

SMOKELESS TOBACCO USE AND DENTAL CARIES RISK IN TYPE 2 DIABETES MELLITUS: A CASE-CONTROL STUDY

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ABSTRACT

Smokeless tobacco (SLT) products are widely used across the globe in various forms, often containing diverse chemical additives and artificial sweeteners. In India, the extensive use of SLT has raised concerns due to its link with serious oral health problems. Among individuals with Type 2 Diabetes Mellitus (T2DM), the sugar content in these products may further increase the risk of developing dental caries. The study included patients aged 20–79 years with or without SLT use and T2DM. Using a consecutive sampling method, 48 participants were enrolled: 24 SLT users (cases) and 24 non-users (controls). Data were collected through a structured questionnaire and clinical oral examination. Statistical analysis was performed using SPSS version 20.0. Chi-square test assessed association, and logistic regression was used to identify significant predictors. Male participants had significantly higher odds of developing dental caries than females (OR = 6.6, $p = 0.04$). Lower socioeconomic status was also linked with a greater prevalence of caries ($p = 0.03$). Among diabetic individuals, those with additional systemic illnesses showed a strong association with dental caries (OR = 5.48, $p = 0.01$). SLT users irrespective of diabetic status, had 11.66 times higher odds of developing dental caries compared to non-users ($p = 0.01$). This case-control study highlights a significant association between SLT use and increased prevalence of dental caries, particularly among individuals with type 2 diabetes Mellitus and lower socioeconomic status, emphasizing the need for targeted preventive strategies.

Key words: Smokeless tobacco, Diabetic, Diabetes mellitus, Dental caries, Oral health.

Introduction

Dental caries continues to be one of the most common chronic diseases affecting millions of people globally, especially in developing countries like India, because of diet alterations and lack of access to preventive care [1, 2]. Dental caries develop due to complicated processes between the host, cariogenic bacteria, fermentable carbohydrates, and time. Saliva plays an essential role in protecting against dental caries as it buffers, acts as an antimicrobial agent, and promotes remineralization [3, 4].

Type 2 diabetes mellitus (T2DM) is a metabolic disorder defined by prolonged hyperglycaemia caused by insulin resistance or deficiency, and it is one of the most affected countries within the global pandemic of the disease [5, 6]. Hyperglycaemia impairs the function of the salivary glands causing decreased flow and change in composition, as well as high glucose levels in the saliva, which cause increased proliferation of acidogenic bacteria such as *Streptococcus mutans* [7-9]. As a result, T2DM patients with uncontrolled levels have much more prevalence of caries than non-diabetic individuals [10].

Smokeless tobacco (SLT) preparations like khaini, gutkha, and tobacco-infused betel quid are extensively used in South Asian countries including India [11]. They are made up of nicotine, fermentable sugars, and cancer-causing agents that impair oral well-being by means of prolonged retention in

the mouth [12, 13]. Use of SLT results in an increase in the prevalence of dental caries due to increased plaque formation, greater fermentable sugar levels, decreased salivary secretion, and a shift towards cariogenic bacteria [14, 15].

It seems that the coexistence of T2DM and SLT consumption would increase the risk of developing dental caries due to diabetes-related problems of saliva as well as the effects of smoking on the composition of the oral microbiota [16]. Other factors like poor oral hygiene practices and poor dietary habits common in people who consume SLT can worsen this susceptibility [17]. Even though both health issues are highly prevalent in the population, there is little information available on the combined effects of T2DM and SLT use on the development of dental caries [18, 19].

The present study aimed to evaluate the association between smokeless tobacco (SLT) use and dental caries among individuals with and without type 2 diabetes mellitus (T2DM). The objectives were to compare the prevalence of dental caries between SLT users and non-users, assess the influence of T2DM on caries occurrence, and determine the independent and combined effects of SLT use and systemic factors on dental caries risk.

Materials and Methods

Study design, setting, and population

The present case-control study was conducted from June 2023 to October 2024 in the outpatient department of an institutional hospital. The study population comprised patients aged 20–79 years who attended the outpatient services during the study period.

Sampling

Participants were enrolled using a consecutive sampling

technique, and the sample size was determined based on a previous study [20]. Using the OpenEpi programme (Version 3), the sample size was calculated with a 95% confidence interval (CI), 80% power, and a sample size ratio of 1. The total sample size was 48, and each group, comprising cases and controls, consisted of twenty-four participants, respectively. The data for the study is presented in **Figure 1**.

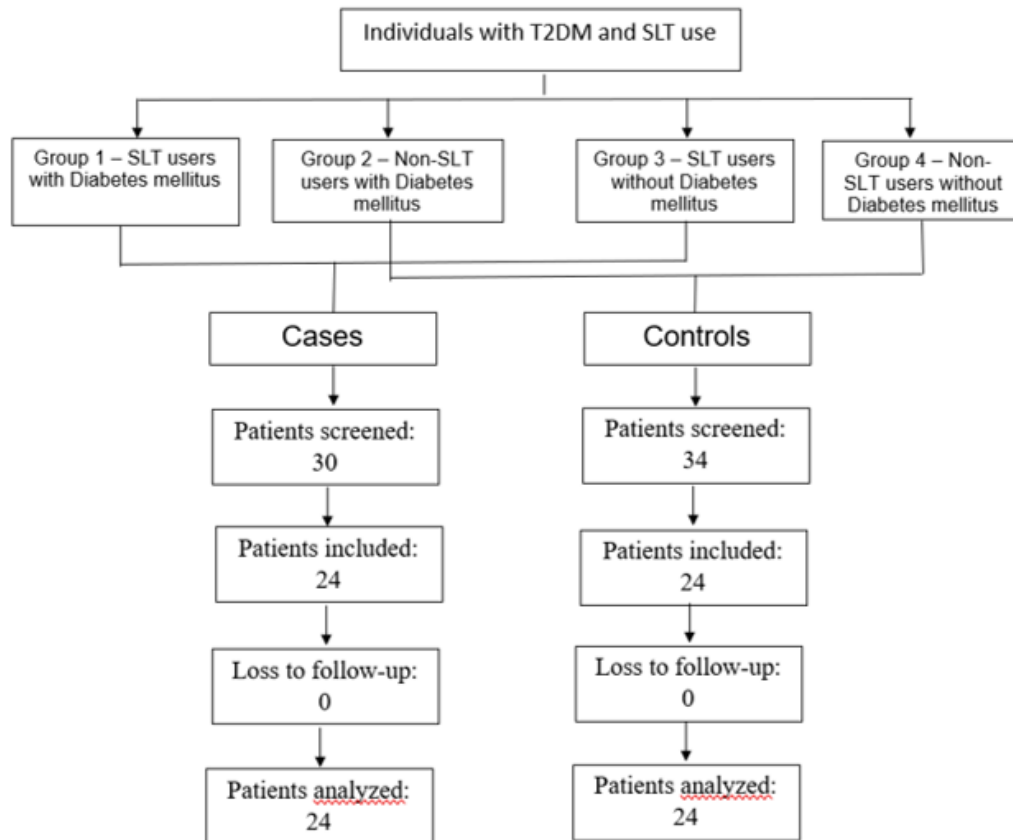


Figure 1. Study flowchart

Inclusion and exclusion criteria

The study included individuals aged 20-79 years. Criteria for selecting diabetic participants involved a minimum of 2 years since the onset of type II diabetes, with HbA1c values equal to or greater than 6.5 mg/dL, and a willingness to participate. Only individuals who were current users of smokeless tobacco were considered.

Exclusion criteria encompassed individuals taking medications affecting salivary parameters, those using both smoking and smokeless tobacco, individuals with a history of radiation therapy, salivary gland diseases or disorders, and individuals wearing complete dentures.

Selection of participants

Cases: Between June 2023 and October 2024, the study focused on tobacco chewers diagnosed with type 2 diabetes

mellitus. The study exclusively included patients with confirmed smokeless tobacco use, which was recorded based on the criteria established by the Global Adult Tobacco Survey conducted in 2016-17 in India [21]. The presence of type 2 diabetes, was verified by HbA1c values, following the guidelines outlined by the Indian Council of Medical Research (ICMR) [22].

Cases were grouped as:

Group 1 – SLT users with diabetes mellitus

Group 3 – SLT users without diabetes mellitus

Controls: for each included case, one matched control subject was selected from the social circles of the case participants, including friends, relatives, or partners. It was

ensured that the control group comprised non-SLT individuals with or without diabetes mellitus. Moreover, the controls were carefully matched with the cases based on their age and gender. Controls were further grouped into:

Group 2 – Non-SLT users with diabetes mellitus

Group 4 – Non-SLT users without diabetes mellitus

Written informed consent was obtained from each participant before the start of the study.

A single interviewer conducted interviews with each participant. The questionnaire encompassed sections on demographic information, oral health habits, past dental history, dietary habits, details about smokeless tobacco use, and diabetes status.

Exposure data

The questionnaire consisted of demographic details (name, age, sex, and socioeconomic status); oral health habits of the patients (use of toothbrush and toothpaste, use of fluoridated/non-fluoridated toothpaste, duration of brushing, and frequency of brushing); presence of T2DM (Yes/ No), duration of T2DM (less than 3 years/more than 3 years); presence of systemic illness; any medications in use; past dental history (number of visits in past one year); presence of malalignment; nutrition evaluation chart [22]; and information about smokeless tobacco and status of alcohol consumption. Malalignment was recorded as present or absent based on Angle's classification of malocclusion [23]. Socioeconomic status was recorded based on the Modified Kuppuswamy Scale [24], which was dichotomized by including 'Upper' and 'Upper middle class' into Upper class and 'Lower middle,' 'Upper lower,' and 'Lower' into Lower class. Use of any other medication specifically pertained to the utilization of solely oral medications. For inclusion in the smokeless tobacco (SLT) user category, participants had to meet the criteria of being current SLT user. Detailed inquiries about SLT use included questions about the quantity of packs consumed per day, the duration and frequency of consumption, and whether participants swallowed the tobacco juice [25].

Alcohol consumption was assessed based on the presence or absence of the habit (Yes/No) and the duration of consumption (less than 6 months/more than 6 months) [21]. A typical interview lasted 20 to 25 minutes.

Pilot study

A pilot study was conducted among 10 participants, and clinical data was recorded by a single examiner. The examiner was trained and calibrated. The intra-examiner reliability was obtained by performing the evaluation of the same participants after 7 days and yielded a kappa score of 0.89.

Clinical examination

Following the questionnaire, participants underwent a clinical examination conducted by a single calibrated examiner with assistance from a recorder who was well versed in case history recording and examination procedure. The examiner was blinded to the allocation of the participants to the case and the control groups. The armamentarium used for intraoral examination comprised sterilized sets of a plain mouth mirror, a Shephard's hook probe, tweezers, and cotton swabs. Caries diagnosis was established using the criteria outlined by the World Health Organization [26].

Statistical analysis

Data were collected and analyzed using MS Excel 2019 and SPSS software 20.0 (IBM, Chicago, Illinois, USA), respectively. Significance level was established at $p < 0.05$. For analysis of the categorical data, chi-squared test was used while the effect size for odds ratios (ORs) with 95% confidence interval (CI) was analyzed.

Results and Discussion

Table 1 presents the demographic characteristics of the study participants. The mean age of cases was 49.29 years, which was higher compared to 30.87 years in controls. Among cases, males ($n = 15$) were more frequent than females ($n = 4$), whereas in the control group, females ($n = 13$) outnumbered males ($n = 11$). Regarding socioeconomic status, the upper category included 13 cases and 15 controls, while the lower category comprised 11 cases and 9 controls.

Table 1. Demographic data of study participants

	Cases	Controls
Age (Mean age)	49.29 years	30.87 years
Gender		
Males	15	11
Females	4	13
Socioeconomic status		
Upper	13	15
Lower	11	9

Table 2 shows the variables that demonstrated statistically significant associations with dental caries. Gender showed a significant association ($p = 0.04$) with an odds ratio of 6.6. Lower socioeconomic status was also significantly associated ($p = 0.03$) with an odds ratio of 0.13. The presence of systemic illness demonstrated a significant relationship ($p = 0.01$) with an odds ratio of 5.48. **Table 3** summarizes other assessed factors that did not show statistically significant associations. Oral medication use had p-values greater than 0.1. Sugar score and exposure showed p-values greater than 0.05. Toothbrushing practices had p-values above 0.2, while fluoridation use showed p-values above 0.3. Alcohol consumption demonstrated p-values greater than 0.5. SLT quantity and duration had p-

values above 0.05, and juice swallowing showed p-values greater than 0.09.

Table 2. Statistically Significant Associations with Dental Caries (Group 1 vs 2)

Variable	p-value	Odds Ratio
Gender	0.04*	6.6
SES (Lower)	0.03*	0.13
Systemic Illness	0.01*	5.48

*Significant: (p value< 0.05)

Table 3. Other Factors Assessed – Non-Significant Associations

Factor	p-value Range	Interpretations
Oral medication use	> 0.1	Not significant in both groups
Sugar score & exposure	> 0.05	Borderline in some comparisons
Tooth brushing (frequency/duration)	> 0.2	No significant impact
Fluoridation use	> 0.3	No association
Alcohol consumption	> 0.5	Not statistically significant
SLT quantity & duration	> 0.05	Some trends but not significant
Juice swallowing	> 0.09	Not significant

Table 4 depicts the association between dental caries and SLT use in grouped analysis. In the comparison of Group 1 vs. Group 2, dental caries was present in 14 participants compared to 2 without caries, while in the comparison group, 3 had caries and 5 did not (p = 0.01; OR = 11.66). Similarly, in Group 3 vs. Group 4, 5 participants had caries compared to 2 without caries, while in the comparison group, 3 had caries and 14 did not (p = 0.01; OR = 11.66). **Table 5** presents the logistic regression analysis. SLT use showed a statistically significant association (p = 0.032) with an adjusted odds ratio of 4.296 and an unadjusted odds ratio of 0.011. Systemic illness had a p-value of 0.591 with an adjusted odds ratio of 3.299. Socioeconomic status showed a p-value of 0.358 with an adjusted odds ratio of 0.237. Gender had a p-value of 0.836 with an adjusted odds ratio of 0.629. The model demonstrated an R² value of 0.32.

Table 4. Association Between Dental Caries and SLT Use (Grouped Analysis)

Group Comparison	Dental Caries Present	Caries Absent	p-value	Odds Ratio
Group 1 vs Group 2	14 vs 2	3 vs 5	0.01*	11.66
Group 3 vs Group 4	5 vs 2	3 vs 14	0.01*	11.66

*Significant: (p value< 0.05)

Table 5. Logistic Regression Analysis

Variable	p-value	Adjusted OR (CI)	Unadjusted OR (CI)	R ² Value
Group (SLT use)	0.032*	4.296	0.011	0.32
Systemic illness	0.591	3.299	0.019	
SES	0.358	0.237	0.032	
Gender	0.836	0.629	0.043	

*Significant: (p value< 0.05)

In this case-control study, the relationship between the usage of smokeless tobacco (SLT) and dental caries in patients was analyzed with emphasis on the role played by type 2 diabetes mellitus (T2DM). Results showed that there were significant relationships between dental caries and various risk factors, including gender, socio-economic status, systemic disease, and SLT use. However, no statistically significant relations could be found for various behavioral and oral hygiene measures [27-32].

In the current study, the average age of cases (49.29 years) was higher than controls (30.87 years), indicating that older individuals had a greater prevalence of dental caries. This finding agrees with the results presented by Kassebaum *et al.* (2017), who found that untreated dental caries increased in adulthood because of cumulative risk factor exposure and decline in saliva flow rate [33]. Furthermore, Broadbent *et al.* (2013) have also noted that caries development continued throughout adulthood in patients with comorbid systemic diseases [34].

A statistical significance was observed between gender and dental caries (OR = 6.6, p = 0.04). The cases included more men compared to the control sample in which more women were included [35-41]. Such results correspond to the study conducted by Vellappally *et al.* who showed that men had a higher tendency towards tobacco use and poor oral hygiene habits, leading to a greater risk of tooth decay [42]. Likewise, in the study by Al-Ansari *et al.* (2014), gender disparities in oral behavior associated with higher risk for tooth decay were found [43]. Such behavioral habits could influence the development of dental caries.

Socioeconomic status was found to be significantly associated with dental caries (p=0.03), where a high level of SES had a strong association with dental caries. This result was supported by global literature, suggesting that those who belong to a lower SES group suffer greatly from dental caries because of less access to dental care facilities, poor health knowledge, and poor eating habits. Petersen *et al.* (2005) suggested that SES plays a very important role in determining the oral disease profile [44]. Likewise, Peres *et al.* (2019) found that social determinants had a major influence on caries prevalence [45]. The findings of this study support the established link between SES and oral health outcomes.

The data revealed a strong, statistically significant association between systemic conditions, particularly diabetes, and the occurrence of dental caries (OR = 5.48, $p = 0.01$). This outcome aligns with findings by Taylor *et al.* (2008), who highlighted that diabetes contributes to various oral health complications, including a heightened vulnerability to tooth decay [46]. Furthermore, Lamster *et al.* (2008) demonstrated that hyperglycemic states impair salivary function, diminish buffering capacity, and elevate glucose concentrations in saliva, thereby fostering an environment conducive to cariogenic bacterial growth [47]. More recently, Mwesiwa *et al.* (2025) confirmed a significant correlation between diabetes mellitus and increased susceptibility to caries [48]. Ultimately, the substantial link identified in this research underscores the critical influence of systemic metabolic dysregulation on an individual's overall risk for dental decay, reinforcing the established consensus regarding the oral-systemic health connection in clinical settings.

Intriguingly, several behavioral factors such as oral drug administration, brushing habits, use of fluoridation, drinking of alcohol, and drinking of juices did not have a statistically significant relationship [49-54]. This is partly supported by the findings from Sheiham & James (2015), where they argue that although oral hygiene measures play a critical part, other factors like sugar and diet play a more pronounced influence on caries formation [26]. Likewise, according to Moynihan & Kelly (2014), sugar is one of the most critical determinants of caries, but this depends on various factors associated with the host [55]. In this study, sugar score reveals borderline significance, suggesting a possible contributory role without reaching a statistical threshold.

The most important finding of the present study was the association between SLT use and dental caries, as shown in the grouped analysis (OR = 11.66, $p = 0.01$). Such an association is considered to point out the risk posed by the use of smokeless tobacco (SLT) as one of the risk factors for developing dental caries. These results corroborate those of Khan *et al.* (2024), who explored the relationship between smoking and SLT use in relation to dental caries among individuals from a hospital setting, reporting that there is a positive relationship despite the heterogeneity of strength between subgroups [19]. The reason for the higher odds ratio observed in the present study is related to the presence of patients with comorbidities like diabetes.

Consistent with the results above is a recent study conducted by Niu *et al.* (2024), who showed that the interaction between tobacco use and dietary habits, especially sugar consumption, increased the risk of developing dental caries [56]. This interaction may explain the stronger association noted in this study, where multiple risk factors coexist.

Moreover, in their latest narrative review, Bogdanska *et al.* (2025) found that the usage of smokeless tobacco was

significantly related to the prevalence of caries because of the presence of sugars, prolonged retention in the oral cavity, and abrasives capable of causing tooth enamel demineralization [18]. The results coincide with the findings of the current research when SLT users were identified as having increased prevalence of caries.

Furthermore, Lee *et al.* (2025) noted that tobacco usage in relation to smoking had a detrimental effect on the health of the oral cavity owing to increasing the level of plaque formation and the risk of developing caries owing to changes in the environment and functioning of saliva in the mouth [57]. It may be particularly true for SLT users due to the prolonged contact.

Nevertheless, some scholars argue against the relationship between tobacco consumption and dental caries. In particular, Elshahry *et al.* (2024) noticed that despite being harmful to the oral cavity, the relationship between tobacco consumption and the development of caries decreases when controlling other variables, such as oral hygiene and nutrition habits [58]. This is in line with the observations of this study, where several behavioral factors did not show statistical significance in multivariable analysis.

Additionally, it was established in the logistic regression analysis performed in the current study that SLT usage still constituted a predictor of dental caries (adjusted OR = 4.296, $p = 0.032$). It is in line with the results obtained by Khan *et al.* (2024), which demonstrated that the presence of smokeless tobacco usage was a statistically significant factor predicting dental caries [19].

Conversely, the presence of any systemic illness, SES, and gender was no longer statistically significant in the multivariate analysis, most probably due to the clustering of multiple risk factors for caries. It is in agreement with the findings of Peres *et al.* (2019) that emphasized the multiple etiological mechanisms associated with the development of caries, including social and behavioral factors [45].

Moreover, the simultaneous existence of type 2 diabetes and smokeless tobacco usage may exacerbate caries risk, primarily due to diabetes-induced salivary impairments and tobacco-driven shifts in oral microbiota. Consistent with these findings, research demonstrates that patients diagnosed with diabetes exhibit a significantly elevated susceptibility to the development of dental caries within their oral cavities [17].

However, this study is subject to several limitations. Primarily, the cross-sectional methodology precludes definitive causal conclusions, and the limited sample size may restrict the generalizability of these results. Furthermore, relying on patient self-reporting to evaluate smoking habits introduces a potential for reporting bias. Despite these methodological challenges, this research provides valuable insights regarding how smokeless tobacco

consumption, in conjunction with various systemic factors, contributes to the overall prevalence and development of dental caries within the observed population.

Conclusion

According to the present study, smokeless tobacco consumption was found to be strongly linked to dental caries and acts as an independent predictor, even when the effect of other confounders was controlled. In addition, the presence of systemic disease, especially diabetes, may increase this risk. These findings highlight the need for integrated preventive strategies addressing both tobacco cessation and metabolic control to reduce the burden of dental caries.

Clinical trial registration

Clinical Trials Registry - India (CTRI) (URL: <https://ctri.nic.in/Clinicaltrials/login.php>) Registration no.: CTRI/2023/07/055557

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Conflict of interest: None

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Ethics statement: The study protocol was reviewed and approved by the Institutional Ethics Committee of Dr. D. Y. Patil Dental College and Hospital, Dr. D. Y. Patil Vidyapeeth (Deemed to be University), Pune, India and the research was conducted in accordance with the principles of the Declaration of Helsinki.

Written informed consent was obtained from all participants prior to their enrolment in the study, after providing detailed information regarding the objectives, procedures, potential risks, and benefits of participation. Participants' confidentiality and anonymity were maintained throughout data collection, analysis, and reporting.

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