Original Article

DOI: 10.7860/JCDR/2023/64911.18718

Epidemiology Section

Prevalence of Diabetes Mellitus and its Associated Risk Factors among Tuberculosis Patients in Sonipat District, Haryana: A Cross-sectional Study

JAGMOHAN SINGH[1], ANITA PUNIA[2], SANJAY KUMAR JHA[3], MURUGDASS NARENDRAN[4], SANJEET SINGH[5], DEEPIKA KATARIA[6]

ABSTRACT

Introduction: The global increase in Diabetes Mellitus (DM) is a recognised re-emerging risk and challenge to Tuberculosis (TB) control. The bidirectional association between TB and DM is currently one of the major concerns for clinicians. India has the highest prevalence of TB and the second highest prevalence of DM worldwide.

Aim: To estimate the prevalence of DM and its associated risk factors among TB patients in District Sonipat, Haryana, India.

Materials and Methods: A cross-sectional study was conducted to determine the prevalence and factors associated with Diabetes among TB patients registered at the Nikshay portal. A total of 400 patients were interviewed using consecutive sampling technique from eight randomly selected Designated Microscopy Centres (DMCs) in District Sonipat, Haryana , India. To identify associations, a multivariable logistic regression model was applied.

Results: The prevalence of diabetes among TB patients was found to be 16.25% (65/400). The mean age of the study subjects was 39.9±17.3 years. DM was significantly associated with increasing age, literacy, marital status, occupation, smoking, second-hand smoking, duration of smoking, sputum status at the time of initiation of treatment, pulmonary TB, and other chronic diseases such as hypertension and cardiovascular disease.

Conclusion: The present study found a higher prevalence of diabetes among TB patients than in the general population. Therefore, it is recommended to strengthen early bidirectional screening and timely management of TB/DM co-morbidity.

Keywords: Diabetes mellitus, Nikshay portal, Prevalence

INTRODUCTION

Non Communicable Diseases (NCDs) like DM are spreading like an epidemic, disproportionately affecting Low- and Middle-Income Countries (LMICs) where the burden of infectious diseases is also high [1]. The prevalence of diabetes has increased worldwide due to population ageing, urbanisation, changes in diet, and reduced physical activity patterns resulting in increasing obesity [2]. Globally, 537 million adults are now living with diabetes, and the total number of diabetic patients is predicted to rise to 783 million by 2045. In 2021, India alone had 74.2 million people with diabetes, and it is expected to increase to 124.9 million in 2045 [3]. The global increase in type II DM is a recognised re-emerging risk and challenge to TB control [4]. It has been estimated that nearly 15% of people with TB have diabetes, compared to 9.3% of the general adult population [1,4]. Diabetes is linked to a threefold increase in the risk of TB disease, a twofold increase in the risk of death during TB treatment, a fourfold increase in the risk of TB relapse after treatment completion, and a twofold increase in the risk of Multidrug-resistant TB (MDR-TB) [5-7].

The DM is caused by a combination of genetic and environmental factors. Both genes and the environment play a significant role in insulin resistance and beta-cell dysfunction [8]. The prevalence of DM increases with advancing age, Low Socio-economic Status (SES) [9], a family history of DM [10], unhealthy lifestyle factors (physical inactivity, increased Body Mass Index [BMI], and smoking), and pregnancy [11]. Both active and passive smoking increase the risk of developing diabetes, exacerbate the micro- and macrovascular complications of DM, and are also associated with insulin resistance and inflammation [12]. People with chronic kidney failure who are on dialysis are 6.9 to 52.5 times more likely to get TB and are also at risk of developing DM [13].

Diabetes is estimated to affect nearly 20% of all TB patients in India, which adversely affects their management [14]. The National Tuberculosis Elimination Program (NTEP) has recommended routine testing of diabetes among TB patients in accordance with World Health Organisation (WHO) recommendations [15,16]. There is limited research on DM in TB patients in Sonipat District of Haryana State, India [17]. Thus, against this background, the current study was planned with the objective to study the prevalence of diabetes and its associated factors among TB patients currently on treatment.

MATERIALS AND METHODS

This cross-sectional study was conducted among TB patients in District Sonipat, Haryana, India, who were registered under NTEP on the Nikshay portal at Designated Microscopic Centres (DMCs) between August 2021 and August 2022. The study received approval from the Institutional Ethics Committee (BPSGMCW/RC635/IEC/20). The purpose of the study was explained to the participants, and their confidentiality and data privacy were assured throughout the study. After assessing the eligibility of each patient, the purpose of the study was explained, and written consent was obtained.

Inclusion criteria: The study included all TB patients aged 18 and above, including new and retreatment cases, extrapulmonary cases, and MDR cases, who visited the DMC for antitubercular treatment and were willing to participate.

Exclusion criteria: Patients with immunosuppressive disorders like Human Immunodeficiency Virus (HIV) and those already on immunosuppressive treatment were excluded.

DM was diagnosed based on one of the following criteria:

1) Self-reported history of DM and ongoing diabetes treatment.

2) Fasting plasma glucose ≥126 mg/dL [18].
3) Random plasma glucose ≥200 mg/dL [18].

Sample size: The sample size was calculated considering a diabetes prevalence of 20% [19] and an absolute error of 4% at a 95% significance level. Therefore, the final sample size was 400.

Study Procedure

Out of the 16 DMCs in District Sonipat, eleven were operational. A list of all DMCs with the number of registered TB patients was obtained from the District TB Officer and served as a sampling frame. Using a lottery method, eight DMCs were randomly selected. At each selected DMC, 50 eligible TB patients were consecutively sampled to reach the required sample size of 400. As one randomly selected DMC had only 26 registered patients, another DMC was randomly selected to ensure a sample size of 50 for that DMC. Senior TB Laboratory Supervisors (STLS), Senior TB Supervisors (STS), Multi-Purpose Health Workers (MPHWs), Multi-Purpose Worker Supervisors (MPW(S)), and Accredited Social Health Activists (ASHAs) were involved in motivating patients to participate in the study and facilitating blood sugar level testing. Random blood glucose levels were measured on the spot using a glucometer.

A semistructured schedule, which was modified based on a pilot study was conducted on 40 subjects (10% of the sample size) from a neighbouring district. The variables of the semistructured schedule were finalised based on their coefficient of reliability, calculated using Cronbach's Alpha, with scores of 0.80. The required data were collected using a schedule, which included socio-demographic characteristics such as age, gender, education, occupation, religion, caste, and marital status. Anthropometric measurements for height, weight, and blood pressure were taken.

To measure height, a wall-mounted measuring tape was used without footwear or headgear, and the measurement was recorded in centimetres to the nearest 0.1 cm. Body weight was measured using a portable electronic weighing scale, and the measurement was recorded in kilograms to the nearest 0.1 kg, without shoes, socks, or heavy clothing. Blood pressure was measured three times using a digital automatic blood pressure monitor, following WHO guidelines [20]. The measurements were taken from the left arm, with the cuff positioned at the same level as the heart, and the procedure was performed with elbow support using the universal cuff. The average of the three readings for both systolic and diastolic blood pressure was recorded for data analysis.

All eligible TB patients who were diagnosed and registered on the Nikshay portal were screened for DM according to the guidelines specified by the National Programme for Prevention and Control of Non-Communicable Diseases (NPNCD), erstwhile NPCDCS (National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular diseases, and Stroke) [21]. Patients with a self-reported history of taking antidiabetic drugs after diagnosis by a medical professional were also considered. TB patients were initially screened using a Random Blood Sugar (RBS) test conducted with a Dr. Morepen glucometer. The waste generated during the procedure was disposed of in accordance with biomedical waste management rules. If the RBS was less than 140 mg/dL, no further tests were conducted, and the patient was labelled as non diabetic. If the RBS was ≥140 mg/dL, a Fasting Blood Glucose (FBS) test was performed. An FBS value ≥126 mg/dL indicated diabetes. Additionally, details about the sputum status at the time of diagnosis (i.e., sputum positive, sputum negative, or extrapulmonary TB) were noted from the TB treatment record.

STATISTICAL ANALYSIS

The collected data were entered into an excel spreadsheet. Analyses were performed using R statistical software version 4.2.1. Descriptive statistics were computed, and the results were presented as mean and standard deviation for continuous variables, and frequency and proportion for categorical variables. To assess associations, either Pearson's Chi-square test or Fischer's-exact test was applied. A p-value less than 0.05 was considered statistically significant. Bivariate logistic regression was conducted, and variables with a p-value less than 0.25 were included in the multivariable logistic regression to identify the risk factors for DM among the participants. Finally, variables with a p-value less than 0.05 in the multivariable logistic regression model were considered statistically significant.

RESULTS

A total of 400 TB patients were selected during the study period. The mean age of the study subjects was 39.9±17.3 years. Approximately three-fifths (236) of the TB patients belonged to the economically productive age group of 21-50 years, while 14.5% of TB patients were less than 20 years old. More than half of the study subjects were male, 67.25% resided in nuclear families, 63% resided in rural areas, and 20.5% had completed education up to the matric level [Table/Fig-1].

Variables	Details	Diabetic No. (%)	Non diabetic No. (%)	Total No. (%)	p-value
Age group (years)	≤20	1 (1.72)	57 (98.28)	58 (100)	0.001*
	21-30	4 (4)	96 (96)	100 (100)	
	31-40	7 (12.96)	47 (87.03)	54 (100)	
	41-50	22 (26.83)	60 (73.17)	82 (100)	
	51-60	12 (26.67)	33 (73.33)	45 (100)	
	>60	19 (31.11)	42 (68.85)	61 (100)	
Gender	Male	44 (19.13)	186 (80.87)	230 (100)	0.069
	Female	21 (12.35)	149 (87.65)	170 (100)	
Category	SC	11 (10.09)	98 (89.91)	109 (100)	0.071
	OBC	28 (21.05)	105 (78.95)	133 (100)	
	Others (general)	26 (16.46)	132 (83.54)	158 (100)	
Family type	Joint family	26 (19.85)	105 (80.15)	131 (100)	0.174
	Nuclear family	39 (14.49)	230 (85.51)	269 (100)	
Residence	Rural	41 (16.27)	211 (83.73)	252 (100)	0.989
	Urban	24 (16.22)	124 (83.78)	148 (100)	
Literacy status	Illiterate	17 (26.56)	47 (73.44)	64 (100)	0.037*
	Primary	12 (19.35)	50 (80.65)	62 (100)	
	Middle	14 (18.42)	62 (81.58)	76 (100)	
	Matric	13 (15.85)	69 (84.15)	82 (100)	
	10+2	6 (7.5)	74 (92.5)	80 (100)	
	Graduate and above	3 (8.33)	33 (91.67)	36 (100)	
Occupation	Business	12 (31.58)	26 (68.42)	38 (100)	0.001*
	Unemployed	24 (18.6)	105 (81.4)	129 (100)	
	Farmer/diary	17 (17)	83 (83)	100 (100)	
	Govt./Pvt. employee	12 (16.9)	59 (83.1)	71 (100)	
	Student	0 (0)	62 (100)	62 (100)	

[Table/Fig-1]: Distribution of study subjects according to their socio-demographic profile and diabetic status (N=400).
*Statistically significant

Prevalence and factors associated with DM among TB patients: The prevalence of DM among TB patients was 16.25% (65/400), with 5.66% (12/212) of patients up to 40 years of age and 28.19% (53/188) in older individuals. The prevalence was 19.85% (26) and 14.49% (39) among those residing in joint and nuclear families, respectively, and 16.27% (41) in rural areas and 16.22% (24) in urban areas [Table/Fig-1]. The mean body weight of diabetic TB patients was 56.02±11.67 kg, the mean BMI was 20.48±3.66 kg/m^2, and the mean blood pressure was significantly higher in diabetic patients compared to non-diabetic TB patients [Table/Fig-2].

The prevalence of DM was 22.86%, 20.83%, and 13.75% among regular drinkers, social drinkers, and non smokers, respectively.

Quantitative variable		Diabetic no. (%)	Non-diabetic no. (%)	Test of significance (p-value)
Age (years)	Mean±SD	51.71±13.95	37.60±16.968	0.001*
Body weight (kg)	Mean±SD	56.02±11.67	49.12±10.385	0.001*
Height (cm)	Mean±SD	166.91±7.903	165.89±12.308	0.5
BMI (kg/m^2)	Mean±SD	20.48±3.66	18.59±4.79	0.003*
BP (mmHg)	Mean systolic	123.23±9.424	115.90±9.965	0.001*
	Mean diastolic	81.09±6.841	76.39±6.628	0.001*
RBS (mg/dL)	Mean RBS	210.92±77.261	105.67±13.067	0.001*

[Table/Fig-2]: Quantitative parameters of study subjects and their diabetic status (N=400).
*Statistically significant

Among smokers, the prevalence of DM was 23.08%, 22.54%, 19.91%, and 11.64% among current smokers, ex-smokers, passive smokers, and non-smokers, respectively. The prevalence of DM was 21.09% and 5.6% among pulmonary and extrapulmonary TB cases, and 21.42% and 8.59% among sputum positive and negative cases. Those who had thyroid problems, kidney diseases, and liver diseases had a significantly higher prevalence of diabetes [Table/Fig-3].

Variables	Details	Diabetic no. (%)	Non-diabetic no. (%)	Total no. (%)	p-value
BMI (kg/m^2)	<18.5	24 (11.32)	188 (88.68)	212 (100)	0.001*
	18.5-22.99	23 (17.29)	110 (82.71)	133 (100)	
	23-24.99	8 (27.58)	21 (72.42)	29 (100)	
	>25	10 (38.46)	16 (61.54)	26 (100)	
Smoking	Don't smoke	27 (11.64)	205 (88.36)	232 (100)	0.013*
	Ex-smoker	32 (22.54)	110 (77.46)	142 (100)	
	Current smoker	6 (23.08)	20 (76.92)	26 (100)	
	Passive smokers	44 (19.91)	177 (80.09)	221 (100)	
Alcoholic status	Not drinking	37 (13.75)	232 (86.25)	269 (100)	0.14
	Social drinking	20 (20.83)	76 (79.17)	96 (100)	
	Regular drinking	8 (22.86)	27 (77.14)	35 (100)	
Type of TB patients	Pulmonary	58 (21.09)	217 (78.91)	275 (100)	0.001*
	Extrapulmonary	7 (5.6)	118 (94.4)	125 (100)	
Sputum status	Positive	51 (21.42)	186 (78.58)	237 (100)	0.001*
	Negative	14 (8.59)	149 (91.41)	163 (100)	
HTN status	Hypertensive	15 (68.18)	7 (31.82)	22 (100)	0.001*
CVD disease	Yes	4 (50)	4 (50)	8 (100)	0.009*
Thyroid disease	Yes	1 (33.33)	2 (66.67)	3 (100)	0.007*
Kidney disease	Yes	3 (75)	1 (25)	4 (100)	0.015*
Liver disease	Yes	4 (66.67)	2 (33.33)	6 (100)	0.007*
Allergy	Yes	4 (36.36)	7 (63.64)	11 (100)	0.067

[Table/Fig-3]: Distribution of TB patients according to diabetic status with their personal and clinical profile (N=400).
*Statistically significant

The multivariable logistic regression analysis of the selected variables, as mentioned in the statistical analysis, revealed that the odds of TB-DM were 38.9 times significantly higher {Adjusted Odds Ratio (AOR)=38.90; Confidence Interval (CI)=1.60-1425.82} in the 51-60 years age group compared to the ≤20 years age group. The odds of DM among pulmonary TB patients were 15.7 times significantly higher (AOR=15.73; CI=1.64-150.49) compared to those with extrapulmonary TB. The odds were 15.0 times higher in hypertension (AOR=15.03; CI=3.76-59.96) and 26.7 times higher in those with kidney disease (AOR=26.72; CI=1.46-487.44), and these associations were statistically significant. The odds of TB-DM were 27.0 times significantly higher for those with a normal BMI (AOR=27.00; CI=4.46-163.29) compared to underweight patients. The influence of factors such as gender, literacy, marital status, alcohol consumption, smoking, second-hand smoking, and sputum status were not significant in the logistic regression [Table/Fig-4].

Characteristics		Crude odds ratio (95% CI)	Adjusted odds ratio (95% CI)
Age (years)	≤20	1	1
	21-30	2.37 (0.25-21.77)	1.14 (0.042-31.08)
	31-40	8.48 (1.01-71.47)*	10.19 (0.30-341.57)
	41-50	20.90 (2.727-160.17)*	30.43 (0.97-951.56)
	51-60	20.92 (2.578-166.66)*	38.90 (1.06-1425.82)*
	>60	25.78 (3.32-200.30)*	15.46 (0.51-466.97)
Sex	Male	1.67 (0.956-2.946)	1.15 (0.21-6.15)
	Female	1	1
Category	SC	1	1
	OBC	2.376 (1.12-5.02)*	0.86 (0.26-2.88)
	General	1.755 (0.82-3.72)	0.68 (0.18-2.52)
Family type	Joint	1.46 (0.845-2.52)	1.16 (0.47-2.85)
	Nuclear	1	1
Literacy	Illiterate	3.97 (1.07-14.68)*	0.54 (0.05-5.66)
	Primary	2.64 (0.692-10.76)	0.63 (0.06-6.17)
	Middle	2.48 (0.66-9.26)	0.84 (0.08-8.62)
	Matric	2.07 (0.55-7.77)	1.22 (0.11-12.61)
	10+2	0.89 (0.21-3.78)	0.17 (0.02-1.09)
	Graduate and above	1	1
Occupation	Unemployed	1	1
	Farmer	0.89 (0.45-1.77)	0.24 (0.06-0.90)*
	Government employees	0.89 (0.41-1.90)	0.51 (0.11-2.23)
	Students	Omitted	Omitted
	Business	2.01 (0.89-4.56)	0.39 (0.07-2.18)
Alcohol	Not drink	1	1
	Social drinker	1.65 (0.90-3.01)	1.29 (0.39-4.16)
	Regular drinker	1.85 (0.78-4.39)	1.64 (0.36-7.34)
Smoking status	Don't smoke	1	1
	Ex-smoker	2.27 (0.84-6.17)	0.53 (0.06-4.38)
	Current smoker	2.20 (1.25-3.87)*	0.67 (0.13-3.37)
Second hand smoking	Yes	1.87 (1.06-3.28)*	2.15 (0.53-8.64)
	No	1	1
Case type	Pulmonary	4.50 (1.99-10.18)*	15.73 (1.64-150.49)*
	Extrapulmonary	1	1
Sputum status	Positive	2.91 (1.55-5.47)*	0.92 (0.23-3.63)
	Negative	1	1
Other chronic disease present	Hypertension	14.05 (5.46-36.17)*	15.03 (3.76-59.96)*
	CVD	5.42 (1.32-22.28)*	1.01 (0.09-10.87)
	Thyroid disease	2.60 (0.23-29.12)	7.96 (0.26-241.38)
	Kidney disease	16.16 (1.65-157.90)*	26.72 (1.46-487.44)*
	Liver disease	10.91 (1.95-60.92)*	6.62 (0.69-63.01)
	History of allergy	3.07 (0.87-10.81)	6.87 (0.77-61.37)
BMI	<18.5 kg/m^2	1	1
	18.5-22.99 kg/m^2	2.99 (1.20-77.41)*	27.00 (4.46-163.29)*
	23-24.99 kg/m^2	1.82 (0.72-4.61)	2.88 (0.63-12.99)
	>25 kg/m^2	0.61 (0.33-1.13)	0.66 (0.27-1.58)

[Table/Fig-4]: Factors associated with Diabetes Mellitus (DM) among Tuberculosis (TB) patients registered for treatment in Sonipat district, Haryana, as estimated by univariate and multivariate analysis (N=400).
*Statistically significant

S. No.	Author's name and year	Place of study	Sample size	Objective	Conclusion
1)	Wang Q et al., [27] 2013	Linyi, China	6382	To investigate the prevalence of DM and pre-DM and evaluated the risk factors for the presence of DM among newly detected PTB patients in rural areas of China.	Increasing age, family history of DM, positive sputum smear, cavity on chest X-ray and higher yearly income ($10000 RMB yuan) were positively associated with DM in PTB patients.
2)	Khanna A et al., [29] 2013	New Delhi	458	To assess whether sputum smear conversion and treatment outcomes were affected by DM status in a hospital setting in Delhi, India.	14% had TB-DM. Age >40 years, smear-positive pulmonary TB and recurrent TB were significantly more common.
3)	Nair S et al., [32] 2013	Trivandrum	920	To determine factors associated with the prevalence of DM among TB patients and examine differences in the proportion of new DM cases among TB patients diagnosed at tertiary care centres and PHIs.	32.4% were diabetic. Overall, age >50 years and pulmonary TB were independently associated with a higher prevalence of diabetes.
4)	Chiang CY et al., [36] 2015	Taiwan	1574	To know the influence of DM, glycaemic control, and diabetes-related comorbidities on pulmonary TB.	In multivariate analysis adjusted for age, sex, smoking, and drug resistance, diabetic patients with HbA1c >9% and HbA1c 7-9% were significantly more likely to be smear positive as compared with non-diabetic patients.
5)	Workneh MH et al., [38] 2016	Amhara, Ethiopia	1314	To determine the prevalence and analyse associated factors of TB and DM co-morbidity in South-Eastern Amhara Region, Ethiopia.	The prevalence of DM was estimated at 8.3%. Being female, patients age {41-64 years (OR 3.35; 95% CI (2.01-5.57), 65-89 years (OR 3.18; 95% CI (1.52-6.64)}, being a pulmonary TB case and having a family history of DM were associated factors identified with TB and DM co-morbidity.
6)	Sembiah S et al., [30] 2020	Bhopal	662	To determine the prevalence and associated factors of diabetes in TB patients and their impact on treatment outcome of TB.	12.39% TBDM prevalence. Age >50 years, males, higher BMI, pulmonary TB, patients on Category-II treatment, and history of smoking were found to be predictors of diabetes in TB patients.
7)	Christopher DS et al., [31] 2020	Vellore	1979	Evaluate association between DM and TB over 10-year period in a tertiary care hospital.	24% of the TB patients were diabetic. Diabetics were more likely to be men >40 years of age; heavier; tobacco smokers and alcohol consumers.
8)	Mave V et al., [33] 2020	Three Medical college rural study areas in Maharashtra	799	Investigate hypothesis that, due to higher baseline mycobacterial burden and altered immune response to TB [18], DM would lead to prolonged sputum culture positivity and higher risk of TB treatment failure, recurrence, or death.	12.6% TB-DM prevalence. TB-DM participants were more likely to be male, above age 40 years, anaemic, to have lower household income, and to have normal Body Mass Index (BMI) or be overweight.
9)	Xiao W et al., [37] 2021	Zhejiang China	969	To assess the diagnostic delay of TB patients with known DM and identify the factors associated with this delay.	7% TB patients had DM co-morbidity. Compared with TB patients without DM, TB patients with DM had significantly higher median age (58), higher proportion above 60 years, local residents, smear positive, new patients, severe cases, with cavity.
10)	Rajaa S et al., [34] 2021	3 districts in South India	1188	To determine the prevalence and determinants of DM among TB patients and to assess the additional yield and number needed to screen.	Prevalence of DM among TB patients was 39%, in adjusted analysis only marital status and BMI category were found to be significant determinants.
11)	Present study 2021-2022	Sonipat	400	Estimate prevalence of DM and associated factors among TB patients in Sonipat District.	Prevalence of DM- 16.25% of TB patients. Risk factors- >40 years, married, illiteracy, smoking, second hand smoking, pulmonary TB, sputum positive, BMI of overweight and above, hypertension, cardio vascular disease.

[Table/Fig-5]: Similar studies from the literature [27,29-34,36-38].

DISCUSSION

The TB is known to be diabetogenic [22,23], impairing glucose tolerance [24,25], and increasing the risk of developing Type 2 Diabetes Mellitus (T2DM) in the future [26]. The present study also revealed a higher prevalence of 16.25% (65/400) of DM among TB patients compared to the general population (9.6%) [4], indicating its diabetogenic nature. This risk was shown to increase with age, particularly beyond 40 years, as observed in several other studies [27-33]. The current study also observed a significant increase in prevalence beyond the age group of 50 years. Despite 63% of the study subjects residing in rural areas, the place of residence did not show a difference in prevalence in the current study, possibly due to homogeneity in dietary habits, lifestyles, and exposure to equivalent risk factors in the region.

Literacy plays an important role in comprehension, acceptance of behaviour change communication, treatment compliance, and adoption of favourable lifestyles and habits, all of which are essential for control of TB. Rajaa S et al., also observed the protective effect of literacy in TB-DM prevalence [34]. The current study suggests that poor literacy poses challenges to TB control (illiterate crude OR 3.97), while female illiteracy disparity puts the entire family at risk of TB [35]. Male TB patients were found to have a higher prevalence of DM in the current study and in other studies conducted elsewhere [30,31,34]. The higher prevalence of health-damaging lifestyles and habits among males, such as smoking [Table/Fig-4] and alcohol consumption, which were also observed as risk factors for TB-DM in the current study, could contribute to this association.

This was also observed in other studies [30,36,37]. Males also become vulnerable to increased exposure due to travel, social and working environments, thus increasing their risk.

Literature has observed a higher prevalence of DM among cases of pulmonary TB compared to extrapulmonary cases [30,32,38]. The current study also observed a significantly higher prevalence of DM among pulmonary cases (pulmonary adjusted OR 15.73, [Table/Fig-4]). DM also compromises their immunity further [3,39], reflecting in a higher prevalence of positive sputum status [27,29,34,36,37] among them [Table/Fig-4], persisting as potential sources of TB transmission.

Co-morbidities such as higher BMI, hypertension, and renal diseases, which are known to cause diabetes, were found to be significantly associated with TB-DM co-morbidity in the current study [Table/Fig-4]. With the exception of the lack of association between BMI and TB-DM in Ethiopia [38], these chronic co-morbidities were found to significantly contribute to the condition in various studies [30,31,33], highlighting the need for their monitoring and management to ensure the possibility of remission for TB-DM. Similar findings have been mentioned in other studies [27,29-34,36-38] (see [Table/Fig-5]).

Limitation(s)

The present study has a few limitations. The data collection used consecutive sampling, so it may not be truly representative of TB-DM patients. The present was a cross-sectional study, and the study subjects were not followed-up after a single visit, so there is a possibility that some study subjects could have developed

DM during the course of Antituberculosis Treatment (ATT). Details of tobacco use and DM treatment practices/daily drug adherence were self-reported and not verified. The generalisability of the present study is limited to the district only.

CONCLUSION(S)

The prevalence of DM among TB patients was 16.25%. TB patients with profiles of >40 years, being married, illiterate, smoking, exposed to second-hand smoking, with pulmonary TB, sputum positive, with BMI in the overweight and above range, and with co-morbidities of hypertension and cardiovascular disease were observed to be significantly more prone to diabetes. It is recommended that bidirectional screening for TB and diabetes be strengthened among patients with such profiles to ensure favourable outcomes in their TB treatment.

REFERENCES

[1] Dooley KE, Chaisson RE. Tuberculosis and diabetes mellitus: Convergence of two epidemics. The Lancet Infect Dis. 2009;9(12):737-46.
[2] Guariguata L, Whiting DR, Hambleton I, Beagley J, Linnenkamp U, Shaw JE. Global estimates of diabetes prevalence in adults for 2013 and projections for 2035. Diabetes Res Clin Pract. 2014;103(2):137-49.
[3] IDF Diabetes Atlas, 10th edn. International Diabetes Federation (IDF); 2021. Available from: https://www.diabetesatlas.org.
[4] 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.
[5] 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;9(1):01-15.
[6] Liu Q, Li W, Xue M, Chen Y, Du X, Wang C, et al. Diabetes mellitus and the risk of multidrug resistant tuberculosis: A meta-analysis. Scientific Reports. 2017;7(1):01-07.
[7] Roden M, Shulman GI. The integrative biology of type 2 diabetes. Nature. 2019;576(7785):51-60. Doi: 10.1038/s41586-019-1797-8.
[8] Rabi DM, Edwards AL, Southern DA, Svenson LW, Sargious PM, Norton P, et al. Association of socio-economic status with diabetes prevalence and utilization of diabetes care services. BMC Health Serv Res. 2006;6:124. Doi: 10.1186/1472-6963-6-124. PMID: 17018153; PMCID: PMC1618393.
[9] Yoon PW, Scheuner MT, Khoury MJ. Research priorities for evaluating family history in the prevention of common chronic diseases. Am J Prev Med. 2003;24(2):128-35.
[10] Tuomi T, Santoro N, Caprio S, Cai M, Weng J, Groop L. The many faces of diabetes: A disease with increasing heterogeneity. Lancet. 2014;383(9922):1084-94. Doi: 10.1016/S0140-6736(13)62219-9.
[11] Chang SA. Smoking and type 2 diabetes mellitus. Diabetes Metab J. 2012;36(6):399-403. Doi: 10.4093/dmj.2012.36.6.399.
[12] Hussein MM, Mooij JM, Roujouleh H. Tuberculosis and chronic renal disease. Semin Dial. 2003;16(1):38-44.
[13] Bates M, Marais BJ, Zumla A. Tuberculosis comorbidity with communicable and noncommunicable diseases. Cold Spring Harb Perspect Med. 2015;5(11):a017889.
[14] 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-e460.
[15] IDF Diabetes Atlas, 9th edn. Brussels: International Diabetes Federation (IDF); 2019. Available from: https://www.diabetesatlas.org.
[16] Workneh MH, Bjune GA, Yimer SA. Prevalence and associated factors of tuberculosis and diabetes mellitus comorbidity: A systematic review. PLoS One. 2017;12:e0175925.
[17] Majumdar A, Wilkinson E, Rinu PK, Maung TM, Bachani D, Punia JS, et al. Tuberculosis-diabetes screening: How well are we doing? A mixed-methods study from North India. Public Health Action. 2019;9(1):03-10. Doi: 10.5588/pha.18.0048.
[18] Classification of diabetes mellitus. Geneva: World Health Organization; 2019. Licence: CCBY-NC-SA 3.0 IGO.
[19] Central TB Division. India TB Report 2020. New Delhi: MoHFW; 2020. https://tbcindia.gov.in/WriteReadData/l892s/India%20TB%20Report%202020.pdf.
[20] WHO technical specifications for automated non-invasive blood pressure measuring devices with cuff. Geneva: World Health Organization; 2020. Licence: CC BY-NC-SA 3.0 IGO.
[21] DGHS. National framework for joint TB-Diabetes collaborative activities. New Delhi: MoHFW GoI; 2017.
[22] Faurholt-Jepsen D, Range N, Praygod G, Kidola J, Faurholt-Jepsen M, Aabye MG, et al. The role of diabetes co-morbidity for tuberculosis treatment outcomes: A prospective cohort study from Mwanza, Tanzania. BMC Infect Dis. 2012;12:01-08.
[23] Basoglu OK, Bacakoglu F, Cok G, Saymer A, Ates M. The oral glucose tolerance test in patients with respiratory infections. Monaldi Arch Chest Dis. 1999;54(4):307-10.
[24] Jeon CY, Harries AD, Baker MA, Hart JE, Kapur A, Lönnroth K, et al. Bi-directional screening for tuberculosis and diabetes: A systematic review. Trop Med Int Health. 2010;15(11):1300-14.
[25] Amrit G, Ashok S. Tuberculosis and diabetes: An appraisal. Ind J Tub. 2000;47(1):03-08.
[26] Jacob S, George LS, Joy A, Mathew MM, Vijayakumar K, Kumar A, et al. Prevalence of diabetes mellitus and HIV/AIDS among tuberculosis patients in Kerala. J Family Med Prim Care. 2020;9(12):6209-12.
[27] Wang Q, Ma A, Han X, Zhao S, Cai J, Ma Y, et al. Prevalence of type 2 diabetes among newly detected pulmonary tuberculosis patients in China: A community based cohort study. PloS one. 2013;8(12):e82660.
[28] Ko PY, Lin SD, Tu ST, Hsieh MC, Su SL, Hsu SR, et al. High diabetes mellitus prevalence with increasing trend among newly-diagnosed tuberculosis patients in an Asian population: A nationwide population-based study. Prim Care Diabetes. 2016;10(2):148-55. Doi: 10.1016/j.pcd.2015.09.005.
[29] Khanna A, Lohya S, Sharath BN, Harries AD. Characteristics and treatment response in patients with tuberculosis and diabetes mellitus in New Delhi, India. Public Health Action. 2013;3(Suppl 1):S48-S50. Doi: 10.5588/pha.13.0025.
[30] Sembiah S, Nagar V, Gour D, Pal DK, Mitra A, Burman J. Diabetes in tuberculosis patients: An emerging public health concern and the determinants and impact on treatment outcome. J Family Community Med. 2020;27(2):91-96. Doi: 10.4103/jfcm.JFCM_296_19.
[31] Christopher DS, Christopher J, Jeyaseelan L, Michael JS, Veeraraghavan B, Manipadam MT, et al. Burden of diabetes among patients with tuberculosis: 10-year experience from a tertiary care referral teaching hospital in South India. Lung India. 2020;37(3):232-37.
[32] Nair S, Kumri AK, Subramonipillai J, Shabna DS, Kumar SM, Balakrishnan S, et al. High prevalence of undiagnosed diabetes among tuberculosis patients in peripheral health facilities in Kerala. Public Health Action. 2013;3(Suppl1):S38-42. Doi: 10.5588/pha.13.0037.
[33] 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. Doi: 10.1093/ofid/ofab097.
[34] 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.
[35] Katiyar SP. Gender disparity in literacy in India. Social Change. 2016;46(1):46-69. https://doi.org/10.1177/0049085715618558.
[36] Chiang CY, Bai KJ, Lin HH, Chien ST, Lee JJ, Enarson DA, et al. The influence of diabetes, glycemic control, and diabetes-related comorbidities on pulmonary tuberculosis. PloS One. 2015;10(3):e0121698.
[37] Xiao W, Huang D, Li S, Zhou S, Wei X, Chen B, et al. Delayed diagnosis of tuberculosis in patients with diabetes mellitus co-morbidity and its associated factors in Zhejiang Province, China. BMC Infect Dis. 2021;21(1):272. Doi: 10.1186/s12879-021-05929-8.
[38] Workneh MH, Bjune GA, Yimer SA. Prevalence and associated factors of diabetes mellitus among tuberculosis patients in South-Eastern Amhara Region, Ethiopia: A cross sectional study. PloS One. 2016;11(1):e0147621.
[39] Zhou T, Hu Z, Yang S, Sun L, Yu Z, Wang G, et al. Role of adaptive and innate immunity in type 2 diabetes mellitus. Journal of Diabetes Research. 2018;2018:7457269. Doi: 10.1155/2018/7457269.

PARTICULARS OF CONTRIBUTORS:
1. Postgraduate Student, Department of Community Medicine, BPSGMC for Women, Khanpur Kalan, Sonipat, Haryana, India.
2. Professor, Department of Community Medicine, BPSGMC for Women, Khanpur Kalan, Sonipat, Haryana, India.
3. Professor, Department of Community Medicine, BPSGMC for Women, Khanpur Kalan, Sonipat, Haryana, India.
4. Postgraduate Student, Department of Community Medicine, BPSGMC for Women, Khanpur Kalan, Sonipat, Haryana, India.
5. Associate Professor, Department of Community Medicine, BPSGMC for Women, Khanpur Kalan, Sonipat, Haryana, India.
6. Postgraduate Student, Department of Community Medicine, BPSGMC for Women, Khanpur Kalan, Sonipat, Haryana, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Anita Punia,
Professor, Department of Community Medicine, BPSGMC for Women, Khanpur Kalan, Sonipat-131305, Haryana, India.
E-mail: dranitapunia15@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Mar 25, 2023
- Manual Googling: aug 16, 2023
- iThenticate Software: Sep 20, 2023 (16%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Apr 21, 2023**
Date of Peer Review: **Aug 02, 2023**
Date of Acceptance: **Sep 23, 2023**
Date of Publishing: **Nov 01, 2023**