

## “Prevalence Of Oral Precancerous Lesions And Conditions And Their Environmental, Behavioral, And Quality Of Life Correlates Among Tobacco Users In Northern India: A Cross-Sectional Study”

Dr. Tannu Kumari<sup>1\*</sup>, Dr. Pradeep Tangade<sup>2</sup>, Dr. Vikas Singh<sup>3</sup>, Dr. Ankita Jain<sup>4</sup>, Dr. Rupali Malik<sup>5</sup>, Dr. Swayam Sourav Tripathy<sup>6</sup>

<sup>1\*</sup>Dr. Tannu Kumari, Post-graduate, Department of Public Health Dentistry, Teerthanker Mahaveer Dental College and Research Centre.

<sup>2</sup>Dr. Pradeep Tangade, MDS, Principal and Head of Department, Department of Public Health Dentistry, Teerthanker Mahaveer Dental College and Research Centre.

<sup>3</sup>Dr. Vikas Singh, MDS, Professor, Department of Public Health Dentistry, Teerthanker Mahaveer Dental College and Research Centre.

<sup>4</sup>Dr. Ankita Jain, MDS, PhD, Vice-Principal and Professor, Department of Public Health Dentistry, Teerthanker Mahaveer Dental College and Research Centre.

<sup>5</sup>Dr. Rupali Malik, MDS, Assistant Professor, Department of Public Health Dentistry, Teerthanker Mahaveer Dental College and Research Centre.

<sup>6</sup>Dr. Swayam Sourav Tripathy, Post-graduate, Department of Public Health Dentistry, Teerthanker Mahaveer Dental College and Research Centre.

\*Corresponding Author:- Dr. Tannu Kumari

\*Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India (244001),

E-mail address - tankashra@gmail.com

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### Abstract

#### **Background:**

Tobacco use is a major behavioral and environmental risk factor for oral diseases, particularly precancerous lesions and conditions. In Northern India, the widespread availability and cultural acceptance of smokeless and smoked tobacco contribute to a rising burden of oral health issues. This study aimed to assess the prevalence of oral precancerous lesions and conditions among adult tobacco users, evaluate their oral health status, and analyze the associations between environmental, behavioral, and quality of life factors.

#### **Methods:**

This cross-sectional study was conducted among 800 adults aged 35 years and above attending the dental outpatient department of a tertiary care institution in Northern India. Data collection included structured interviews to capture sociodemographic and behavioral variables, clinical examinations based on the WHO Oral Health Assessment Form for Adults (2013), and the OHIP-14 questionnaire to assess oral health-related quality of life (OHRQoL). Environmental and behavioral correlates such as residence, education level, tobacco type, and duration of use were analyzed using chi-square and t-tests.

#### **Results:**

Of the 800 participants, 53.5% were male and 46.5% were female. Among males, 52.1% were smokers, and 47.9% were tobacco chewers; among females, 52.4% were chewers and 47.6% were smokers. The overall prevalence of oral precancerous lesions was high, with Oral Submucous Fibrosis (OSMF) and Leukoplakia being the most common. Smokeless tobacco users, particularly those from rural and lower socioeconomic backgrounds, exhibited more severe mucosal lesions and significantly worse OHRQoL scores ( $p < 0.001$ ). A clear association was observed between prolonged tobacco use, environmental disadvantage, and impaired oral health status.

#### **Conclusions:**

The findings indicate a significant burden of oral precancerous conditions among tobacco users in Northern India, influenced by both behavioral habits and environmental exposures. These results underscore the need for region-specific screening programs, oral health promotion, and community-based interventions to address the interrelated impact of tobacco use, poor living conditions, and quality of life.

**Keywords:** Oral precancer, Tobacco use, Environmental health, Oral Submucous Fibrosis, Leukoplakia, Quality of life, Northern India.

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## INTRODUCTION

Universally, cancer is a prominent cause of death. India reports approximately 700,000 new cancer cases annually, of which nearly 300,000 are tobacco-related. Among these, oral cancer forms a significant proportion, with an average treatment cost of around ₹3.5 lakh per patient, imposing a substantial burden on both the healthcare system and affected individuals [1]. Oral cancer refers to any malignant tumor that arises in the tissues of the tongue, submandibular, cheek lining, gingiva, palate, or lips. Additionally, poor dental hygiene and an inadequate diet can contribute significantly to the development of oral cancer [2]. It has been a long time since tobacco was rapidly integrated into Indian society and is now widely manufactured and utilized [3]. The occurrence of tobacco use among Indian adults is approximately 35%. In India, bidi smoking is the most common form of tobacco smoking, while paan with tobacco is widely consumed in the chewing form [4]. Dry tobacco-areca nut preparations, such as paan masala, gutkha, and mawa, are also highly popular and addictive [5].

Premalignant lesions of the oral cavity, often appearing as abnormal areas on the mucosal lining, can cause significant patient anxiety. These lesions are commonly linked to betel nut chewing, cigarette smoking, and alcohol consumption, and are frequently associated with the development of oral squamous cell carcinoma [6]. Given this context, the present investigation aims to evaluate the prevalence of oral precancerous lesions and conditions, assess the oral health status of smokers and tobacco users, and examine the environmental and behavioral correlates, such as tobacco use patterns, education level, and place of residence, among patients attending the dental outpatient department. Additionally, the study investigates the association between these factors and oral health-related quality of life (OHRQoL), utilizing the validated Oral Health Impact Profile-14 (OHIP-14) questionnaire. The null hypothesis formulated for this study states that there is no significant association between the presence of oral precancerous lesions or conditions and OHRQoL among smokers and tobacco users.

## MATERIALS AND METHODS

### 1. Study Design and Population

This cross-sectional observational study was conducted among adult patients attending the outpatient department of Teerthanker Mahaveer Dental College and Research Centre, Moradabad, Uttar Pradesh. Data collection included structured interviews and clinical oral examinations to assess oral health status, tobacco use patterns, and quality of life.

**Inclusion criteria** were:

- Adults aged over 35 years
- Current or past users of tobacco in smoked or smokeless forms
- Individuals who provided written informed consent to participate

**Exclusion criteria** included:

- Individuals unwilling to participate
- Patients currently undergoing orthodontic treatment

### 2. Ethics Approval and Consent to Participate

Ethical approval was obtained from the Institutional Ethics Committee of Teerthanker Mahaveer Dental College and Research Centre with Reference no. TMDCR/IEC/TH/22-23/PHD 02, before the commencement of the study. Participants were provided with detailed information about the study's purpose and gave informed consent before completing the survey.

### 3. SAMPLE SIZE ESTIMATION

The sample size for the study was determined based on both a pilot study and previously reported prevalence data. A pilot study was conducted on 40 participants to provide a preliminary understanding of the prevalence. In addition, previously published prevalence figures were used for precise estimation. The sample size was calculated separately for smokers and tobacco chewers using the formula:  $N = Z^2PQ/d^2$ , where  $N$  = sample size,  $Z$  = standard normal deviate at 95% confidence level = 1.96,  $P$  = estimated prevalence (%),  $Q = 100-P$ ,  $d$  = allowable margin of error = 5%. For smokers, using a prevalence of 55%:  $N = (1.96)^2 \cdot 55 \cdot 45 / 5^2 = 380$ . For tobacco chewers, using a prevalence of 60%:  $N = (1.96)^2 \cdot 60 \cdot 40 / 5^2 = 368$ . The calculated minimum sample sizes were 380 for smokers and 368 for tobacco chewers. However, accounting for potential non-responses or dropouts, the final sample size was increased to 400 participants in each group, resulting in a total sample size of 800 participants (400 smokers and 400 tobacco chewers).

### 4. STUDY TOOL

Data collection was conducted among patients aged over 35 years attending the outpatient department of Teerthanker Mahaveer Dental College and Research Centre (TMDC&RC), Moradabad. A comprehensive Type III clinical oral examination was carried out for each participant to assess oral health status. Prior to participation, written informed consent was obtained from all individuals. The study utilized structured questionnaires that had undergone expert validation, yielding a content validity index (CVI) of 0.95 and a Cronbach's alpha reliability coefficient of 0.85. Sociodemographic data were recorded, and oral health-related quality of life (OHRQoL) was assessed using the Oral Health Impact Profile-14 (OHIP-14) questionnaire. The questionnaire was translated into Hindi and pretested in a pilot study to ensure clarity, comprehension, and reliability. General oral health status was evaluated using the WHO Oral Health Assessment Form for Adults (2013), following the standardized protocol for clinical examination as per WHO guidelines. Strict infection control procedures were maintained throughout all examinations, including the use of sterilized instruments, disposable gloves, and face masks.

### 5. STATISTICAL ANALYSIS

Data were entered in Microsoft Excel 2007 and analyzed using SPSS version 20.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize the data. Normality was assessed before applying parametric tests. Group comparisons were performed using independent t-tests and chi-square tests. A  $p$ -value  $< 0.05$  was considered statistically significant.

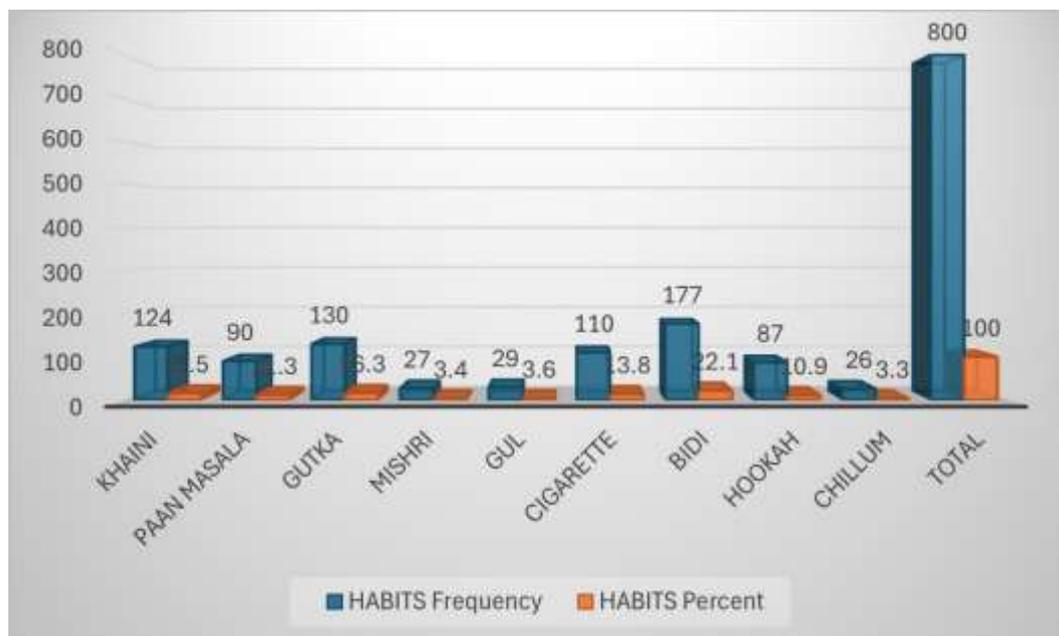
### RESULTS:

The current research was conducted with 800 subjects. As indicated in Table 1, 205 men (47.9%) were tobacco chewers and 223 (52.1%) were smokers. In contrast, among women, 195 (52.4%) were tobacco chewers and 177 (47.6%) were smokers, reflecting a statistically significant correlation between gender and smoking status ( $\chi^2 = 1.628$ ,  $p = 0.014$ ). Though not statistically significant ( $\chi^2 = 8.606$ ,  $p = 0.072$ ) in the association with socio-economic status, smoking was found to be higher in the upper class 55 (58.5%) and upper-middle class 69 (58.0%), whereas tobacco chewing was found more frequently in the lower-middle 100 (52.1%), upper-lower 90 (55.9%), and lower 121 (51.7%) classes. There was no statistically significant difference for residence ( $\chi^2 = 1.815$ ,  $p = 0.178$ ), although smokers were more prevalent in urban residents 195 (52.6%) and tobacco chewers were more prevalent in rural residents 224 (52.2%). The level of education was found to be significantly correlated with the smoking status ( $\chi^2 = 9.586$ ,  $p = 0.006$ ); 57 (63.3%) postgraduates were smokers and 33 (36.7%) tobacco chewers, while 129 (55.8%) students educated till the 10th standard were tobacco chewers. Tobacco use duration indicated a very strong correlation ( $\chi^2 = 64.718$ ,  $p = 0.000$ ); among recent ( $< 1$  year) users, there were 184 (68.9%) tobacco chewers and just 83 (31.08%) smokers, whereas among long-term users ( $> 10$  years), there were 97 (66.4%) smokers and 49 (33.6%) tobacco chewers. Tobacco frequency of use was also highly correlated ( $\chi^2 = 2.536$ ,  $p = 0.001$ ); of users who used tobacco 21–30 times daily, 61 (54.1%) were smokers and 50 (45.0%) were chewers, while less frequent users (1–10 times/day) were more nearly equally distributed between chewing tobacco (187; 51.5%) and smoking (176; 48.5%).

**Table 1: Distribution of Participants by Sociodemographic Variables and Tobacco Use Behavior (N = 800)**

Variable	Category	Smoking status		Chi-square value ( $\chi^2$ )	p-value
		Tobacco Chewing N (%)	Smokers N (%)		
Gender	Male	205(47.9%)	223(52.1%)	1.628	0.014
	Female	195(52.4%)	177(47.6%)		
Sociodemographic	Upper class	39(41.5%)	55(58.5%)	8.606	0.072
	Upper middle	50(42.0%)	69(58.0%)		
	Lower middle	100(52.1%)	92(47.9%)		
	Upper lower	90(55.9%)	71(44.1%)		
	Lower class	121(51.7%)	113(48.3%)		
Residence	City	176(47.4%)	195(52.6%)	1.815	0.178
	Village	224(52.2%)	205(47.8%)		
Education	10th pass	129(55.8%)	102(44.2%)	9.586	0.006
	12th pass	150(49.5%)	153(50.5%)		
	Graduation	88(50.0%)	88(50.0%)		
	Post-graduation	33(36.7%)	57(63.3%)		
Consumption of Tobacco Users	<1 year	184(68.9%)	83(31.08%)	64.718	0.000
	1-5 years	103(51.00%)	99(49.00%)		
	5-10 years	64(34.56%)	121(65.40%)		
	>10 years	49(33.56%)	97(66.43%)		
Frequency of Tobacco Users	not every day	54(46.15%)	63(53.84%)	2.536	0.001
	1-10	187(51.51%)	176(48.48%)		
	11-20	109(52.15%)	100(47.845)		
	21-30	50(45.04%)	61(54.05%)		

\*Data presented as N (%). Statistical analysis performed using the Chi-square test. p-value <0.05 considered statistically significant.



**Figure 1: Distribution of Tobacco-Related Habits Among Study Participants (N = 800)**

Figure 1 depicts the subjects' tobacco habits. Frequently reported habits were Khaini, n=124 (15.5%), gutka, n=130 (16.3%), Bidi, n=177(22.1%). With 90 (11.3%) reporting consumption of paan masala, 110 (13.8%) subjects reported smoking cigarettes. 27 (3.4%) subjects reported having used Mishri, 29 (3.6%) subjects reported using chillum, and 87 (10.9%) subjects reported using hookah.

As indicated in Table 2, there was a statistically significant relationship between smoking status and loss of attachment ( $\chi^2 = 7.345, p = 0.000$ ). Of those with minimal loss of attachment (0–3 mm), most were smokers (43; 84.3%) as opposed to only 8 (15.7%) tobacco chewers. But as the severity of loss of attachment increased, so did the percentage of tobacco chewers. Among the 4–5 mm, 82 (39.2%) were chewers and 127 (61.0%) were smokers. Surprisingly, among the larger categories of attachment loss (6–8 mm, 9–11 mm, and 12 mm), tobacco chewers were more than smokers. For instance, among 6–8 mm loss individuals, 129 (59%) were chewers and 91 (41%) were smokers; for 9–11 mm group, 137 (58%) were chewers and 101 (42%) were smokers; and for 12 mm group, 36 (55%) were chewers and 30 (45%) were smokers. The pattern indicates that tobacco chewing might be more directly linked with advanced periodontal damage, while smoking is more common at the initial stages. Data not documented (n = 16) revealed even distribution 8 (50%). Overall, this reflects a major change in severity of periodontal damage with various tobacco habits.

**Table 2: Association of Smoking Status with Clinical Oral Health Parameters: Gingival Condition, Loss of Attachment (LOA), and OHIP-14 scores.**

Variable	Category	Smoking status		Chi-square value ( $\chi^2$ )	p-value
		Tobacco Chewing N (%)	Smokers N (%)		
Loss of Attachment	0-3mm loss of attachment	8(15.68%)	43(84.3%)	7.345	.000
	4-5mm loss of attachment	82(39.2%)	127(61%)		
	6-8mm loss of attachment	129(59%)	91(41%)		
	9-11mm loss of attachment	137(58%)	101(42%)		
	12mm loss of attachment	36(55%)	30(45%)		
	not recorded	8(50%)	8(50%)		
Gingival condition	Positive	299 (74.75%)	247 (61.75%)	2.335	.000
	Negative	101 (25.25%)	153 (38.25%)		
OHIP-14	0-14	38(61.29%)	24(38.70%)	43.194	.001
	15-28	113(41%)	164(59%)		
	29-42	162(48%)	182(52%)		
	43-56	87(74.35%)	30(25.64%)		
	0-14	38(61.29%)	24(38.70%)		

\*Data presented as N (%). Statistical analysis performed using the Chi-square test. p-value <0.05 considered statistically significant.

Table 2 depicts that 299 tobacco chewers (74.75%) and 247 smokers (61.75%) had a positive gingival condition. Negative gingival condition was observed in 101 tobacco chewers (25.25%) and 153 smokers (38.25%). The Chi-square test showed a significant association between smoking status and gingival condition ( $\chi^2 = 2.335, p = 0.000$ ), indicating that tobacco chewing is more strongly associated with gingival disease compared to smoking.

Table 2 depicts an analysis of OHIP-14 scores for smoking status. It reveals significant differences in OHRQoL among tobacco chewers and smokers ( $\chi^2 = 43.194, p=0.001$ ). Lowest OHIP-14 scores of 0-14 indicate a minimal impact on OHRQoL. This is more common among tobacco chewers 38(61.29%) and smokers 24(38.70%). OHIP-14 score of 15-28 suggests moderate impairment and 164(59%) smokers outnumber 113(41%) tobacco chewers, showcasing a greater impact on oral health in this group. Scores between 29-42 had about 182(52%) smokers and 162(48%) tobacco chewers with significant oral health impairment. Scores between 43-56, which were the highest, indicate the most severe impact on OHRQoL, with 87(74.35%) tobacco chewers and 30(25.64%) smokers. Moderate impairment is common among smokers, and severe impairment is common among tobacco chewers. Table 2 represents the data visually, showcasing the distribution of OHIP-14 scores across smoking status.

**Table 3: Association of Tobacco Chewing and Smoking Status with the Condition and Location of Oral Mucosal Lesions.**

Variable	Category	Smoking status		Chi-square value ( $\chi^2$ )	p-value
		Tobacco Chewing N (%)	Smoking N (%)		
Oral Mucosal Lesion (Condition)	No abnormal condition	48(53.3%)	42 (46.7%)	371.714	0.000
	Oral Submucous Fibrosis	186 (95.4%)	9 (6.7%)		
	Leukoplakia	46 (25.1%)	137 (74.9%)		
	Oral Cancer	10 (21.7%)	36 (78.3%)		
	Tobacco Pouch Keratosis	45 (100.0%)	0 (0.0%)		
	Smoker's Palate	0 (0.0%)	91(100.0%)		
	Black Hairy Tongue	0 (0.0%)	7 (100.0%)		
	Erythroplakia	0 (0.0%)	24(100.0%)		
	Oral Lichen Planus	59 (52.2%)	54 (47.8%)		
Oral Mucosal Lesion (Location)	No lesion	48(53.9%)	42(46.1%)	221.717	0.000
	Vermillion Border	31(75.6%)	10(24.4%)		
	Lips	8(17.0%)	39(83.0%)		
	Sulci	24(85.7%)	4(14.3%)		
	Buccal Mucosa	209(65.1%)	112(34.9%)		
	Floor of the Mouth	58(74.4%)	20(25.6%)		
	Tongue	12(24.0%)	38(76.0%)		
	Hard Palate	0(0.0%)	98(100.0%)		
Alveolar Ridges / Gingiva	10(20.8%)	38(79.2%)			

\*Data presented as N (%). Statistical analysis performed using the Chi-square test. p-value <0.05 considered statistically significant.

Table 3 shows that among tobacco chewers, the most frequently observed conditions were Oral Submucous Fibrosis in 186 (95.4%) individuals, Tobacco Pouch Keratosis in 45 (100.0%), and oral lichen planus in 59 (52.2%). Less common conditions included Leukoplakia in 46 (25.1%) and Oral Cancer in 10 (21.7%), while 48 (53.3%) had no abnormal condition. Lesions in chewers were most commonly located on the Buccal Mucosa 209 (65.1%), Floor of the Mouth 58 (74.4%), Sulci 24 (85.7%), and Vermillion Border 31 (75.6%). Less frequent sites included the Lips 8 (17.0%), Tongue 12 (24.0%), and Alveolar Ridges/Gingiva 10 (20.8%), with no lesions reported on the Hard Palate.

In contrast, among smokers, the most prevalent conditions were Leukoplakia in 137 (74.9%) individuals, Oral Cancer in 36 (78.3%), and Smoker's Palate in 91 (100.0%). Erythroplakia 24 (100.0%) and Black Hairy Tongue 7 (100.0%) were also seen exclusively in smokers, while Oral Lichen Planus was present in 54 (47.8%). A total of 42 (46.7%) smokers had no abnormal condition. Lesion locations most commonly involved the Hard Palate 98 (100.0%), Tongue 38 (76.0%), Lips 39 (83.0%), and Alveolar Ridges/Gingiva 38 (79.2%). Other affected sites included the Buccal Mucosa 112 (34.9%), Floor of the Mouth 20 (25.6%), Sulci 4 (14.3%), and Vermillion Border 10 (24.4%). Both oral lesion condition and location showed statistically significant associations with tobacco use patterns, with chi-square values of  $\chi^2 = 371.714$  for condition and  $\chi^2 = 221.717$  for location, respectively, and p-values < 0.001 for both.

**Table 4 : Independent samples t-test for OHIP-14 scores between smokers and tobacco chewers.**

Test	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval (Lower, Upper)
OHIP-14 (Equal Variances Assumed)	15.704	0.000 <sup>*</sup>	3.460	798	0.001	0.200	0.058	(0.087, 0.313)
OHIP-14 (Equal Variances Not Assumed)	N/A	N/A	3.460	760.256	0.001	0.200	0.058	(0.087, 0.313)

\*Comparison of mean OHIP-14 (Oral Health Impact Profile – 14) scores between tobacco chewers and smokers. Data are presented as Mean  $\pm$  Standard Deviation (SD). Independent samples t-test was used to compare groups. Levene's test for equality of variances was applied.  $p < 0.05$  was considered statistically significant. N/A = Not Applicable for Levene's test under the "Equal variances not assumed" condition.

Table 4 depicts an independent sample t-test that was performed to compare the OHIP-14 scores between smokers and tobacco chewers. Levene's test for equality of variances was put into application that yielded a significant result of  $F=15.704$  and a  $p=0.000$ . Results of the t-test showed a statistically significant difference between the two groups ( $t = 3.460$ ,  $df = 760.256$ ,  $p = 0.001$ ). The mean difference in OHIP-14 scores between smokers and tobacco chewers was found to be 0.200 (95% CI: 0.087, 0.313). Since the confidence interval does not include zero, the difference is considered statistically significant.

These findings by the OHIP-14 scale suggest that smoking and tobacco chewing have differing impacts on oral health-related quality of life.

## DISCUSSION:

This cross-sectional study evaluated 800 participants to assess the prevalence and distribution of oral precancerous lesions and conditions among tobacco users and to explore their environmental, behavioral, and quality of life correlates in Northern India. A male predominance was observed, and notably, females demonstrated higher use of smokeless tobacco, a trend that aligns with prior studies by Ahsan et al. [8] and Sarkar et al. [9].

Standardized socioeconomic classifications confirmed participant categorization. The majority belonged to the lower class, followed by the lower middle class, and the upper lower class. The study found a significant association between socioeconomic status and tobacco use, aligning with findings from the Barabanki study [10], and Kumar S. et al. [11]. Participants from lower socioeconomic status tend to face major obstacles to health education, awareness, and access to cessation services, which could be a factor in the increased prevalence of tobacco use among this group.

The geographical distribution of the participants indicated a higher rural representation than in urban locations. Pandey H. et al. [12] and Chockalingam et al. [13] also made similar observations.

This rural dominance could be attributed to greater tobacco intake and a higher prevalence of oral lesions, presumably as a consequence of restricted access to health care and preventive education. Education was also an important determinant of tobacco usage patterns; persons with higher levels of schooling reported lower tobacco intake than less-educated individuals. These results agree with those of Pandey H. et al. [12] and Ruokolainen et al. [14], both of whom found an inverse correlation between education level and smoking.

An overview of the study findings indicates that bidis were the most commonly used tobacco product, followed by gutka, khaini, cigarettes, paan masala, hookah, mishri, gul, and chillum in descending order of prevalence. These results align with studies by Goel A et al. [15], Gupta T et al. [16], and Choudhary A et al. [17], which highlight higher tobacco use in lower-income groups, with smokeless tobacco being more prevalent than smoked forms. Participants revealed to have a gingival condition that was associated with smoking, and it was more common with chewable tobacco consumption than in smokers. The findings also showed a higher number of gingival conditions among chewable than smoke users. Ahsan et al. [8] also reported higher bleeding on probing, periodontal pockets, and Loss of attachment among smokeless tobacco consumers. This was also confirmed by

Goyal J. et al. [18], who found bleeding on probing that increased in tobacco consumers. Shimazaki et al. [19], reported a higher loss of attachment in smokeless tobacco consumers. The investigation reveals that there is a significant impact of smoking and tobacco chewing on OHRQoL, examined with OHIP-14 scores. Those with lower scores (0-14) had minimal impairment and were linked more highly to tobacco chewers than smokers.

Scores 15-28 indicated moderate impairment and were linked more strongly to smokers than tobacco chewers. This matches the findings of a study by Gupta T et al. [16], which revealed higher OHIP-14 scores among smokers than smokeless tobacco consumers. Pandey H et al. [12] also highlighted the extensive effects of tobacco use on OHRQoL with findings that linked gum disease and tooth loss to smoking. OHIP-14 scores had a significant correlation to tobacco use, both in smoke and smokeless form. Bakri N et al. [20], reported similar findings. Srivastava R et al. [21], highlighted that OHRQoL measures the broader influence of oral health on psychological, social, and functional aspects of life. The reason for smoking to a higher influence could be because of a synergistic effect on periodontal tissues, halitosis and oral irritation.

Lesion distribution is highly dependent on the individual consuming either smoked or smokeless tobacco, thereby linking each to a specific site in the oral cavity. This study's findings align with Gupta T et al. [16], who reported that the most frequent site for lesions was buccal mucosa for the smokeless form of tobacco consumers. This was because of direct contact of the tobacco with the mucosa in the region for prolonged periods. The carcinogenic compounds present in tobacco show their ill-health effects upon prolonged contact with the delicate oral mucosal tissues. A study by Patil PB et al. [22], reveals that lesions were frequent on the vestibular and submandibular regions with smokeless tobacco use, while smoke forms of tobacco consumption had frequent lesions on the palate and lips. Although tobacco consumption site is an important factor, the duration of use and mucosal sensitivity play an important factor.

The study thereby highlights several recurrent patterns of oral health conditions and tobacco usage. Oral submucous fibrosis (OSMF) is highly common among chewers and leukoplakia is more common among smokers. Tobacco pouch keratosis is exclusive to smokeless tobacco consumers, and similarly, smoker's palate and black hairy tongue are common among the smoke forms of tobacco consumers. However, it is to be noted that female smokers had a higher prevalence of oral cancer.

Gupta et al. [16] confirm these findings and conclude that OSMF is due to areca nut exposure, a key risk factor. Their study also confirms that smokers are prone to leukoplakia and erythroplakia, possibly due to heat and the work of carcinogens. There exists a high correlation that signifies the importance of frequent habit-specific screening and smoking cessation programs for the prevention of oral problems.

There was a significant difference in OHIP-14 scores between smokers and tobacco chewers, with smokers experiencing a greater negative impact on oral health-related quality of life. These findings are consistent with those of Singh S. et al. [23], who also reported that adolescents with tobacco habits had poorer OHRQoL scores, highlighting the detrimental effects of tobacco use on oral health.

Despite its strengths, including a large sample size and use of validated tools, the study has limitations. The cross-sectional design restricts causal inference. Reliance on self-reported tobacco use may introduce recall and reporting bias. The study was geographically limited to a single region, which affects generalizability beyond similar populations. Additionally, unmeasured confounders, such as genetic susceptibility and other oral habits, may have influenced outcomes.

The study's external validity is moderate, and findings are most applicable to rural, lower-income populations in Northern India. Although the results provide valuable insights for public health and dental practice, caution is warranted when extrapolating to urban, affluent, or culturally distinct groups. Future research should adopt longitudinal designs and incorporate biomarkers to strengthen causal inferences.

## CONCLUSION

This study establishes a significant association between tobacco use, both in smoked and smokeless forms, and adverse oral health outcomes. Tobacco users demonstrated poorer gingival health, higher prevalence of mucosal lesions, increased periodontal pathology, greater clinical attachment loss, and significantly reduced oral health-related quality of life (OHRQoL). While smokers tended to exhibit moderate oral health impairment and lesions such as leukoplakia, tobacco chewers were more likely to develop severe mucosal conditions, particularly oral submucous fibrosis.

The high prevalence of precancerous oral lesions among tobacco users underscores the urgent need for targeted public health strategies, including early screening, community-based education, and tobacco cessation programs. Region-specific interventions are essential to mitigate the burden of oral precancer, particularly among socioeconomically disadvantaged and rural populations. These findings reinforce the importance of integrating behavioral and environmental risk assessments into oral health surveillance and prevention efforts in Northern India.

#### AUTHORS' CONTRIBUTION

The Authors equally contributed to the writing of the manuscript.

#### LIST OF ABBREVIATIONS

OHRQoL- Oral health-related quality of life

OHIP-14- Oral Health Impact Profile -14

OSMF- Oral submucous fibrosis

LOA- Loss of attachment

WHO- World Health Organization

#### FUNDING

None

#### CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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