight individuals also slightly increased from 16.7% to 19.4%. The proportion of obese participants remained stable at 8.3%. These findings suggest that anti-tuberculosis treatment, combined with dietary counseling and overall clinical care, contributed to improved nutritional outcomes, which is particularly important in ensuring better immunity and treatment response in PTB-DM patients.

Table 5: Comparison of Baseline and End-of-Treatment Nutritional Status (n=72)

BMI Category	Baseline (n, %)	End of Treatment (n, %)
Underweight (<18.5)	18 (25%)	12 (16.7%)
Normal (18.5-22.9)	36 (50%)	40 (55.6%)
Overweight (23-24.9)	12 (16.7%)	14 (19.4%)
Obese (≥25)	6 (8.3%)	6 (8.3%)
Total	72 (100%)	72 (100%)

Discussion

This longitudinal observational study assessed newly diagnosed pulmonary tuberculosis (PTB) patients with coexisting diabetes mellitus (DM) over a treatment period at five tuberculosis units (TUs) under the Revised National Tuberculosis Control Program (RNTCP) in Gujarat. The socio-demographic analysis indicated that middle-aged individuals (31-50 years) constituted the majority of the study population (47.5%), with a male predominance (61.25%). This aligns with global and national reports indicating that TB is more common in working-age men due to occupational exposure,

lower healthcare-seeking behavior, and higher rates of smoking and alcohol consumption in men compared to women [10]. Similar findings were reported by Singla et al., who found that in North India, 60% of PTB patients with DM were males, and most were in the economically productive age group of 30-50 years [11].

The clinical profile showed that nearly 42.5% were laborers, indicating that lower socio-economic strata are at greater risk due to overcrowded living conditions, malnutrition, and poor healthcare access. The BMI distribution revealed a dual burden—22.5% were underweight, indicating nutritional vulnerability, while 28.75% were overweight/obese, reflecting the metabolic impact of diabetes mellitus. This bimodal distribution has been previously highlighted" in a study by Restrepo BI, which emphasized the complex interplay between TB, undernutrition, and DM, particularly in low- and middle-income countries [12]. Smoking history, with 37.5% being current smokers, further compounds the risk, as smoking has been shown to impair lung immunity and glycemic control, contributing to poorer TB outcomes [13].

The study demonstrated significant improvement in glycemic control over the treatment period, with fasting blood glucose (FBG) reducing from 162.8 mg/dL at baseline to 139.5 mg/dL at the end of treatment ($p<0.001$), and post-prandial blood glucose (PPBG) reducing from 247.3 mg/dL to 210.9 mg/dL ($p<0.001$). HbA1c, a marker of long-term glycemic control, also significantly improved from 8.7% to 7.5%. These findings highlight the potential benefits of concurrent TB and diabetes management under supervised care. A similar longitudinal study in Indonesia by Alisjahbana et al. demonstrated that glycemic control improved significantly among TB-DM patients following integrated treatment, emphasizing that TB treatment adherence positively influences diabetes control [14]. Effective TB therapy reduces systemic inflammation, which can improve insulin sensitivity and glycemic control [15]. However, achieving optimal control requires consistent adherence to anti-diabetic medications, dietary counselling, and lifestyle modifications—an area where health system strengthening is essential.

The treatment success rate in the study (90.2%) was relatively high, with 70.8% completing treatment and 19.4% being microbiologically confirmed as cured. However, 6.9% of patients were lost to follow-up, and 2.8% died. Compared to TB-only cohorts, these unfavourable outcomes are slightly higher, reflecting the known association between DM and poorer TB treatment outcomes due to immunosuppression and delayed sputum conversion [16]. A multi-country study by Jiménez-Corona et al. found that TB-DM patients had significantly higher risks of treatment failure, relapse, and mortality compared to non-diabetic TB patients [17]. This highlights the importance of tailored follow-up and glycemic monitoring for co-morbid patients, along with patient education to enhance treatment adherence and reduce attrition.

Quality of life (QoL), assessed using the WHOQOL-BREF tool, significantly improved across all domains—physical health, psychological well-being, social relationships, and environment. The physical health domain improved the most (39.5 to 61.2, $p<0.001$), indicating that symptom relief and improved functional capacity significantly enhanced overall well-being. Psychological and social domains also showed marked improvement, underscoring the holistic benefits of successful treatment. This is consistent with findings from Aggarwal et al., who reported that QoL significantly improved in Indian TB patients following successful treatment completion, especially among those receiving regular counseling and nutritional support [18]. Notably, improvements were less pronounced in patients with poor glycemic control, highlighting the bidirectional impact of uncontrolled diabetes on both physical and mental health [19].

Nutritional status improved significantly, with the proportion of underweight participants declining from 25% to 16.7%, while the proportion of those with normal BMI increased from 50% to 55.6%. This improvement reflects the benefits of TB symptom resolution, improved appetite, and dietary counseling provided during treatment. Nutritional recovery is crucial for TB outcomes, as undernutrition is associated with delayed sputum conversion, increased risk of relapse, and higher mortality [20]. This underscores the importance of integrating nutritional interventions into TB-DM management programs to break the cycle of malnutrition and disease.

The findings of this study emphasize the need for integrated management of tuberculosis and diabetes mellitus at the programmatic level, especially in high-burden countries like India. Regular glycemic monitoring, combined with dietary counseling, lifestyle modification, and psychosocial support, can significantly enhance treatment outcomes and quality of life in this vulnerable group. Health systems should also focus on minimizing loss to follow-up by employing patient-centric approaches such as home visits, telephonic reminders, and peer-support programs. Furthermore, nutritional supplementation programs targeting undernourished TB-DM patients should be prioritized to improve both metabolic and treatment outcomes. Future research should explore the role of advanced glycemic monitoring (such as continuous glucose monitoring) in optimizing diabetes control in TB-DM patients.

Conclusion

This study highlights the complex interplay between pulmonary tuberculosis and diabetes mellitus, demonstrating that integrated management significantly improves glycemic control, treatment outcomes, nutritional status, and quality of life. However, patients with dual disease face higher risks of poor outcomes, emphasizing the need for close monitoring and tailored interventions. Addressing socio-economic determinants, ensuring regular glycemic assessments, and providing nutritional and psychosocial support are critical for optimizing outcomes in this vulnerable population. Strengthening collaborative TB-DM care at the programmatic level is essential to mitigate the dual burden. Further longitudinal studies with larger cohorts are needed to establish long-term impacts and refine management strategies.

Reference

1. World Health Organization. Global tuberculosis report 2023. Geneva: WHO; 2023. Available from: https://www.who.int/publications/i/item/9789240078901
2. Jeon CY, Murray MB. Diabetes mellitus increases the risk of active tuberculosis: a systematic review of 13 observational studies. PLoS Med. 2008 Jul 15;5(7):e152. Available from: https://doi.org/10.1371/journal.pmed.0050152
3. Baker MA, Harries AD, Jeon CY, Hart JE, Kapur A, Lönnroth K, et al. The impact of diabetes on tuberculosis treatment outcomes: a systematic review. BMC Med. 2011 Jul 1; 9:81. Available from: https://doi.org/10.1186/1741-7015-9-81
4. India TB Report 2023. Central TB Division, Ministry of Health and Family Welfare, Government of India. Available from: https://tbcindia.gov.in/showfile.php?lid=3659
5. Harries AD, Kumar AM, Satyanarayana S, Lin Y, Zachariah R, Lönnroth K, et al. Addressing diabetes mellitus as part of the strategy for ending TB. Public Health Action. 2016 Jun 21;6(2):74-80. Available from: https://doi.org/10.5588/pha.16.0022
6. Dooley KE, Chaisson RE. Tuberculosis and diabetes mellitus: convergence of two epidemics. Lancet Infect Dis. 2009 Dec;9(12):737-46. Available from: https://doi.org/10.1016/S1473-3099(09)70282-8
7. International Diabetes Federation and The Union. A Guide to the Essential Practice of Diabetes Care in Tuberculosis Patients. 2019. Available from: https://www.theunion.org/technical-publications/a-guide-to-the-essential-practice-of-diabetes-care-in-tuberculosis-patients
8. India's National Framework for Joint TB-Diabetes Collaborative Activities, 2017. Central TB Division, Ministry of Health and Family Welfare, Government of India. Available from: https://tbcindia.gov.in/showfile.php?lid=3240
9. Lönnroth K, Roglic G, Harries AD. Improving tuberculosis prevention and care through addressing the global diabetes epidemic: from evidence to policy and practice. Lancet Diabetes Endocrinol. 2014 Sep;2(9):730-9. Available from: https://doi.org/10.1016/S2213-8587(14)70109-3
10. Lönnroth K, Jaramillo E, Williams BG, Dye C, Raviglione M. Drivers of tuberculosis epidemics: the role of risk factors and social determinants. Soc Sci Med. 2009;68(12):2240-6.
11. Singla R, Khan N, Al-Sharif N, Al-Sayegh MO, Shaikh MA, Osman MM. Influence of diabetes on manifestations and treatment outcome of pulmonary TB patients. Int J Tuberc Lung Dis. 2006;10(1):74-9.
12. Restrepo BI. Diabetes and tuberculosis. Microbiol Spectr. 2016;4(6): 10.1128/microbiolspec.TNMI7-0023-2016.
13. Bates MN, Khalakdina A, Pai M, Chang L, Lessa F, Smith KR. Risk of tuberculosis from exposure to tobacco smoke: a systematic review and meta-analysis. Arch Intern Med. 2007;167(4):335-42.
14. Alisjahbana B, Sahiratmadja E, Nelwan EJ, et al. The effect of type 2 diabetes mellitus on the presentation and treatment response of pulmonary tuberculosis. Clin Infect Dis. 2007;45(4):428-35.
15. Jeon CY, Murray MB. Diabetes mellitus increases the risk of active tuberculosis: a systematic review of 13 observational studies. PLoS Med. 2008;5(7):e152.
16. Magee MJ, Salindri AD, Gujral UP, et al. Convergence of the tuberculosis and diabetes epidemics: renewal of old acquaintances. Clin Infect Dis. 2021;72(11):1874-9.
17. Jiménez-Corona ME, Cruz-Hervert LP, García-García L, et al. Association of diabetes and tuberculosis: impact on treatment and post-treatment outcomes. Thorax. 2013;68(3):214-20.
18. Aggarwal AN. Quality of life with tuberculosis. J Clin Tuberc Other Mycobact Dis. 2019; 17:100121.
19. Huangfu P, Ugarte-Gil C, Golub JE, Pearson F. Diabetes and tuberculosis: programmatic management in high-tuberculosis burden countries. Int J Tuberc Lung Dis. 2019;23(5):540-6.
20. Bhargava A, et al. Nutritional support and tuberculosis treatment outcomes in India: a prospective cohort study. BMJ Glob Health. 2020;5(3):e002220.