ISSN 0973-2063 (online) 0973-8894 (print)

Bioinformation 22(10): 7210-7215 (2026)

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BIOINFORMATION
Discovery at the interface of physical and biological sciences

BIOMEDICAL INFORMATICS

www.bioinformation.net

Volume 22(10)

Research Article

Received October 1, 2026; Revised October 31, 2026; Accepted October 31, 2026, Published October 31, 2026

DOI: 10.6026/973206300227210

SJIF 2026 (Scientific Journal Impact Factor for 2026) = 8.478
2022 Impact Factor (2023 Clarivate Inc. release) is 1.9

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Citation: Meesala *et al*. Bioinformation 22(10): 7210-7215 (2026)

Mapping the oral lesion burden: Demographic, behavioral and histopathological patterns in a retrospective cohort

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ISSN 0973-2063 (online) 0973-8894 (print)
Bioinformation 22(10): 7210-7215 (2026)
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Abstract:
Oral mucosal lesions include reactive, benign, potentially malignant and malignant conditions influenced by demographic and tobacco-related factors. Therefore, it is of interest to evaluate the demographic profile, habits and clinicopathological spectrum of 1,736 patients from a hospital-based archival record. Benign lesions were most common (814; 46.9%), followed by malignant lesions (638; 36.8%) and OPMDs (284; 16.4%). Malignant and OPMD cases were significantly older than benign cases, with significant associations with sex and tobacco-related habits ($P < 0.001$). Thus, older age, male sex and tobacco habits were associated with malignant and potentially malignant lesions, highlighting the need for comprehensive oral examination.

Keywords: Oral lesions, oral pathology, oral potentially malignant disorders (OPMDs), oral cancer, squamous cell carcinoma, tobacco habits, retrospective study, histopathology

Background:
Oral lesions comprise a heterogeneous spectrum of pathological conditions, ranging from reactive and benign proliferations to oral potentially malignant disorders (OPMDs) and invasive malignancies **[1]**. The development and distribution of these lesions are influenced by host susceptibility, environmental exposures, behavioral factors, microbial influences and cumulative tissue injury **[2]**. Oral squamous cell carcinoma (OSCC) represents the predominant malignant epithelial neoplasm of the oral cavity and continues to constitute a major global health burden **[3]**. Lip and oral cavity cancers contribute substantially to the worldwide cancer burden, with considerable geographic, demographic and socioeconomic variation in incidence and mortality **[4]**. South and Southeast Asian populations experience a particularly high burden, largely reflecting widespread exposure to tobacco, smokeless tobacco, areca nut and betel quid-related practices **[5].** In India, oral cancer remains an important public health concern, with tobacco and related carcinogenic exposures contributing significantly to disease occurrence **[6]**. Oral carcinogenesis is a multistep process involving genetic and epigenetic alterations, genomic instability, dysregulated cell-cycle control and changes within the local tissue microenvironment **[7]**. These alterations may accumulate over prolonged periods and produce recognizable clinical and histopathological changes before the development of invasive carcinoma **[8]**. The terminology surrounding potentially malignant oral lesions has evolved substantially over time. The term OPMD was adopted to replace earlier concepts such as "precancerous lesions" and "precancerous conditions," recognizing that these disorders do not invariably progress to malignancy **[9].** OPMDs constitute a heterogeneous group with variable malignant transformation potential and their clinical behavior may differ considerably among individual disorders **[10]**. Histopathological epithelial dysplasia provides important evidence of abnormal epithelial biology and may assist in assessing malignant potential, although its predictive value is not absolute. Therefore, appropriate evaluation should integrate clinical presentation, lesion characteristics, behavioral risk factors and histopathological findings **[11]**. Therefore, it is of interest to evaluate the clinicopathological spectrum of oral lesions and evaluate associations between diagnostic category, age, sex and tobacco-related habits.

Materials and Methods:
This study was designed as a retrospective cross-sectional observational study based on archival clinical and histopathological records of patients diagnosed with oral lesions. It involved the retrospective review and analysis of routinely collected clinical and histopathological information to characterize the demographic and clinicopathological distribution of oral lesions and to evaluate their association with age, sex and tobacco-related habits. The study was conducted at a single hospital-based clinical centre using records maintained by the relevant clinical and histopathology departments. A total of 1,736 patient records containing a documented diagnosis of an oral lesion were included in the analysis. The records were reviewed for relevant demographic and clinicopathological variables, including age, sex, tobacco-related habit status,

histopathological diagnosis and diagnostic category. The available information was extracted from the archival records and entered into the study database for statistical analysis. For the purpose of analysis, individual oral lesions were grouped into three broad diagnostic categories: benign lesions, oral potentially malignant disorders (OPMDs) and malignant lesions. The terminology and classification of OPMDs were aligned with established consensus nomenclature. Individual lesion names documented in the database were standardized for obvious spelling and terminology variations before frequency tabulation, while preserving the original underlying diagnostic category. This standardization was undertaken to ensure consistency in the analysis and presentation of lesion frequencies without altering the recorded diagnoses. Tobacco-related habit status was classified according to the information available in the archival clinical records. Patients were categorized as having no recorded habit, smoking or chewing. The category of "no recorded habit" was used when no tobacco-related habit was documented in the available records and therefore does not necessarily indicate confirmed lifelong absence of tobacco exposure. Quantitative information regarding the duration, frequency intensity, age at initiation or cumulative exposure to tobacco was not consistently available in the source dataset and was consequently not included in the present analysis. Statistical analysis was performed to evaluate the demographic and clinicopathological characteristics of the study population and to determine associations between diagnostic categories and selected variables. Continuous variables were summarized using mean and standard deviation, while median and interquartile rangewere used to describe the distribution of age. Categorical variables were expressed as frequencies and percentages. The Kruskal-Wallis test was used to compare age distributions across the three diagnostic categories. Pearson's chi-square test was used to assess associations between diagnostic category and sex, tobacco-related habit status and age-group distribution. All statistical tests were two-sided and a P value < 0.05 was considered statistically significant. The study involved retrospective analysis of previously recorded clinical and histopathological patient data. Ethical approval was obtained from the institutional ethical committee. As the study involved retrospective review of existing records and no direct intervention was performed, the requirement for individual informed consent was waived in accordance with institutional policies governing retrospective record-based research.

Results:

A total of 1,736 cases were included in the present analysis. The overall mean age of the study population was 46.3 ± 16.4 years, with a median age of 46 years (interquartile range (IQR): 35-58 years) and an age range of 10-90 years. Males constituted the majority of the study population (1,014; 58.4%), whereas females accounted for 722 (41.6%) cases. Regarding tobacco-related habits, the majority of patients had no recorded habit (1,218; 70.2%). Smoking was documented in 248 (14.3%) cases, while chewing was reported in 270 (15.6%) cases. Thus, approximately 30% of the study records contained documentation of either smoking or chewing habits. The demographic and behavioral characteristics of the study population are summarized in **Table 1**. Of the 1,736 cases, 814 (46.9%) were classified as benign lesions, 284 (16.4%) as OPMDs and 638 (36.8%) as malignant lesions. Benign lesions therefore constituted the largest diagnostic category, followed by malignant lesions and OPMDs. A progressive increase in age was observed across the diagnostic categories. Patients with benign lesions had a mean age of 38.8 ± 15.7 years, whereas those with OPMDs had a mean age of 51.5 ± 13.6 years and those with malignant lesions had a mean age of 53.4 ± 14.2 years. The corresponding median ages were 38 years (IQR: 27-49), 52 years (IQR: 43-61) and 54 years (IQR: 44-63), respectively. The difference in age distribution among the three diagnostic categories was statistically significant according to the Kruskal-Wallis test ($P < 0.001$). These findings indicate that OPMDs and malignant lesions were represented predominantly among older patients compared with benign lesions. The distribution of lesions according to diagnostic category and age is presented in **Table 2**. A statistically significant association was observed between sex and diagnostic category (Pearson $\chi^2 = 204.4$, $P < 0.001$). Among patients with benign lesions, females constituted the larger proportion (482; 59.2%), while males accounted for 332 (40.8%) cases. In contrast, males predominated among both OPMDs and malignant lesions. Males accounted for 186 (65.5%) of the OPMD cases compared with 98 (34.5%) females. Among malignant lesions, 496 (77.7%) cases occurred in males and 142 (22.3%) in females. Thus, male representation increased progressively from benign lesions to OPMDs and malignant lesions. The association between sex and diagnostic category is presented in **Table 3**. A strong and statistically significant association was observed between tobacco-related habit status and diagnostic category (Pearson $\chi^2 = 540.8$, $P < 0.001$). Among patients with benign lesions, 726 (89.2%) had no recorded habit, while smoking and chewing were documented in 48 (5.9%) and 40 (4.9%) cases, respectively. Among patients with OPMDs, 208 (73.2%) had no recorded habit, whereas smoking and chewing were documented in 30 (10.6%) and 46 (16.2%) cases, respectively. The malignant group demonstrated a markedly different distribution. Only 284 (44.5%) malignant cases had no recorded habit, while smoking was documented in 148 (23.2%) and chewing in 206 (32.3%) cases. Therefore, the proportion of documented smoking and chewing habits increased progressively across the benign, OPMD and malignant categories, with chewing being the most frequently documented tobacco-related habit among malignant cases. The association between tobacco-related habit status and diagnostic category is shown in **Table 4**. The distribution of diagnostic categories varied significantly across age groups (Pearson $\chi^2 = 346.1$, $P < 0.001$). Benign lesions were predominantly observed among younger adults. The highest proportion of benign lesions occurred in the 30-39-year age group (190; 23.3%), followed by the 20-29-year group (180; 22.1%) and the 40-49-year group (142; 17.4%). OPMDs demonstrated a shift toward older age groups. The largest proportion of OPMDs occurred among patients aged 40-49 years (82; 28.9%), followed by those aged 50-59 years (62; 21.8%) and 60-69 years (54; 19.0%). No OPMDs were recorded

among patients aged ≤19 years. Malignant lesions were predominantly observed among patients aged 40 years and above. The highest proportion occurred in the 50-59-year group (158; 24.8%), followed by the 40-49 year group (154; 24.1%) and the 60-69-year group (120; 18.8%). A further 76 (11.9%) malignant cases occurred among patients aged 70-79 years, while 26 (4.1%) occurred among those aged ≥80 years. Overall, the distribution demonstrated a progressive shift toward older age groups from benign lesions to OPMDs and malignant lesions. The age-group distribution according to diagnostic category is presented in **Table 5**. The frequency distribution of the ten most commonly recorded individual oral lesions demonstrated considerable histopathological diversity. Pyogenic granuloma was the most frequently recorded lesion, accounting for 306 (17.6%) cases, followed by well-differentiated squamous cell carcinoma (SCC) with 292 (16.8%) cases and fibroma with 196 (11.3%) cases. Peripheral ossifying fibroma was recorded in 150 (8.6%) cases, while moderately differentiated SCC accounted for 144 (8.3%) cases. Moderate-to-well-differentiated SCC was identified in 108 (6.2%) cases. Among potentially malignant epithelial alterations, moderate epithelial dysplasia was documented in 74 (4.3%) cases and mild epithelial dysplasia in 58 (3.3%) cases. Verrucous carcinoma accounted for 72 (4.1%) cases, while oral lichen planus was recorded in 52 (3.0%) cases. The frequency distribution therefore included reactive and benign lesions as well as epithelial dysplasia and multiple histopathological subtypes of SCC, reflecting the broad spectrum of oral pathology represented within the study population. The ten most frequently recorded lesions are summarized in **Table 6**. Overall, the results demonstrated a distinct demographic and behavioral pattern across the three major diagnostic categories. Benign lesions constituted the largest proportion of the study population and were associated with a younger age distribution and female predominance. In contrast, OPMDs and malignant lesions were observed predominantly among older individuals and demonstrated increasing male representation. A similar gradient was observed for tobacco-related habits, with smoking and chewing documented more frequently among OPMD and malignant cases than among benign lesions. The significant associations observed for sex, tobacco-related habits and age-group distribution indicate that these variables were not evenly distributed across diagnostic categories in this study population. The individual lesion analysis further demonstrated that the pathological spectrum ranged from common reactive and benign lesions, such as pyogenic granuloma and fibroma, to epithelial dysplasia and several histopathological subtypes of SCC.

Table 1: Demographic and behavioral characteristics of the study population

Characteristic	Overall, n (%) / Mean ± SD
Total participants	1,736 (100)
Age, years	46.3 ± 16.4
Median age, years (IQR)	46 (35-58)
Age range, years	10-90
Sex	
Male	1,014 (58.4)
Female	722 (41.6)
Habit status	
No recorded habit	1,218 (70.2)
Smoking	248 (14.3)
Chewing	270 (15.6)

Table 2: Distribution of oral lesions according to diagnostic category and age

Diagnostic category	n (%)	Mean age ± SD, years	Median age (IQR), years	Range
Benign lesions	814 (46.9)	38.8 ± 15.7	38 (27-49)	10-90
OPMDs	284 (16.4)	51.5 ± 13.6	52 (43-61)	18-82
Malignant lesions	638 (36.8)	53.4 ± 14.2	54 (44-63)	18-90
Total	1,736 (100)	46.3 ± 16.4	46 (35-58)	10-90

Kruskal-Wallis test; P < 0.001

Table 3: Association between sex and diagnostic category

Diagnostic category	Female, n (%)	Male, n (%)	Total, n
Benign lesions	482 (59.2)	332 (40.8)	814
OPMDs	98 (34.5)	186 (65.5)	284
Malignant lesions	142 (22.3)	496 (77.7)	638
Total	722 (41.6)	1,014 (58.4)	1,736

Pearson $\chi^2 = 204.4$; $P < 0.001$.

Table 4: Association between tobacco-related habits and diagnostic category

Diagnostic category	No recorded habit, n (%)	Smoking, n (%)	Chewing, n (%)	Total, n
Benign lesions	726 (89.2)	48 (5.9)	40 (4.9)	814
OPMDs	208 (73.2)	30 (10.6)	46 (16.2)	284
Malignant lesions	284 (44.5)	148 (23.2)	206 (32.3)	638
Total	1,218 (70.2)	248 (14.3)	270 (15.6)	1,736

Pearson $\chi^2 = 540.8$; $P < 0.001$.

Table 5: Age-group distribution according to diagnostic category

Category	≤19	20-29	30-39	40-49	50-59	60-69	70-79	≥80 / Total

Benign	70 (8.6)	180 (22.1)	190 (23.3)	142 (17.4)	124 (15.2)	78 (9.6)	30 (3.7)	0 (0.0) / 814
OPMD	0 (0.0)	14 (4.9)	38 (13.4)	82 (28.9)	62 (21.8)	54 (19.0)	22 (7.7)	12 (4.2) / 284
Malignant	2 (0.3)	18 (2.8)	84 (13.2)	154 (24.1)	158 (24.8)	120 (18.8)	76 (11.9)	26 (4.1) / 638

Values are n (%). The final column shows the ≥80-year group followed by the row total. Pearson $\chi^2 = 346.1$; $P < 0.001$.

Table 6: Ten most frequently recorded oral lesions

Rank	Lesion	n (%)
1	Pyogenic granuloma	306 (17.6)
2	Well-differentiated SCC	292 (16.8)
3	Fibroma	196 (11.3)
4	Peripheral ossifying fibroma	150 (8.6)
5	Moderately differentiated SCC	144 (8.3)
6	Moderate-to-well-differentiated SCC	108 (6.2)
7	Moderate epithelial dysplasia	74 (4.3)
8	Verrucous carcinoma	72 (4.1)
9	Mild epithelial dysplasia	58 (3.3)
10	Oral lichen planus	52 (3.0)

Discussion:

The present retrospective study of 1,736 oral lesion records showed significant associations between diagnostic category and age, sex and tobacco-related habits. Benign lesions constituted the largest group (46.9%) and occurred predominantly in younger patients, whereas OPMDs (16.4%) and malignant lesions (36.8%) were concentrated among older individuals. Male representation also increased progressively from benign lesions to OPMDs and malignancies, while documented tobacco exposure was substantially more frequent among malignant cases. Age demonstrated a clear diagnostic gradient, with mean ages of 38.8 years for benign lesions, 51.5 years for OPMDs and 53.4 years for malignant lesions ($P < 0.001$). This pattern is consistent with Jain *et al.* (2023) **[12],** who reported that males constituted 61.78% of 369 patients with oral mucosal lesions and that oral carcinomas represented 20.33% of cases. Similarly, Abbas *et al.* (2024) **[13]** observed a slight male predominance among 400 tobacco users with oral mucosal lesions and identified malignancy, leukoplakia and oral submucous fibrosis among the principal tobacco-associated lesions. The present study extends these observations by demonstrating an age-related shift across the complete spectrum from benign lesions through OPMDs to malignancy. Tobacco-related habits showed the strongest association with diagnostic category ($\chi^2 = 540.8$, $P < 0.001$). Documented smoking or chewing was present in 10.8% of benign cases, 26.8% of OPMDs and 55.5% of malignant cases, with chewing more frequent than smoking among malignant lesions. These findings are consistent with Kumbhalwar *et al.* (2022) **[14],** whose systematic review and meta-analysis of more than 823,000 individuals identified substantial burdens of leukoplakia and oral submucous fibrosis in India and emphasized the contribution of tobacco, particularly smokeless tobacco. Importantly, 44.5% of malignant cases in the present study had no recorded tobacco-related habit. This finding should be interpreted cautiously because retrospective records may underestimate previous or unreported exposure. Nevertheless, it is supported by Pandya *et al.* (2026) **[15],** who reported that 17% of OSCC patients in a 10-year Indian institutional study were non-tobacco users and that these patients demonstrated distinct clinicopathological characteristics. Thus, absence of a documented tobacco habit should not exclude malignancy from the differential diagnosis. OPMDs occupied an intermediate position between benign and malignant lesions, with a mean age of 51.5 years and predominance in the 40–69-year age range. The presence of mild and moderate epithelial dysplasia further emphasizes the importance of histopathological evaluation. Hankinson *et al.* (2021) **[16]** demonstrated substantially different malignant transformation risks according to dysplasia grade, supporting the clinical importance of identifying and grading epithelial dysplasia. Guan *et al.* (2023) **[17]** similarly reported a pooled malignant transformation rate of 7.2% for oral leukoplakia and identified dysplasia grade and lesion characteristics as important risk factors. The broad histopathological spectrum observed in this study, ranging from pyogenic granuloma and fibroma to epithelial dysplasia and multiple SCC subtypes highlights the diagnostic diversity encountered in hospital-based oral pathology services. Overall, the findings support an integrated approach incorporating age, sex, behavioral history, clinical assessment and histopathological examination rather than relying on a single risk factor. The substantial proportion of malignant lesions without a documented tobacco habit further emphasizes the need for comprehensive examination and appropriate biopsy of clinically suspicious lesions regardless of apparent risk-factor status.

Conclusion:

We show the significant associations of oral lesion categories with age, sex and tobacco-related habits. Benign lesions predominated among younger individuals, whereas OPMDs and malignant lesions were more frequent among older males with documented tobacco exposure. Comprehensive oral examination and histopathological evaluation remain essential, as the absence of a recorded tobacco habit does not exclude malignancy.

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