ORIGINAL RESEARCH

Prevalence of Oral Potentially Malignant Disorders and Oral Cancer Risk Among Industrial Workers in Guntur, Andhra Pradesh, South India: A Cross-Sectional Study

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Abstract

Background: Oral cancer is among the most common malignancies, with over 90% of cases arising from oral potentially malignant disorders (OPMDs) such as Leukoplakia, Erythroplakia, oral submucous fibrosis, and oral lichen planus. Early identification is key to reducing recurrence and mortality. Industrial workers are at high risk due to occupational exposures, poor oral hygiene, and high tobacco use. This study evaluates the prevalence of oral cancer and OPMDs among industrial workers in Guntur.

Aim: To assess the prevalence of oral cancer and OPMDs among industrial workers and examine their association with tobacco consumption.

Materials and methods: A cross-sectional study was conducted over six months among 2,000 industrial workers aged 28 years and above. Data collection included structured questionnaires on demographics, health status and tobacco use, followed by clinical oral examinations. Suspected lesions underwent biopsy and histopathological analysis. Statistical analysis using chi-square test, regression analysis evaluated associations between tobacco use and OPMDs.

Results: Among 2,000 industrial workers, 13.4% had oral lesions, with strong links to tobacco use ($p < 0.05$). OSMF was seen in smokeless tobacco users, while Leukoplakia and Erythroleukoplakia occurred in smokers. Males and adults aged 30–49 had higher risk, especially for OSMF and lichen planus. Dual tobacco users had the highest odds (OR = 5.75) of lesion development.

Conclusion: Findings highlight the need for targeted workplace oral cancer screening and prevention strategies to reduce the burden of malignancies among high-risk groups.

Key words: Oral cancer, Oral potentially malignant disorders (OPMDs), Industrial workers, Tobacco consumption, Oral cancer screening

Introduction

Oral cancer is the eighth most prevalent malignancy globally, accounting for over 90% of all malignant neoplasms of the oral cavity.[1] The majority of oral cancers originate from oral potentially malignant disorders (OPMDs), including Leukoplakia, Erythroplakia, oral submucous fibrosis, oral lichen planus, and verrucous hyperplasia.[2] The precise mechanisms underlying the transformation of these OPMDs into malignancies remain a subject of debate. Despite advancements in understanding oral cancer, preventive measures have not yet achieved satisfactory outcomes.[3] Malignant tumors have a recurrence rate of 40–50% within five years of treatment; however, when detected at an early stage, this recurrence rate can be significantly reduced to 10–20%, thereby improving survival rates.[4] Early detection is, therefore, a crucial strategy in preventing the malignant transformation of OPMDs, ultimately enhancing treatment success, increasing survival rates, and improving patients' quality of life.[5]

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The majority of studies on tobacco-related habits and their association with oral lesions have primarily focused on younger populations, such as students, as well as industrial workers. A potential reason for this is the communication gap in achieving behavioral change through anti-smoking campaigns, coupled with socioeconomic constraints and illiteracy.[6] Furthermore, economic disadvantage and lack of awareness are significant contributors to the high prevalence of oral mucosal lesions among tobacco users.[7] Given the significant impact of these lesions on morbidity, quality of life, and mortality, increased attention should be directed toward oral lesions associated with tobacco use.[8]

According to GLOBOCAN (2022), cancers of the lip and oral cavity rank among the most common malignancies in males aged 15–74 years in low- and middle-income countries (LMICs), accounting for approximately 10.5% of cases.[9] Despite a well-documented natural history, the presence of Oral Potentially Malignant Disorders (OPMDs), and the availability of early detection methods, oral cancer (OC) continues to be the third leading cause of cancer-related mortality among men in LMICs, contributing to 8.6% of male cancer deaths. In the Indian subcontinent, oral cancer is the most frequently diagnosed malignancy among men and remains a leading cause of cancer-related fatalities.[10]

Tobacco and areca nut are classified as Group I carcinogens for oral cancer. Despite intensified tobacco control measures by the Indian government, tobacco consumption remains widespread. The national framework for cancer prevention and control relies on trained primary healthcare professionals to conduct community-level screenings and identify high-risk populations, particularly tobacco users. High-risk individuals undergo oral visual examinations (OVE), and those with suspected malignancies are referred to higher-level healthcare facilities for further assessment. However, National Oral Cancer Screening (OCS) coverage remains suboptimal, with only 1.2% of males and 0.9% of females reported to have been screened.[11]

Various diagnostic techniques are available for early detection, including visual examination, brush biopsy, Oral CDx, toluidine blue staining, ViziLite, and autofluorescence-based imaging technologies such as VELscope and Oroscope. Among these, biopsy remains the gold standard for definitive diagnosis.

This study aims to evaluate the prevalence of oral cancer and OPMDs among industrial workers in and around Guntur. Additionally, the study will assess the association between tobacco consumption and the occurrence of OPMDs within this population.

Materials and Methods

This cross-sectional epidemiological study aimed to determine the prevalence of on oral cancer and Oral Potentially Malignant Disorders (OPMDs), among industrial workers in the Guntur region. The study was conducted over a six-month period as part of a scheduled health screening program.

A total sample of 2000 Industrial workers employed in factories and manufacturing units in and around Guntur were selected through convenience sampling. The study was approved by the Institutional Ethics Committee of Sibar Institute of Dental Sciences, Guntur, Andhra Pradesh. Ethical clearance was obtained prior to data collection (Approval No. 454/IEC/SIBAR/2024, dated 24-06-2024). All participants provided informed consent before participation.

All collected data were anonymized to maintain confidentiality. Eligibility criteria included individuals aged 28 years or older who provided written informed consent and were present on the screening day. Individuals with acute, painful dental conditions, a prior diagnosis of oral cancer or recent treatment for the disease, and those unwilling to provide consent were excluded.

Oral examinations were performed by trained clinicians using both visual and tactile assessment techniques. The screening involved a systematic evaluation of the oral mucosa, tongue, lips, palate, and buccal mucosa, with photographic documentation of any suspicious lesions. OPMDs were categorized into two primary groups: tobacco-associated OPMDs, including oral Leukoplakia, Erythroplakia, palatal changes linked to reverse smoking, and oral submucous fibrosis and non-tobacco-associated OPMDs, such as oral lichen planus, oral lichenoid lesions, discoid lupus erythematosus, epidermolysis bullosa, dyskeratosis congenita, and actinic cheilitis. Lesions with clinical features suggestive of malignancy were subjected to biopsy, followed by histopathological examination for dysplasia or malignant transformation.

An interview based questionnaire was administered to collect demographic details and lifestyle-related risk factors, including tobacco use (both smoking and smokeless forms), health status. Descriptive statistics, including frequencies and percentages, were employed to assess the prevalence of oral cancer and OPMDs. Data was analysed using SPSS Version 26, The chi-square test was used to determine statistical significance ($p<0.05$), and logistic regression analysis was performed to identify predictors of OPMD development.

Potential risks in this investigation were primarily linked to biopsy procedures in cases where malignancy was suspected. While biopsy-associated complications were minimal, potential adverse effects included pain, localized swelling, or infection. The study underscored the importance of early detection of OPMDs, enabling timely intervention and reducing the likelihood of malignant transformation. Additionally, findings contributed to enhanced awareness regarding oral cancer prevention and early diagnosis, particularly in high-risk occupational groups.

Results

A total of 2,000 industrial workers participated in the study, with 268 individuals (13.4%) presenting oral lesions. The mean age of the total population screened was 35.37±9.60 years. 228 patients with oral Potentially malignant lesions underwent histopathological examination.

Table 1 highlights a distinct correlation between different forms of tobacco use and particular oral lesions. Leukoplakia and erythroleukoplakia were observed solely among smokers and those who used both smoking and smokeless tobacco. In contrast, oral submucous fibrosis (OSMF) and tobacco pouch

keratosis were found exclusively in users of smokeless tobacco. Lichen planus was present in all groups, including individuals with no history of tobacco use. The Chi-square test revealed a statistically significant relationship ($p < 0.05$) between the type of tobacco habit and the occurrence of specific oral lesions.

In table 2 The majority of oral potentially malignant lesions were observed in the 20–49 years age group. OSMF and Leukoplakia were most prevalent in individuals aged 20–39 years. Lichen planus peaked in the 30–49 years range, while Erythroleukoplakia occurred across a wider age range, including older adults. Tobacco pouch keratosis and smokers' melanosis were less frequent and seen mostly in the 30–59 years group. No lesions were reported in individuals aged 17–19 years, and very few were seen above 60 years.

Table 1: Distribution of Oral potentially malignant lesions by Type of Tobacco Habit Among Individuals

Lesions	Smokers	Smokeless form of tobacco	Mixed habit (smokers & smokeless form users)	No habit
Erythroleukoplakia	10	0	11	0
Leukoplakia	85	0	14	0
Lichen planus	6	9	11	8
OSMF	0	60	47	0
Tobacco pouch keratosis	0	6	0	0
Leukoplakia and OSMF	0	0	1	0

Table 3: Logistic Regression Models for Estimation of Association of Gender in Relation to Oral potentially malignant lesions

Lesions	Gender	B	St error	wald	Odds ratio	P value
OSMF	Male	0.61	0.31	3.87	1.84	0.04
	Female (Ref)					
Leukoplakia	Male	0.34	0.30	1.29	1.40	0.25
	Female (Ref)					
Lichen planus	Male	-0.15	0.36	0.17	0.86	0.67
	Female (Ref)					
Erythroleukoplakia	Male	1.25	0.65	3.70	3.5	0.05
	Female (Ref)					
Tobacco pouch keratosis	Male	1.10	0.84	1.72	3.00	0.19
	Female (Ref)					

p-value <0.05 statistically significant

In table 3 Males showed a significantly higher risk of developing OSMF compared to females (OR = 1.84, p = 0.04).

Table 2: Age-wise Distribution of Oral potentially malignant lesions Among Individuals

	Age categories (n)					
	17-19	20-29	30-39	40-49	50-59	60-72
OSMF	0	33	37	28	9	0
Leukoplakia	0	21	39	26	11	2
Leukoplakia & OSMF	0	0	0	1	0	0
Erythroleukoplakia	0	5	6	5	4	1
Lichen planus	0	5	12	14	3	0
Tobacco pouch keratosis	0	0	2	2	2	0

Table 4: Logistic Regression for Association of Age Categories with Oral potentially malignant lesions

Lesions	Age	B	St error	wald	Odds ratio	P value
OSMF	30-49 years	1.62	0.53	9.27	1.84	0.00
	50-72 years	-0.18	0.79	0.05	0.17	0.82
	17-29 years (Ref)					
Leukoplakia	30-49 years	1.48	0.56	7.00	1.48	0.00
	50-72 years	1.08	0.64	2.84	0.84	0.09
	17-29 years (Ref)					
Lichen planus	30-49 years	1.76	0.61	8.29	1.71	0.00
	50-72 years	0.41	0.84	0.24	0.29	0.62
	17-29 years (Ref)					

p-value <0.05 statistically significant

Table 5: Logistic Regression Analysis for Association between Tobacco Habit and presence of Oral potentially malignant lesions

Variables	B	St error	wald	Odds ratio	P value
Smokers	1.30	0.40	10.56	3.67	0.001
Smokeless form	1.10	0.45	5.98	3.00	0.015
Mixed habit	1.75	0.60	8.50	5.75	0.004
No habit (Ref)					

Erythroleukoplakia also had a higher odds in males, with borderline significance (OR = 3.5, p = 0.05). No significant gender association was found for Leukoplakia, lichen planus, tobacco pouch keratosis, or smokers' melanosis. Thus, male gender is an important risk factor particularly for OSMF and possibly Erythroleukoplakia.

In Table 4, Individuals aged 30-49 years showed a significantly higher risk of developing OSMF, Leukoplakia, and lichen planus compared to those aged 17-29 years ($p < 0.05$).

No significant association was observed for the 50-72 years age group with any lesions.

The highest odds ratio was seen for lichen planus in the 30-49 years group (OR = 1.71).

Thus, middle-aged adults (30-49 years) are at greater risk for these oral potentially malignant lesions.

Table 5 shows logistic regression analysis between tobacco habits and oral lesion development ($p < 0.05$). Compared to individuals with no tobacco habit, smokers had 3.67 times higher odds of developing oral lesions, smokeless tobacco users had 3 times higher odds, and individuals using both forms had the highest risk with 5.75 times greater odds. This suggests a strong correlation between tobacco usage and lesion development.

Figure 1 showing more males (1344) than females (656) in the study. Most participants have secondary education (991), followed by primary (709) and degree holders (300). Majority are healthy (1420), while fewer have hypertension (280), diabetes (260), or both (40).

Among the 2000 individuals screened, the majority (858 individuals) reported no tobacco habits. Smokers accounted for 427 individuals, while 346 used smokeless forms, and 369 reported using both forms. This distribution highlights that over half of the screened population had some form of tobacco habit, which is significant for public health planning and tobacco cessation efforts. (Figure 2)

Among the 278 individuals with lesions, the majority reported some form of tobacco use. Specifically, 90 individuals (32.4%) were smokers, 76 (27.3%) used the smokeless form, and 74 (26.6%) reported using both forms. Only 38 participants (13.7%) reported no history of tobacco use. (Figure 3)

Figure 4 illustrates the distribution of oral lesions by gender. Oral Submucous Fibrosis (OSMF) is the most common lesion, with 74 males and 33 females affected. Leukoplakia follows, affecting 60 males and 39 females. Other lesions such as erythroleukoplakia, lichen planus, tobacco pouch keratosis, and smokers' melanosis are less common.

Discussion

This survey analysis provides crucial insights into the correlation between tobacco usage, oral lesions, and the role

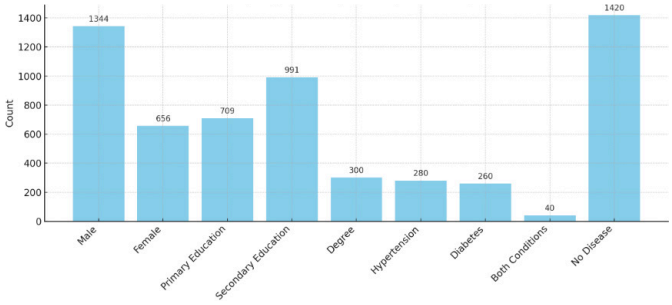

Fig. 1: Distribution of Study Participants by Gender, Education Level, and Health Conditions

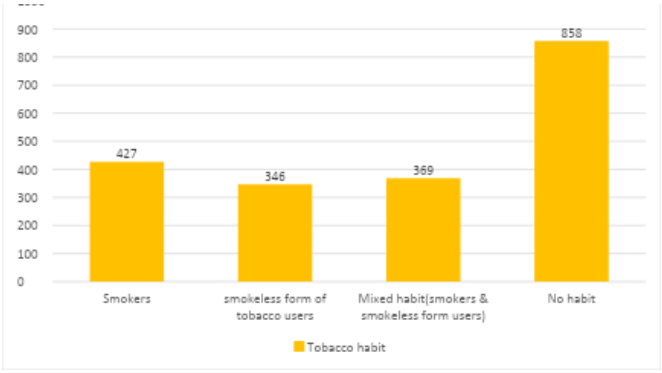

Fig. 2: Distribution of Tobacco Habits Among 2000 individuals

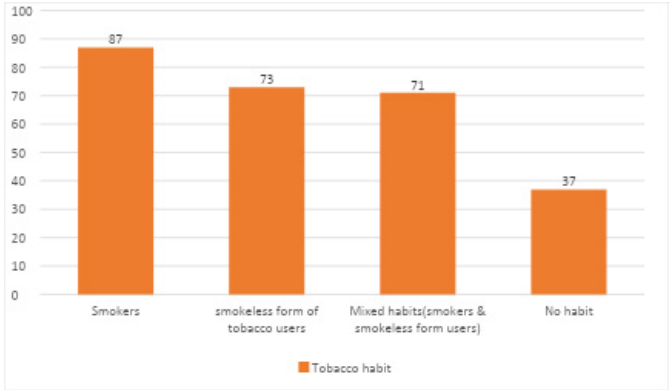

Fig. 3: Distribution of Tobacco Habits Among Individuals with lesions (268)

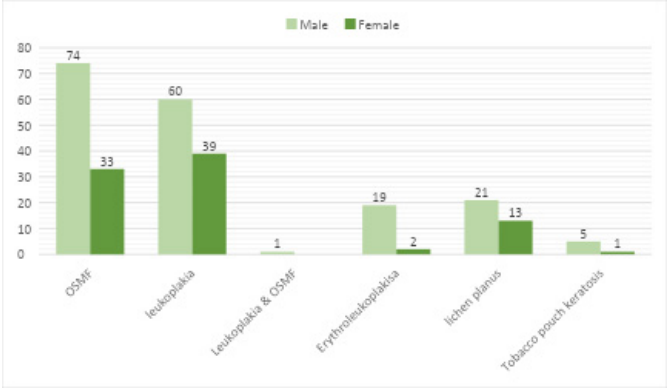

Fig. 4: Gender-wise Distribution of Oral potentially malignant lesions Among individuals

of biopsy in confirming clinical diagnoses, particularly among industrial workers. By comparing this findings with previous studies, we can identify patterns and variations that contribute to a more comprehensive understanding of oral disease prevalence and diagnostic accuracy. The inclusion of biopsy as a confirmatory tool for clinical diagnoses highlights the need for integrating histopathological evaluation into routine oral health screenings, especially in high-risk populations such as industrial workers.

Industrial workers are often exposed to occupational hazards, including dust, chemical fumes, and carcinogenic substances, which may contribute to an increased risk of oral diseases. Additionally, this group has a high prevalence of tobacco consumption, poor oral hygiene practices, and limited access to dental care, making them particularly vulnerable to developing premalignant and malignant oral lesions. Previous studies, such as those conducted by Radhika et al. (2021) and Ayesh das et al. (2024), have reported higher rates of oral cancer and precancerous conditions among industrial workers compared to the general population.[12,13]

In the present work, tobacco habits were found to begin at a young age, particularly with smokeless forms such as gutkha and pan masala. This raises serious concerns about the vulnerability of younger populations to early exposure and addiction, particularly to smokeless forms like gutkha, pan masala, and khaini. These products are often more accessible, discreet to use, and socially tolerated, which may facilitate their early adoption.

Several contributing factors, such as peer influence, curiosity, ease of access, and continued use during work hours, could explain this trend. Our findings are supported by Ansari et al., who also identified family introduction, peer pressure, pleasure-seeking, and media advertisements as major factors behind the initiation of tobacco use among power loom workers[14]

Among the 2000 individuals screened, most participants had secondary education (991), followed by primary education (709) and degree holders (300). This suggests a relatively higher level of educational attainment in current study population compared to the findings of Pulkit et al. (2015), where most of the glass factory workers had their education only till the primary level. The higher proportion of individuals with secondary and higher education in our sample may reflect a broader community-based screening rather than an occupationally restricted group. This could also have implications for awareness levels regarding oral health and tobacco-related risks, as education is often positively associated with health literacy and behavior change readiness.[15]

14% of individuals reported a history of hypertension, 13% had diabetes, and 2% had both conditions, while the majority (71%) had no systemic diseases. These findings align with studies conducted on industrial workers in other regions, such as the study by Goyal et al (2024), Thankappan et al (2017) which reported a similar prevalence of hypertension and diabetes in a factory-based workforce. However, these rates are slightly higher than those observed in general populations, indicating that industrial stress and lifestyle factors may contribute to the increased prevalence of non-communicable diseases.[16,17]

The higher prevalence of systemic diseases in industrial populations can be attributed to factors such as irregular working hours, limited access to healthcare facilities, and higher stress levels associated with demanding physical labor. Studies have consistently shown that tobacco use exacerbates the risk of hypertension and diabetes due to its effects on vascular health and insulin resistance (Keith et al., 2020). These demographic findings support the above stated observations, as many individuals with systemic diseases also reported tobacco consumption, emphasizing the need for targeted health awareness programs within industrial settings.[18,19]

One of the primary motivations for conducting this study was to assess the burden of oral diseases among industrial workers and evaluate the need for early detection and preventive strategies. The demanding nature of industrial work often leads to neglect of oral health, with workers prioritizing occupational commitments over dental check-ups. Moreover, exposure to workplace chemicals and pollutants has been linked to an increased risk of oral mucosal changes and systemic health conditions, as documented in studies on occupational health risks (Divinakumar et al., 2017).[20]

By focusing on this specific population, this study aimed to bridge the gap in oral healthcare access and highlight the necessity of workplace-based oral health interventions. Industrial workers are a crucial segment of the workforce, and ensuring their oral health not only improves their quality of life but also enhances overall productivity by reducing absenteeism due to health issues. These findings can serve as a foundation for policy recommendations, advocating for mandatory oral health screenings in industries with a high prevalence of tobacco consumption and exposure to occupational risk factors.[21,22]

Results revealed that 715 individuals had history of smokeless tobacco use, while khaini was the most commonly reported form of smokeless tobacco, followed by gutka and betel nut consumption. Among the 427 individuals who reported smoking, occasional cigarette use was the most common pattern. These findings align with the study by Abbas et al. (2024)[23]

Mixed tobacco habits, involving both smoking and smokeless forms, are associated with a higher risk of developing oral mucosal lesions compared to single habits. The combined exposure may have a synergistic effect, leading to more severe tissue damage and increased likelihood of conditions like Oral Submucous Fibrosis (OSMF) and Leukoplakia. Studies have consistently shown that individuals with mixed habits are at greater risk for malignant transformation and chronic oral conditions, findings from Lee et al., who reported an increased risk of malignancy with mixed habits compared to chewing alone. Similar associations have also been documented by Behura et al. (2015) reinforcing the compounded risk posed by combined tobacco exposures.[24]

Smokers, smokeless, and combined forms of tobacco had odds ratios of 3.67, 3.00, and 5.75, respectively ($p < 0.05$), indicating a graded increase in risk with combined exposure. The comparative study supports this pattern with even higher adjusted odds ratios: smoking [AOR = 20.827], smokeless

tobacco [AOR = 8.751], and a synergistic effect of all three habits [AOR = 26.222], underscoring the compounded carcinogenic impact of co-exposure. Though the magnitude of the odds differs, likely due to population differences and analytical models, the directional trend is consistent, validating our findings.

Additionally, middle-aged adults (30–49 years) were at significantly higher risk of developing OSMF, leukoplakia, and lichen planus. This is corroborated by the other study, which found that the mean duration and frequency per day of tobacco habits were significantly higher among OPMD cases, often accumulated by middle age. These findings suggest a critical window for intervention in this age group to prevent lesion progression.[25]

Results are partially aligned and partially in contrast with those reported in the meta-analysis by Purohit et al. (2023). Their analysis, which included over 30,000 tobacco smokers and 36,000 tobacco chewers with oral cancer, and over 4,000 individuals in each group with oral potentially malignant disorders (OPMDs), concluded that tobacco chewers had a significantly higher association with both OPMDs and oral malignancy compared to smokersIn alignment with this study, Oral Submucous Fibrosis (OSMF), a high-risk OPMD, was found exclusively in smokeless tobacco users, reinforcing the strong association between chewing tobacco and specific lesions. Additionally, dual users of both smoke and smokeless tobacco were identified as having the highest risk for lesion development, with an odds ratio of 5.75 reported, consistent with these findings.[29]

Compared to present study, where the most affected age group was 30–49 years and males had a significantly higher risk for developing lesions the referenced study found the highest prevalence in an older age group (56–65 years) and also reported male predominance. In terms of lesion distribution, while both studies observed a variety of oral potentially malignant disorders, our study identified OSMF as the most common lesion, particularly among smokeless tobacco users. In contrast, the referenced study reported tobacco pouch keratosis as the most common, followed by leukoplakia. These differences may reflect variations in tobacco habits, occupational exposures, and demographic profiles of the populations studied.[30]

The work environment in industries often facilitates tobacco consumption, as many workers use it as a coping mechanism for stress and fatigue. Break-time tobacco use is a common practice in factory settings, with peer influence further reinforcing this habit. In contrast, office-based employees or non-industrial labourers show lower rates of smokeless tobacco consumption due to different work cultures and social settings.

One of the most significant aspects was the correlation between clinical diagnosis and biopsy results, revealed that while clinical diagnosis provided a strong preliminary assessment, biopsy was essential in confirming or modifying the initial diagnosis. This reinforces the necessity of histopathological evaluation in oral lesion diagnosis, particularly in high-risk groups like industrial workers.

Clinically diagnosed cases were confirmed via biopsy and Histopathological examination This is consistent with the findings of Deorah et al. (2019), who reported that although clinical diagnosis is a strong predictor, histopathology remains the gold standard for confirmation.[26] Study by Bhattacharjee. (2025) have also suggested that mandatory oral screenings in industries could help detect OPMD at an early stage, allowing for better management and prevention of malignant transformation.[27] Agarwal et al. (2025) also highlighted the importance of early biopsy in high-risk populations, as clinical diagnosis alone may not always accurately reflect disease severity.[28]

Recommendations for Future Research and Public Health Strategies

- Workplace-Based Oral Health Programs: Industries should implement periodic oral health check-ups and tobacco cessation initiatives to reduce the burden of oral diseases among workers.
- Integration of Biopsy in Routine Screening: Dental practitioners working in occupational health settings should incorporate biopsy into regular screenings for early detection of premalignant and malignant lesions.
- Long-Term Occupational Health Studies: Future research should focus on longitudinal studies assessing the impact of workplace exposures on oral disease progression and systemic health.
- Tobacco Control Policies in Industrial Settings: Government policies should enforce stricter regulations on tobacco sales near industrial areas and provide workers with access to cessation support programs.
- Use of AI for Early Detection: Machine learning algorithms could be developed to assist in the early identification of oral lesions through photographic screening and biopsy analysis, improving diagnostic accuracy in occupational health clinics.

Conclusion

The findings of current research provides valuable insights into the prevalence of oral diseases among industrial workers, emphasizing the role of biopsy in confirming clinical diagnoses. The findings reveal a significant burden of oral precancerous and cancerous conditions, strongly linked to tobacco use and occupational factors. Compared to other population studies, industrial workers exhibit a higher prevalence of oral lesions, highlighting the urgent need for targeted interventions. The limitations of this cross-sectional study are acknowledged. As causality cannot be inferred from cross-sectional data, the association between tobacco use and periodontal disease should be interpreted with caution. Furthermore, reliance on self-reported tobacco use may have introduced under-reporting bias. Future research employing longitudinal designs is recommended to better establish causal relationships.

The strong correlation between clinical diagnosis and biopsy confirmation underscores the importance of histopathological examination in improving diagnostic accuracy. The implementation of workplace-based oral health programs, combined with strict tobacco control policies, can significantly reduce the prevalence of oral diseases in this high-risk population.

Furthermore, this present work reinforces the necessity of integrating biopsy into routine dental screenings, especially in industrial setups where workers are at heightened risk due to occupational exposures. Future research should focus on innovative diagnostic tools, long-term disease monitoring, and policy-driven approaches to mitigate the growing burden of oral diseases among industrial workers. Ensuring oral health in this population is not just a healthcare priority but also a crucial step in safeguarding workforce productivity and overall well-being.

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