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Prevalence and determinants of oral potentially malignant disorders in western rajasthan

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Oral cancer with incidence (10.2%) and mortality (9.3%) ranks as second most prevalent cancers in India. Oral cancer diagnosis at early stages through the detection of oral potentially malignant disorders (OPMDs) can lead to the prevention and reduction of mortality associated with oral cancer. The objective of the study was to estimate the prevalence and the determinants of OPMDs in Jodhpur, Rajasthan. A cross-sectional study was conducted in six blocks of Jodhpur, Rajasthan. The trained Community Health Officers (CHOs) of Ayushman Arogya Mandir (erstwhile Health and Wellness centers) performed an Oral Visual Examination (OVE) to screen the participants for OPMDs. The inclusion criteria comprised men and women aged 30 years or above or aged between 18 and 29 years with tobacco and/or alcohol consumption habits, visiting Ayushman Arogya Mandir. The association of the OPMD with socio-behavioral risk factors was determined through a bivariate chi-square test and multivariate-binary logistic regression analysis. The overall prevalence of OPMD was found to be 14.84%. The prevalence of leukoplakia (8.61%) was the highest, followed by oral submucous fibrosis (4.78%) and erythroplakia (2.87%). OPMD was significantly higher in lower socioeconomic status (SES). Smokeless tobacco consumption [AOR-8.751(1.500-51.046)], smoking [AOR-20.827 (2.204-196.832], and alcohol consumption [AOR-50.806 (3.617-713.687)] were significantly associated with OPMD. The synergistic effect of smokeless tobacco consumption, smoking, and alcohol consumption on OPMD was observed [AOR-26.222 (2.83-243.48)]. The mean duration and frequency per day of smokeless tobacco consumption and smoking were significantly higher in OPMD. We also found that oral cavity symptoms were strongly associated with OPMD, particularly persistent mouth ulcers and repeated biting injuries due to sharp teeth and dentures. To conclude, the study identified a high prevalence of OPMDs (14.84%) in Jodhpur, with leukoplakia being the most common OPMD. There was a significantly higher prevalence of OPMD in individuals from lower SES. The key modifiable risk factors, including smokeless tobacco use, smoking, and alcohol consumption, were strongly associated with OPMDs, with a notable synergistic effect observed when these behaviors coexisted. Additionally, oral cavity symptoms such as persistent mouth ulcers and repeated biting injuries due to sharp teeth and dentures were found to be determinants of OPMD. The study findings emphasize the need for targeted interventions addressing socio-behavioral risk factors to reduce the burden of OPMDs and prevent the progression to oral cancer.

Keywords Oral Cancer, OPMD, CHO, Jodhpur, Rajasthan, India

Oral Cancer is the 16 th most prevalent cancer worldwide[1]. According to the latest WHO-IARC Global Cancer Observatory data from India, oral cancer ranks first (15.6%) in males and ranks second (10.2%) in both sexes among different types of cancer[1].Oral cancer incidence (10.2%) and mortality (9.3%) are among the top three cancers in India[1]. The prevalence of head & neck and oral cancer was reported to be 32.18% in Rajasthan, India, indicating a notably high burden of the disease[2].

Oral Potentially Malignant Disorders (OPMDs) were previously referred to as "pre-cancerous conditions/ lesions" and, in the year 2005, redefined by WHO as any abnormality in the oral cavity associated with a higher risk of development into oral cancer[3,4]. Leukoplakia, oral submucous fibrosis (OSMF), erythroplakia, and oral lichen planus are the most common OPMDs[5]. Leukoplakia is the uniform flat white velvety patch or plaque; erythroplakia is the red velvety patch or plaque; oral lichen planus is the bilateral white reticular patches; and oral submucous fibrosis is the fibrosis of oral mucosa[6]. The global prevalence of OPMDs was reported to be 1–5%[3,7].

In India, OPMD's overall prevalence was reported to be 13.28%[8]. One of the systematic review and meta-analysis study showed that the average cumulative malignancy transformation rate of the most common OPMDs ranges from 5.2 to 33.1%, and the malignancy rate of specific OPMD were- leukoplakia-9.5%, erythroplakia-33.1%, oral lichen planus-1.4%, oral submucous fibrosis- 5.2% [5].

The significant risk factors of OPMDs in Western countries include cigarette smoking and alcohol drinking. In contrast, the prominent risk factors in Asian countries include smokeless tobacco consumption, smoking, and betel quid chewing[9,10]. Some other OPMD associated factors include alterations of the microbiome, chronic mucosal inflammation, and oral mucosal trauma[11]. A community-based study from North Eastern Thailand reported that individuals with betel quid chewing habit possessed a 5.12-fold enhancement in the probability of developing OPMDs[12]. In an Indonesian-based study, it was revealed that compared to non-drinkers, alcohol drinkers had a 12.2-fold enhanced risk of OPMD[10]. According to data from the National Family Health Survey-5 (NFHS-5), 38% of men and 9% of women aged 15 years and above consume tobacco in India[13]. As per NFHS-5, 18.8% of men and 1.3% of women aged 15 years and above consume alcohol in India[13]. In the Jodhpur district of Rajasthan, tobacco consumption was reported among 43.6% of men and 6.9% of women, with higher consumption observed in rural areas compared to urban areas[13]. The different forms of tobacco commonly consumed in Rajasthan include gutka, khaini, zarda, pan masala, mishri, bidi, gudakhu, cigarettes, chillum, and hookah[14,15]. Additionally, bidi smoking and smokeless tobacco consumption like gutka and pan masala are culturally accepted in rural areas of India contributing to delayed healthcare-seeking behavior and underutilization of oral health services[14,15].

Screening and prevention of Non-Communicable Diseases (NCDs) including oral cancer and basic oral health care are among the twelve Comprehensive Primary Health Care (CPHC) services to be delivered by the Ayushman Arogya Mandir[16]. Community Health Officers (CHOs) at Ayushman Arogya Mandir are responsible for screening of NCDs including oral cancer[17]. For oral cancer screening, OPMDs are detected through the oral visual examination (OVE), which involves the oral cavity examination for the presence of most common OPMDs like leukoplakia, oral submucous fibrosis, and erythroplakia[18]. Previous studies have shown that OVE can be done by trained community health workers[19,20]. An oral cancer screening trial in Kerala involving the detection of OPMDs by trained community health workers reported a 34% decline in oral cancer mortality[20].

In the present study, oral cancer screening through OPMD detection by OVE was done by CHOs at their respective Ayushman Arogya Mandir. The OPMD status was further validated by ENT specialist. The purpose of the study is to identify the prevalence and determinants of OPMDs in Jodhpur, Rajasthan. Although there are many studies aimed at determining the prevalence of OPMD, there has been no previous report on the prevalence and determinants of OPMD in Jodhpur, Rajasthan. Tobacco consumption and alcohol usage are the risk factors for OPMD, but the context-specific association was not known for Western Rajasthan in India. This study evaluated the association of OPMD with sociodemographic and socio-behavioral risk factors, using data collected by trained Community Health Officers from the Jodhpur district of Rajasthan. The identified prevalence and determinants of OPMD will inform the National Programme for Prevention and Control of Non-Communicable Diseases (NP-NCD) and public health policymakers to address the socio-behavioral risk factors and enhance oral cancer screening through trained Community Health Officers.

Methods
Study design and study setting
A descriptive cross-sectional study was conducted in the Jodhpur district of Rajasthan, India. The fifty Community Health officers (CHOs) of the distinct Ayushman Arogya Mandir (erstwhile Health and Wellness Centers) were randomly nominated for this study by Jodhpur's Chief Medical Health Officer. A convenience sampling method was used for the selection of CHOs. The trained CHOs performed the oral cancer screening at their respective Ayushman Arogya Mandir for eight months (May 2023- December 2023).

Study participants
The study participants were the patients visiting the Ayushman Arogya Mandir. The inclusion criteria were that the participants should be either above 30 years or aged between 18 and 30 years with tobacco and/or alcohol consumption habits. The consent of participants was obtained from CHO before their enrollment in the study. CHOs briefed the participants about the study's objective and the risks and benefits associated with the participation.

Sample size
To calculate the sample size (n) for our study, we used the formula $n = Z^2pq/d^2$ where Z: Standard variate at 95% confidence level, p: disease prevalence, q: proportion of participants without disease, d = error rate[7]. Taking the 15% prevalence of OPMD, 5% error rate, and 95% confidence level, the required sample size was 196. The total number of screened participants by CHOs at the respective Ayushman Arogya Mandir was 209 over eight months (May 2023-December 2023). The consecutive sampling method was used to select the study participants who met the inclusion criteria during their visits to the Ayushman Arogya Mandir.

Data collection
The data on the socio-demographics, oral cavity symptoms, medical history, and lifestyle history focusing on oral cancer risk factors of the study participants were collected through structured questionnaire by CHOs. Sociodemographic variables (Age, Gender, Marital Status, Educational Qualification, Occupation and SES), Socio-behavioral risk factor variables (Smokeless tobacco, tobacco and alcohol consumption), and the oral cavity symptoms variable were analyzed for understanding the association with OPMD variable. CHOs did

oral visual examination, and the OPMD and its type, if any, was documented. ENT specialist then validated the OPMD condition.

Statistical analysis

The data were analyzed in SPSS Version 28.0. SES was calculated as per the modified Kuppuswamy Scale for the year 2024 [21]. Bivariate analysis was done through the Chi-square test, and the Odds ratio (O.R.) with a 95% Confidence interval (CI) was determined. Multivariate analysis was done through binary logistic regression, and an Adjusted Odds ratio (AOR) with a 95% Confidence interval (CI) was calculated as described previously[22]. P-values < 0.001 and P-values < 0.05 were considered to be statistically significant.

Ethical considerations

The Institution Ethics Committee of ICMR-National Institute for Implementation Research on Non-Communicable Diseases approved the study (Ref. No- NIIRNCD/2022/002). The present study methods were performed in accordance with the relevant guidelines and regulations. Written informed consent was obtained from all the study participants. No incentives were given to CHO to perform the oral cancer screening. No incentive was given to the study participants. The OPMD positive participants were refereed to district hospital for biopsy confirmation and further treatment.

Results

Sociodemographic characteristics and the prevalence of OPMD among the study participants

The trained Community Health Officers screened 209 participants at their respective Ayushman Arogya Mandir in the Jodhpur district of Rajasthan, India. The OPMD status was then validated by an ENT specialist.

The sociodemographic characteristics and the frequency of tobacco and alcohol usage among the study participants are shown in Table 1. The mean age in years (Standard deviation) of the study participants was 41.77(13.29). Out of 209 screened participants, most belong to the age group 30–39 years (36.4%). There were more female participants (51.7%) than male (48.3%). The majority (89.5%) of the participants were married and belonged to Hindu Religion (89.5%). Concerning the social category, most of the participants belong to Other Backward Class (OBC) (41.1%) followed by Scheduled Caste (SC) (29.7%), General (25.4%) and Scheduled Tribe (ST) (3.8%). Out of the total screened participants, most of them were illiterate (44.5%) and unemployed (47.8%). Socioeconomic Status (SES) was calculated through the modified Kuppuswamy scale[21], and it was observed that most of the participants belonged to Upper Lower (48.8%) followed by lower SES class (35.4%). Among the 209 screened participants, smokeless tobacco users were 149 (71.3%). Most smokeless tobacco users consumed Gutkha (76.5%). Smokers were 13.9% and the majority of them consumed Bidi (82.8%). Alcohol user was only 3.3%. The alcohol consumption pattern is underreported (3.3% only) as associated with stigma among rural populations.

Table 2 shows the prevalence of different oral potentially malignant disorders (OPMD) observed among the 209 screened participants. The prevalence of leukoplakia (8.61%) was the highest. The prevalence of erythroplakia (2.87%) and oral submucous fibrosis (OSMF) (4.78%) were found among the study participants. The overall prevalence of OPMD was found to be 14.84%. The participant specific OPMD prevalence are mentioned in **Supplementary Table 1.** Multiple OPMDs like leukoplakia-OSMF (0.96%), and leukoplakia-erythroplakia (0.48%) were also found in the study participants as shown in Supplementary Table 1.

Comparison of the duration and frequency of tobacco and alcohol usage between OPMD and normal participants

The association of duration and frequency of tobacco and alcohol usage with OPMD is shown in Table 3. The mean duration (13.88 ± 7.63) and the mean frequency per day (3.46 ± 1.13) of smokeless tobacco consumption were significantly higher in the case of OPMD (P< 0.001). Similarly, the mean duration (20.82 ± 13.91) and frequency per day (2.91 ± 0.70) of smoking were higher in OPMD (P< 0.005). The mean duration of alcohol consumption (14.20 ± 5.45) was also significantly higher in the case of OPMD as compared to controls. These findings suggest the significant association between the prolonged use of smokeless tobacco, smoking, and alcohol consumption with the OPMD.

Association of OPMD with the socio-behavioral risk factors

Bivariate analysis (Chi-square) and Multivariate regression analysis were done to understand the association between OPMD and the sociodemographic variables and the socio-behavioral risk factors of OPMD.

Bivariate analysis through Chi-square is shown in **Supplementary Table 2**. Although the prevalence of OPMD increased with age, ranging from 10.3% in the 18–29 age group to 21.1% in those over 50 years, the association was not statistically significant (P> 0.05). However not statistically significant, the prevalence of OPMD was higher in females (19.4%) compared to males (9.9%) (P= 0.052, OR: 2.19, 95% CI: 0.98–4.93). There was no statistically significant difference found in case of variables like marital status, religion, education level, and occupation. The prevalence of OPMD was significantly higher among individuals in the lower socioeconomic class (25.7%) compared to other classes (P< 0.05). Individuals using smokeless tobacco had a significantly higher prevalence of OPMD (18.8%) compared to non-users (5.0%). Smoking was strongly associated with OPMD, with a prevalence of 37.9% among smokers versus 11.1% among non-smokers (P< 0.001; OR: 4.89, 95% CI: 2.02–11.82). Dual users had a higher OPMD prevalence (45.5%) compared to non-dual users (11.2%) (P< 0.001; OR: 6.59, 95% CI: 2.54–17.10). Alcohol users showed a significantly higher prevalence of OPMD (71.4%) compared to non-users (12.9%) (P< 0.001; OR: 16.92, 95% CI: 3.12–91.78). Participants with all three risk factors (smokeless tobacco, smoking, and alcohol usage) had an extremely high prevalence of OPMD (80.0%) compared to those without (13.2%) (P< 0.001; OR: 26.22, 95% CI: 2.83–243.48).

S.No.	Sociodemographic variables		N (%)
1.	Age Group	18–29	29 (13.9%)
		30–39	76 (36.4%)
		39–49	47 (22.5%)
		Above 50	57 (27.3%)
2.	Gender	Male	101 (48.3%)
		Female	108 (51.7%)
3.	Marital Status	Married	195 (93.3%)
		Single/Widowed	14 (6.7%)
4.	Religion	Hindu	187 (89.5%)
		Muslim	22 (10.5%)
5.	Community	General	53 (25.4%)
		OBC	86 (41.1%)
		SC	62 (29.7%)
		ST	8 (3.8%)
6.	Education	Illiterate	93 (44.5%)
		Primary	31 (14.8%)
		High School	55 (26.3%)
		Post High School	22 (10.5%)
		Graduate and above	7 (3.3%)
		Professional	1 (0.5%)
7.	Occupation	Unemployed	100 (47.8%)
		Unskilled worker	42 (20.1%)
		Semi-skilled worker	2 (1.0%)
		Skilled worker	7 (3.3%)
		Clerical/Shop-owner/Farm	53 (25.4%)
		Sem-Professional	4 (1.9%)
		Professional	1 (0.5%)
8.	Socio Economic Status (SES)	Lower	74 (35.4%)
		Upper Lower	102 (48.8%)
		Lower Middle	32 (15.3%)
		Upper Middle	1 (0.5%)
		Upper	0 (0.0%)
9.	Smokeless tobacco (SLT)		
	SLT = Yes		149 (71.3%)
		Gutkha	114 (76.5%)
		Betel quid	28 (18.8%)
		Pan Masala	24 (16.1%)
		Khaini	9 (6.0%)
	SLT = No		60 (28.7%)
10.	Smoke (SMK)		
	SMK = Yes		29 (13.9%)
		Bidi	24 (82.76%)
		Cigarette	6 (20.7%)
		Hukka	1 (3.4%)
	SMK = No		180 (86.1%)
11.	Alcohol	Yes	7 (3.3%)
		No	202 (96.7%)

Table 1. Sociodemographic characteristics and socio-behavioral risk factors among the study participants.

Multivariate binary logistic regression is shown in Table 4. There was no significant association between age groups and OPMD. Females had significantly higher odds of OPMD than males (AOR: 15.762, 95% CI: 0.978–254.029, P = 0.052). There was no significant association of religion, marital status, community, education level, or occupation with OPMD. Upper lower SES shows significantly lower odds of OPMD compared to lower SES (P-value < 0.05, AOR-0.044, 95%CI-0.003–0.691). Smokeless tobacco consumption: AOR = 8.751 (95% CI: 1.5–51.05, P = 0.016) and smoking: AOR = 20.827 (95% CI: 2.204–196.832, P = 0.008) shows significantly higher

	OPMD	Prevalence $n = 209$
1	Leukoplakia	18 (8.61%)
2	OSMF	10 (4.78%)
3	Erythroplakia	6 (2.87%)
	Overall OPMD prevalence	**31 (14.84%)**

Table 2. Prevalence of different types of OPMD.

	OPMD ($n = 31$)	Normal ($n = 178$)	P value
Smokeless tobacco			
Mean no. of years ± SD	13.88 ± 7.63	7.81 ± 6.82	< 0.001
Frequency per day ± SD	3.46 ± 1.13	2.11 ± 1.07	< 0.001
Smoke			
Mean no. of years ± SD	20.82 ± 13.91	10.40 ± 9.25	< 0.05
Frequency per day ± SD	2.91 ± 0.70	1.95 ± 0.99	< 0.05
Alcohol			
Mean no. of years ± SD	14.20 ± 5.45	4.50 ± 0.70	< 0.05

Table 3. Association of OPMD with the duration and frequency of tobacco and alcohol usage.

odds of OPMD. Alcohol consumers also showed significantly higher odds of OPMD (AOR: 50.806, 95% CI: 3.62–713.69, $P = 0.004$).

Association of OPMD with oral cavity symptoms

Bivariate analysis shows a significant association of oral cavity symptoms with OPMD. (**Supplementary Table** 3). Oral cavity symptoms like ulcers persisting for more than three weeks, presence of lumps, difficulty in chewing or swallowing, difficulty in jaw or tongue movement, difficulty tolerating spicy foods, dental caries bleeding gums, numbness of the tongue or oral cavity, oral cavity inflammation, persistent mouth pain, and excessive salivation were strongly associated with OPMD constant bad breath did not show a significant association with OPMD.

Multivariate regression analysis was also done for the above-mentioned oral cavity symptoms, as shown in Table 5. The association of OPMD with ulcers persisting for more than three weeks (AOR-7.352) and repeated biting injuries because of sharp teeth and dentures (A.O.R-11.67) was significantly associated with OPMD.

Discussion

The present study identified the prevalence and determinants of OPMD. The prevalence of OPMD was found to be 14.84%. The identified determinants of OPMD are lower SES, smokeless tobacco consumption, smoking, alcohol usage, persistent mouth ulcers, and repeated biting injuries due to sharp teeth and dentures. The results of the study emphasized the complex multifactorial nature of OPMD, highlighting the critical socio-behavioral risk factors.

As per NFHS-5, 2019-21Rajasthan data, 42% of men and 6.9% of women aged 15 years and above have used any form of tobacco. Jodhpur has 43.6% of men and 6.9% of women's tobacco consumption pattern[13]. In our study, smokeless tobacco consumption habit was found in 71.3% of the screened participants, whereas smoking habit was found in only 13.9% of the participants. Alcohol consumption is underreported and found in only 3.3% of the participants. This may be possibly due to the taboo associated with alcohol consumption in rural areas in India.

Tobacco consumption (smokeless or smoking) exposes the oral mucosal cavity to carcinogens such as polycyclic aromatic hydrocarbons, Tobacco-specific N-nitrosamines, formaldehyde, acetaldehyde, and reactive oxygen species (ROS), leading to oxidative stress, chronic inflammation, and DNA damage[23–25]. Alcohol acts as a solvent that facilitates the penetration of carcinogens into the oral epithelium[26]. The combined effect of tobacco and alcohol enhances the production of reactive oxygen species, promotes epithelial dysplasia, leading to the development of OPMD, and increases the risk of their malignant transformation[27,28]. Tobacco consumption leads to the abnormal expression of *p53*, *p16*, *Glucose transporters 1 (GLUT-1)*, *Death-associated protein kinase (DAPK)*, *O6-methylguanine-DNA methyltransferase (MGMT)*, *phosphatidylinositol 3-kinase (P13 K)*genes in oral epithelium, which is associated with the occurrence of oral cancer[24]. Tobacco consumption causes the inhibition of multiple systemic immune functions and leads to the escape of cancer cells from the immune system thereby leading to the development of OPMD and oral cancer[24]. Tobacco consumption stimulates the production of ROS and causes oxidative stress leading to the development of oral cancer[24].

In our study, the overall prevalence of OPMD was found to be 14.84%, similar to previous studies[8,29]. Previous study from India reported that OPMD's overall prevalence was reported to be 13.28%[8]. Similar to the previously reported study, our study also demonstrated the prevalence of leukoplakia (8.61%) as the highest among OPMDs, followed by OSMF (4.78%) and erythroplakia (2.87%). A population-based study conducted in

S. NO.	Sociodemographic and risk factors	N (%)	OPMD Prevalence	P Value	A.O.R. (95% CI) (Lower CI-Upper CI)
1.	**Age group**				
	18–29 (Reference)	29 (13.9%)	10.3%	-	-
	30–39	76 (36.4%)	10.5%	0.274	2.749 (0.450–16.801)
	40–49	47 (22.5%)	17.0%	0.491	1.979 (0.284–13.813)
	> 50	57 (27.3%)	21.1%	0.081	4.920 (0.819–29.543)
2.	**Gender**				
	Male (Reference)	101 (48.3%)	9.9%	-	-
	Female	**108 (51.7%)**	**19.4%**	**0.052**	**15.762 (0.978–254.029)**
3	**Marital Status**				
	Unmarried/Widow (Reference)	195 (93.3%)	28.6%	-	-
	Married	14 (6.7%)	13.8%	0.333	0.367 (0.048–2.786)
4	**Religion**				
	Hindu (Reference)	187 (89.5%)	14.4%	-	-
	Muslim	22 (10.5%)	18.2%	0.248	3.142 (0.451–21.878)
5	**Community**				
	General (Reference)	53 (25.4%)	20.8%	-	-
	OBC	86 (41.1%)	9.3%	0.121	0.233 (0.037–1.471)
	SC	62 (29.7%)	19.4%	0.398	0.502 (0.102–2.479)
	ST	8 (3.8%)	0.0%	0.999	0.000
6	**Education**				
	Illiterate (Reference)	93 (44.5%)	20.4%	-	-
	Primary	31 (14.8%)	12.9%	0.172	5.858 (0.464–73.877)
	High School	55 (26.3%)	9.1%	0.120	12.230 (0.520–287.567)
	Post High School	22 (10.5%)	13.6%	0.251	8.206 (0.226–298.424)
	Graduate and above	7 (3.3%)	0.0%	0.999	0.000
	Professional	1 (0.5%)	0.0%	1.000	0.000
7	**Occupation**				
	Unemployed (Reference)	100 (47.8%)	19.0%	-	-
	Unskilled worker	42 (20.1%)	9.5%	0.766	1.399 (0.153–12.821)
	Semi-skilled worker	2 (1.0%)	0.0%	0.999	0.000
	Skilled worker	7 (3.3%)	28.6%	0.183	12.254 (0.306–490.738)
	Clerical/Shop-owner/Farm	53 (25.4%)	7.5%	0.904	1.231 (0.042–36.175)
	Sem-Professional	4 (1.9%)	50.0%	0.173	9.800 (0.368–260.875)
	Professional	1 (0.5%)	0.0%	1.000	0.000
8	**SES**				
	Lower (Reference)	74 (35.4%)	25.7%	-	-
	Upper Lower	**102 (48.8%)**	**7.8%**	**0.026**	**0.044 (0.003–0.691)**
	Lower Middle	32 (15.3%)	12.5%	0.380	0.101 (0.001–17.000)
	Upper Middle	1 (0.5%)	0.0%	1.000	0.000
9.	**Smokeless Tobacco User**				
	No (Reference)	60 (28.7%)	5.0%	-	-
	Yes	**149 (71.3%)**	**18.8%**	**0.016**	**8.751(1.500–51.046)**
10	**Smoker**				
	No (Reference)	180 (86.1%)	11.1%	-	-
	Yes	**29(13.9%)**	**37.9%**	**0.008**	**20.827(2.204–196.832)**
11	**Alcohol User**				
	No (Reference)	202 (96.7%)	12.9%	-	-
	Yes	**7 (3.3%)**	**71.4%**	**0.004**	**50.806 (3.617–713.687)**

Table 4. Multivariate analysis showing the association of OPMD with sociodemographic and socio-behavioral risk factors.

South Kerela found that the overall prevalence of OPMD among the high-risk group was 20.27%. In the same study, the prevalence of leukoplakia was 37.1%, and OSMF was 21.1% [30]. A cross-sectional study in Northern India reported the prevalence of leukoplakia- 3.9%, erythroplakia-0.1%, and oral submucous fibrosis- 4.02% [31]. A South Indian rural population-based study reported the overall prevalence of OPMD to be 13.28% with

S.No.	Oral Cavity Symptoms	P value	A.O.R. (95%CI) (Lower CI – Upper CI)
1	**Ulcers persisting for more than three weeks**	**0.008**	**7.352 (1.670–32.374)**
2	Lump or thickening in the oral cavity	0.090	5.005 (0.778–32.208)
3	Difficulty in Chewing or swallowing	0.438	2.080 (0.327–13.222)
4	Difficulty in moving jaw or tongue	0.696	0.663 (0.084–5.224)
5	Difficulty in tolerating spicy foods	0.765	0.753 (0.117–4.834)
6	Dental caries	0.305	2.105 (0.508–8.728)
7	Bleeding gum	0.960	0.944(0.099–9.005)
8	Numbness of the tongue or other area of the oral cavity	0.606	0.444 (0.020–9.696)
9	Constant bad breath	0.593	0.593(0.088–4.018)
10	Oral cavity Inflammation	0.521	2.486 (0.154–40.148)
11	Persistent mouth Pain	0.006	9.874 (1.901–51.284)
12	Excessive salivation	0.562	1.952 (0.204–18.694)
13	**Repeated biting of cheeks because of sharp teeth and dentures**	**0.028**	**11.667 (1.310–103.947)**

Table 5. Multivariate analysis showing the association of OPMD with oral cavity symptoms.

erythroplakia- 1.3% and oral submucous fibrosis-6.21% [8]. In our study, lower SES was significantly associated with OPMD, similar to the previously reported study[32]. Lower SES groups are more likely to engage in high-risk behaviors such as tobacco and alcohol use, increasing their susceptibility to OPMD. Interestingly, age, marital status, community, and education were not significantly associated with OPMD, suggesting that behavioral factors may outweigh sociodemographic influences in the studied population. This contrasts with a previous study where low education is reported as a predictor, underscoring the importance of regional and cultural variations in OPMD epidemiology[32]. The plausible explanation for this variation could be the differences in healthcare access, lifestyle practices, and awareness levels. Limited health literacy and delayed healthcare-seeking behavior may elevate the prevalence of OPMD. These socio-behavioral factors might not necessarily correlate with education level in our specific study setting. Moreover, it was previously reported that smoking (bidi) and smokeless tobacco (gutka, pan masala etc.) consumption are culturally accepted in rural areas of India contributing to delayed healthcare-seeking behavior and underutilization of oral health services[14,15].

Similar to previous studies, the prevalence of OPMD was significantly associated with smokeless tobacco use, smoking, and alcohol consumption[8,10,30]. We observed that the participants with dual (smoking and smokeless tobacco) or triple risk factors (smoking, smokeless tobacco, and alcohol) demonstrated exponentially higher odds of OPMD, highlighting the synergistic effects of combined exposures. Similar to earlier studies, we also reported a significant difference in the duration and frequency of tobacco (smokeless or smoked) and alcohol usage between OPMD and normal participants[30]. The study identified strong associations between OPMD and oral cavity symptoms. For example, ulcers persisting over three weeks and repeated biting injuries due to teeth biting and dentures. Thus, the study identified the prevalence and determinants of OPMD and emphasized the need for routine oral cancer screening by Community Health Workers through Oral Visual Examinations because of its cost-effectiveness and accessibility[33].

Strength and limitations
The study findings have policy implications and inform the National Programme for Prevention and Control of Non-Communicable Diseases (NP-NCD) and policymakers about the importance of targeted reduction of modifiable socio-behavioral risk factors and the advantages of oral cancer screening through an oral visual examination. This study also demonstrated that Community Health Officers (CHOs) can be vital in identifying high-risk individuals and facilitating oral cancer screening. Thus, CHOs can be utilized in oral cancer screening initiatives at the regional level in India. The limitation of the study is its crosssectional study design and selection bias as the study done at Ayushman Arogya Mandir.

Conclusion
In the present study, the comprehensive evaluation of sociodemographic, socio-behavioral, and clinical risk factors using both multivariate and bivariate analysis was done to find the determinants of OPMD. This study determined the prevalence of OPMD to be 14.84%. The present study identified that lower SES, smokeless tobacco consumption, smoking, and alcohol use are the possible determinants of OPMD. The findings of the study highlight the role of modifiable socio-behavioral risk factors like smokeless tobacco consumption, smoking, and alcohol usage. The study highlights the importance of routine oral health checkups and oral hygiene. The present study also highlights the importance of Community Health Workers and suggests that CHOs can be integrated into routine oral cancer screening for early diagnosis of oral cancer.

Data availability
The study data is available on request from the corresponding author.

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Author contributions

JKG wrote the manuscript and prepared all the manuscript tables. S.S. reviewed the manuscript. BVB reviewed the manuscript thoroughly and helped in the finalization of the manuscript. JKG communicated the manuscript. All authors reviewed the manuscript.

Declarations

Competing interests

The authors declare no competing interests.

Additional information

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