Original Article

Smoking and the Risk of Type 2 Diabetes: A Cross-sectional Analytical Study

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Abstract

Background: India is undergoing epidemiological transitions with the increase in noncommunicable disease (NCD) burden. Targeting the modifiable risk factors through lifestyle changes in the early years of life remains the most effective strategy for decreasing the prevalence of type 2 diabetes mellitus (T2DM). To determine the association between cigarette smoking and T2DM. **Materials and Methods:** An analytical cross-sectional study was conducted among the patients attending the outpatient department of a tertiary care teaching hospital in Kolkata, West Bengal, India. Patients aged more than 35 years were enrolled, and details regarding sociodemography, clinical status, and NCD risk factors were collected using pretested semistructured questionnaires after obtaining IEC approval. Data collected were entered in MS Excel and analyzed using SPSS software. Simple logistic regression and multivariable logistic regression analysis were used to calculate the crude and adjusted odds ratio with 95% confidence interval. **Results:** Out of 434 participants, 37.3% had diabetes mellitus, 51.6% were males, and 28.6% had alcohol consumption. Univariate logistic regression analysis revealed age, BMI, systolic BP, diastolic BP, and cigarette smoking were significantly associated with increased risk of T2DM. Multivariable logistic regression analysis revealed cigarette smoking, systolic BP, age, and female gender were significant risk factors for T2DM. **Conclusions:** Our study reported cigarette smoking and systolic BP are modifiable risk factors associated with T2DM. Early identification of smoking through screening and appropriate control of hypertension in T2DM patients will decrease the morbidities and mortalities in T2DM cases.

Keywords: Noncommunicable diseases, risk factors, smoking, type 2 diabetes mellitus

Introduction

According to the prediction, worldwide, the cases of type 2 diabetes mellitus (T2DM) will rise to 642 million by 2040.[1] The development of T2DM is primarily due to two main factors: insulin secretion is defective by pancreatic β-cells and the insulin-sensitive tissues are unable to respond to insulin.[2] With the epidemiological transition, the lifetime risk (95% CI) of diabetes in India among 20-year-old men was estimated to be 55.5 (51.6, 59.7)%, and among women, it was 64.6 (60.0, 69.5)%.[3] Women generally had a higher lifetime risk across the lifespan.[3] The risk factors of T2DM are environmental, nutritional, and lifestyle-related. Age and female gender are some of the nonmodifiable risk factors of T2DM.[4–6] However, physical inactivity, obesity, smoking, alcohol, and diet are some of the modifiable risk factors of T2DM.[7] Targeting the modifiable risk factors through lifestyle changes in the early years of life remains the most effective strategy for decreasing the prevalence of T2DM.[5]

With the WHO estimate of 1.5 billion smokers globally by 2050,[8] smoking is a serious public health threat. 99.5 million of all adults (19% of men, 2% women, 10.7% of all adults) were tobacco smokers according to Global Adult Tobacco Survey 2, India conducted during 2016–17.[9] Smoking also has financial implications with an average monthly expenditure of Rs. 1192.5 for cigarettes and Rs. 284.1 for Bidi.[9] Smoking is one of the multifactorial causes for T2DM and also for other diseases such as respiratory diseases, cancer, and

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cardiovascular diseases.[10] Cigarette smoke causes endothelial dysfunction and vascular damage and activates blood-clotting cascade.[11]

The combination of increased blood glucose in diabetic patients along with smoking accelerates vascular damage and increases the risk of micro- and macrovascular complications of T2DM.[11–13] Evidence has shown that cessation of smoking substantially decreases the risk of micro- and macrovascular complications of T2DM.[14,15] The chemicals in cigarette smoke cause inflammation throughout the body, which may decrease the effectiveness of insulin. The chemicals from cigarette smoke can also cause oxidative stress resulting in cell damage. Both oxidative stress and inflammation may cause an increased risk of diabetes.[16]

However, smoking is not considered as a risk factor for T2DM by the American Diabetes Association and the International Diabetes Federation.[5,17,18] With this background, this study was conducted to determine the association between cigarette smoking and T2DM.

Materials and Methods

An observational analytical cross-sectional study was conducted in the month of November 2022 among patients attending the outpatient department (OPD) of a tertiary care teaching hospital in Kolkata, West Bengal, India. The cases attending the weekly OPD fulfilling the inclusion and exclusion criteria were consecutively enrolled in the study.

Inclusion and exclusion criteria

Participants aged more than 35 years were invited to take part in the study. Those who gave informed consent were enrolled in the study. Severely ill cases requiring emergency hospitalization were excluded from the study.

Sample size calculation

Sample size was calculated using Epi-Info software. Based on a pilot study on 75 OPD cases in the same setting where the study was carried out, it was found that 13 (27.1%) out of 48 nonsmokers and 11 (40.7%) of 27 smokers had T2DM. Using the pilot study data, with a power of 80%, the ratio of unexposed to exposed was 2:1, the two-sided confidence level was 95%, the minimum sample size was determined by Kelsey method as 138 exposed (smokers) and 276 nonexposed (nonsmokers). Based on this estimation, the study enrolled 138 smokers and 296 nonsmokers.

Outcome variable

Study participants were defined as diabetics based on the cut-off values given by American Diabetes Association,[19] HbA1C ≥ 6.5% or fasting plasma glucose (FPG) ≥126 mg/dl (7.0 mmol/l) (fasting was defined as no caloric intake for at least 8 hours) or 2-hour plasma glucose ≥200 mg/dl (11.1 mmol/l) during an oral glucose tolerance test (OGTT) or in a patient with classic symptoms of hyperglycemia or hyperglycemic crisis, a random plasma glucose ≥200 mg/dl (11.1 mmol/l).[19] Those study participants who were already under treatment with oral hypoglycemic agents/insulin were also defined as diabetic irrespective of their blood glucose status.

Smoking status

Cigarette smoking habits were assessed at baseline by a structured interview. The participants were grouped into two mutually exclusive categories. Participants who had smoked <100 cigarettes before the onset of T2DM were defined as smoking exposure 'absent' in the study. The individuals who had smoked >100 cigarettes before the onset of T2DM were considered as smoking exposure 'present' in this study.[20,21]

Covariates and operational definitions

Age and gender were determined through self-reporting by the study subjects.

Blood pressure was measured according to the International Society of Hypertension guidelines (ISH).[22] A digital blood pressure monitor was used to measure the blood pressure. Hypertension was defined as one of the following: systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg, or if the patient was under current pharmaceutical treatment for hypertension.

Anthropometric measurements weight and height were measured using standardized protocols on each of the participants. Body mass index (BMI) was calculated as ratio of weight (kilogram)/height^2 (meter).

Alcohol use was defined as consumption of any type of alcohol in the last 1 year.[21] Moderate consumption of alcohol was defined as one to three drinks/day, whereas heavy alcohol consumption was defined as >3 drinks/day.[23]

Adequate consumption of fruits and vegetables was defined as five servings of fruits and vegetables per day.[24]

Regular physical activity was defined as 150 minutes of at least moderate intensity physical activity per week.[25]

Study tool and variables

The study participants were interviewed using a semistructured questionnaire. The primary outcome of interest was T2DM. The predictor variables for the T2DM risk association were cigarette smoking, age, gender, BMI, systolic and diastolic blood pressure, and alcohol consumption.

Statistical analysis

The data collected were entered in Microsoft Excel and analyzed using Epi-Info software and IBM SPSS version 28.0 (IBM, Armonk, NY, USA). Frequency distributions and percentages were computed for categorical variables. Chi-square test was applied for the association between the categorical variables. A level for testing the statistical significance was set at $P < 0.05$. The unadjusted odds ratio with 95% confidence interval (CI) was calculated using simple logistic regression to assess the risk factors associated with T2DM. Multivariable logistic regression analysis was used to calculate adjusted odds ratio with 95% CI. The variables with clinical or statistical significance were included in the model.

Ethical considerations

Verbal informed consent was taken from each participant prior to collecting data. The purpose of the study was explained to the study subjects. They were assured that their personal identity would be kept confidential and the data will be used for research purposes. National Ethical guidelines and the 1964 Helsinki Declaration and its latest amendment were followed during the study. The study was approved by the Institute Ethics Committee vide reference MC/KOL/IEC/NON-SPON/1572/11/2022 dated 05/11/2022.

Results

A total of 434 study participants were included in the study. T2DM was diagnosed in 37.3% (162/434) study participants. There were 51.6% (224/434) males and 48.4% (210/434) females. 39.6% (172/434) were diagnosed with hypertension. 28.6% (124/434) had moderate consumption of alcohol, whereas 71.4% (310/434) did not consume alcohol at all. No one in the study reported heavy alcohol consumption. 31.8% (138/434) were smoking cigarettes. All the study subjects were found to be consuming an inadequate quantity of fruits and vegetables. The physical activity in the study participants was not regular, that is, less than 150 minutes per week of moderate intensity activity.

As seen in Table 1, T2DM was found in 37.5% (84/224) males, whereas 37.1% (78/210) females were diagnosed with T2DM. 41.4% (67/162) smokers were diagnosed with T2DM as compared to 58.6% (95/162) nonsmokers.

As seen in Table 2 upon univariate logistic regression analysis, five variables were significantly associated with greater risk of T2DM: age, BMI, systolic BP, diastolic BP, and cigarette smoking. However, after controlling for all independent variables in the adjusted (multivariable) logistic regression analysis, cigarette smoking, systolic BP, age, and female gender were significant risk factors for T2DM. Moderate alcohol consumption was associated with a protective effect for the development of T2DM, and this retained its statistical significance in the multivariate analysis.

Based on the reference article by Philip Cole and Brian MacMohan,[26] the attributable risk percentage (AR%) was calculated among the smokers by using the formula AR% among exposed = RR — 1/RR × 100%, where RR, the relative risk, is the ratio of the risk among the exposed to that among the unexposed. AR can be best derived from cohort studies. However, its estimation from case-control studies is also possible if controls represent the general population. In the present study, the attributable risk percent to smoking in diabetic cases is 33.91%.

Discussion

In the present study, after multivariate logistic regression analysis, we found that with every unit (year) increase in age, the risk of developing T2DM was 1.08 times with 95% CI [1.05, 1.10], which was statistically highly significant. Several studies have documented that as age advances, the risk of T2DM increases.[27,28] As the age advances, it is

Table 1: Distribution of study population according to T2DM status

Variable	Characteristics	Diabetes Present *n*=162	Diabetes Absent *n*=272
Age, years	Range	41.0-95.0	35.0-81.0
	Mean age (SD)	59.5 (9.4)	50.4 (9.0)
	Median age (IQR)	60 (53.0-65.0)	48 (43.5-56.0)
Age, years	35-44 (*n*, %)	9 (10.1)	80 (89.9)
	45-54	34 (24.1)	107 (75.9)
	55-64	71 (54.2)	60 (45.8)
	>65 (*n*, %)	48 (65.7)	25 (34.2)
Gender	Male (*n*, %)	84 (51.9)	140 (51.5)
	Female (*n*, %)	78 (48.1)	132 (48.5)
BMI	Range	17.5-30.4	16.0-32.3
	Mean age (SD)	24.3 (2.8)	23.0 (2.7)
	Median age (IQR)	24.0 (22.2-26.0)	22.8 (21.0-24.6)
Systolic BP	Range	90-170	90-210
	Mean BP (SD)	134.9 (14.2)	123.9 (17.3)
	Median BP (IQR)	139 (124-140)	120 (110-130)
Diastolic BP	Range	58-108	60-120
	Mean BP (SD)	83.9 (8.9)	77.2 (10.3)
	Median BP (IQR)	85 (80-90)	78.5 (70-80)
Hypertension	Present	96 (55.8)	76 (44.2)
	Absent	66 (25.2)	196 (74.8)
Moderate Alcohol consumption	Yes (*n*, %)	30 (18.5)	94 (34.6)
	No (*n*, %)	132 (81.5)	178 (65.4)
Cigarette smoking	Yes (*n*, %)	67 (41.4)	71 (26.1)
	No (*n*, %)	95 (58.6)	201 (73.9)

Table 2: Univariate and Multivariate analysis of the risk factors for T2DM

Variable	Unadjusted OR [95% CI]	Adjusted OR [95% CI]	*P*
Age (continuous)	1.1 [1.07–1.13]	1.08 [1.05, 1.10]	0.000
Gender			
Male (reference)			0.032
Female	0.98 [0.67, 1.46]	2.16 [1.07, 4.35]	
BMI (continuous)	1.18 [1.09–1.27]	1.04 [0.95, 1.13]	0.357
Systolic BP (continuous)	1.04 [1.02–1.05]	1.02 [0.99, 1.04]	0.053
Diastolic BP (continuous)	1.07 [1.04–1.09]	1.02 [0.99, 1.06]	0.129
Moderate alcohol consumption			
No (reference)			0.002
Yes	0.43 [0.26, 0.69]	0.35 [0.18, 0.68]	
Cigarette smoking			
No (reference)			0.001
Yes	1.99 [1.32, 3.02]	3.59 [1.71, 7.58]	

associated with the development of insulin resistance, β-cell dysfunction, and glucose intolerance,[28] thus increasing the risk of developing T2DM.[29] The mitochondrial function reduces, which contributes to insulin resistance.[28]

There was no significant difference in gender when we did the univariate analysis. However, in the multivariate analysis, female gender was having 2.16 times greater odds of developing T2DM with 95% CI [1.07, 4.35]. Zhang H *et al*.[30] found that the overall prevalence of T2DM was slightly higher in women as compared to men, but the difference was not statistically significant. Duboz P *et al*.[31] found that women aged > 40 years were at significantly higher risk of diabetes than men.

With every unit rise in systolic blood pressure, the adjusted odds ratio of being diagnosed as T2DM was 1.02 with 95% CI [0.99, 1.04], which came out to be just statistically significant ($P = 0.053$). Individuals with hypertension often exhibit insulin resistance and are at greater risk of developing diabetes than normotensives.[32] In patients with diabetes, hypertension is twice as frequent as compared with those who do not have diabetes.[32] The association between hypertension and T2DM has been found in other studies.[33]

Moderate drinking of alcohol had a protective effect for the development of T2DM in our study. In a systematic review regarding the effect of alcohol consumption on diabetes mellitus by Howard *et al*.,[23] moderate consumption of alcohol was associated with a decreased incidence of diabetes mellitus.

Cigarette smoking was associated with a 3.59 times significantly greater odds of T2DM as compared to nonsmokers in the multivariate analysis. Wannamethee *et al*.[34] found after adjustment for confounders that cigarette smoking increased the risk of diabetes. Rimm *et al*.[35] investigated a comparatively rare study among women to explore the relationship between smoking and incidence of diabetes and found that current smokers exhibited an increased risk of diabetes. Manson *et al*.,[36] studied US male physicians and found significantly increased risk of self-reported diabetes and smoking. Foy *et al*.[20] concluded that current smokers had greater risk of diabetes than never smokers after adjustment for confounding factors. However, study by Henkin *et al*.[37] did not reveal an association between active smoking and insulin sensitivity. The authors concluded that the association between exposure to the environmental tobacco smoke (ETS) and insulin sensitivity was a puzzling finding and further investigations were required in other populations.

Those with T2DM carry a higher risk of mortality from cardiovascular disease (CVD) as compared to nondiabetics.[38] Cigarette smoking is also a risk factor for development of CVD.[39]

Conclusion

Prevention of smoking habits during the early years of life will benefit the population in decreasing the burden of T2DM and CVD. Our study reported cigarette smoking and systolic BP are modifiable risk factors associated with diabetes mellitus. Early identification of smoking through screening and appropriate control of hypertension in T2DM patients will decrease the morbidities and mortalities in T2DM cases.

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Conflicts of interest

There are no conflicts of interest.

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