Journal of Oral Biology and Craniofacial Research 16 (2026) 101403

Contents lists available at ScienceDirect

Journal of Oral Biology and Craniofacial Research

journal homepage: www.elsevier.com/locate/jobcr

Tooth loss among adults with and without presence of systemic diseases – Age and Gender matched case control study

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ARTICLE INFO

Keywords:
Tooth loss
Systemic diseases
Case-control study

ABSTRACT

Background: Systemic diseases contribute to tooth loss by affecting immunity, circulation, and bone health. While most studies focus on elderly, this study assesses tooth loss among adults with and without systemic diseases to support early care.

Aim: To assess tooth loss among adults with and without systemic diseases in age- and gender-matched cases and controls.

Design: A case-control study was conducted among 280 adults (140 cases and 140 controls). Data on demographics, lifestyle factors (alcohol, smoking, oral hygiene), and systemic diseases were collected. Tooth loss was assessed using Tooth Loss Index. Statistical analysis included Chi-square, Mann-Whitney *U* test, logistic regression, and correlation analysis.

Results: Cases had higher rates of alcohol use, smoking, and poor oral hygiene ($p < 0.05$). Tooth loss was significantly higher among cases (87.1 %) than controls (50 %), with greater mean missing teeth and higher Tooth Loss Index scores. Low education, alcohol, and smoking were significantly associated with increased tooth loss. Cases had nearly four times higher odds of significant tooth loss (OR = 3.82, $p = 0.0001$), with a strong positive correlation. ($r = 0.82$, $p = 0.0001$).

Conclusion: Systemic diseases are strongly associated with increased tooth loss in adults, highlighting need for early oral health interventions.

1. Introduction

The most common non-communicable diseases today are oral diseases, affecting 3.9 billion people worldwide.[1] One of the most impactful oral conditions is tooth loss which affects an individual's normal functioning such as chewing, speech, taste, and appearance or expressions. Tooth loss is highly prevalent condition with numerous consequences, nevertheless, it is a preventable oral health issue.[2]

In adults, the number of teeth loss can be viewed as an index of lifetime accumulation of poor oral health which mainly stems from untreated dental caries and periodontal disease. Tooth loss remains a significant deterrent to oral health and adversely affects the dietary intake and nutritional status of individuals compromising their general health. World Health Organization (WHO) states that minimum number of 20 permanent teeth are required for individuals to take part in social activities and achieve an adequate masticatory function.[3] Among Indian adults, the reported prevalence of complete tooth mortality (loss of 32 teeth) is 10.7 % and partial tooth mortality (having one or more teeth) is 58.8 %.[4]

In recent years, the oral-systemic connection has been largely recognized by the dental and medical professions. A systemic disease is defined as a disorder that can affect a few organs and tissues or even the whole body.[5] If persist for a longer duration, systemic diseases can affect the ability of a person to function normally.

Systemic diseases can significantly impact tooth loss by altering the body's immune response, affecting blood flow, and influencing bone metabolism.[6] A recent study conducted by Zmavc JB et al. emphasized that certain chronic systemic diseases are strongly associated with the increased risk of tooth loss among the elderly in Slovenia.[6] Likewise, study conducted by Granillo et al.[7] among Mexican elderly individuals

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https://doi.org/10.1016/j.jobcr.2026.01.007
Received 19 August 2025; Received in revised form 1 January 2026; Accepted 12 January 2026
Available online 20 January 2026

reported that overall prevalence of chronic conditions was 27.3 % and the presence of tooth loss in this sample of Mexican older adults was higher in subjects with chronic conditions. Hence, though the existing literature has highlighted evidence of relationship between systemic chronic diseases and tooth loss[8–10], it was mainly limited to elderly population. Studying younger adults is clinically important because early manifestations of systemic diseases may influence oral health long before old age. Early detection of oral–systemic interactions in adulthood allows timely preventive interventions, which may help reduce later tooth loss.

However, systemic diseases are mostly detected in late adulthood, which can form basis for secondary prevention. Hence, it becomes essential to evaluate effect of systemic diseases on oral health in adults. Therefore, the present study will explore tooth loss among adult population with and without presence of a systemic disease.

2. Materials and method

Age and gender-matched case-control study was conducted over a three-month period among adults attending the outpatient department of Government Dental College and Hospital, Hyderabad. A total of 280 participants were recruited, comprising 140 cases (individuals with a history of at least one systemic disease) and 140 controls (individuals without any known systemic condition). Adults aged 18 years and above who provided written informed consent were eligible for inclusion. For the case group, participants were required to have a confirmed history of at least one systemic disease (Diabetes, cardiovascular diseases, renal disorders, obesity, respiratory infections, stroke, bone and joint diseases, neurological or psychological disorders, thyroid disorders, gastrointestinal issues, and other diseases which included autoimmune diseases and infectious diseases). Controls were individuals without any known systemic conditions. Exclusion criteria for both groups included physically or mentally challenged individuals who were unable to participate in the interview or clinical examination.

Ethical approval for the study was obtained from the Institutional Review Board of Osmania Medical College (IEC/OMC/M.NO (10)/P-120), and permission to conduct the study was granted by the Principal of Government Dental College and Hospital, Hyderabad. All participants were provided with detailed information about the study, and informed consent was obtained prior to data collection. Participation was voluntary, and anonymity and confidentiality were maintained throughout the study.

Data collection was performed using a structured questionnaire followed by a clinical oral examination. The questionnaire gathered demographic data including age, gender, and educational status, as well as lifestyle-related variables such as alcohol consumption, cigarette smoking, and oral hygiene behaviours. A detailed history of systemic diseases was recorded, covering conditions such as diabetes, cardiovascular disease, renal disorders, obesity, cancer, respiratory infections, stroke, bone and joint diseases, neurological and psychological disorders, thyroid disorders, gastrointestinal problems, and other relevant medical conditions.

Clinical oral examinations were carried out using standard infection control procedures and included the assessment of missing teeth using the Dentition Status according to WHO criteria.[5] Tooth loss was further evaluated using the Tooth Loss Index by Batista MJ et al.,[6] which classifies tooth loss based on the number and type of missing teeth due to caries or periodontal disease. The Tooth Loss Index scoring system ranged from 0 (no tooth loss) to 5 (edentulous), with intermediate scores reflecting progressive levels of tooth loss.

The examinations were conducted using sterilized equipment including mouth mirrors, Community Periodontal Index (CPI) probes, tweezers, kidney trays, and disposable gloves, masks, and head caps. Data were recorded using a pretested data collection form.

Sample size was calculated based on a reported chronic disease prevalence of 24 % resulting in a minimum required sample of 280 participants, equally distributed between cases and controls.

2.1. Statistical analyses

Data analysis was conducted using IBM SPSS Statistics version 26.0. Descriptive statistics such as means, standard deviations, frequencies, and percentages were used to summarize the data. Chi-square tests were applied to assess associations between categorical variables, and independent t-tests or Mann-Whitney U tests were used to compare continuous variables between groups. Logistic regression analysis was used among cases to identify predictors of tooth loss, and Pearson's correlation was used to examine the relationship between cases and controls with Tooth Loss Index scores.

3. Results

The study sample included 280 subjects (140 cases and 140 controls) with a mean age of 38.91 ± 10.27 years. The largest proportion of participants (42.9 %) belonged to the 36–45 years age group. A higher proportion of cases had no formal education (31.4 %), whereas a greater number of controls had middle school to higher secondary education (34.2 %) ($p = 0.01$).

Majority of participants (65.8 %) did not consume alcohol. A statistically significant difference was observed between cases and controls regarding alcohol consumption habit ($p = 0.01$) with alcohol consumption being more prevalent among cases (29.3 %) compared to controls (15 %).

Similarly, a significant difference was found between cases and controls with regard to smoking habit ($p = 0.012$). On comparison, majority of them were non-smokers (60.8 % cases and 76.4 % controls). However, current smokers were more prevalent among cases (35 %) compared to controls (19.3 %).

Tooth brushing habit was reported by 97.1 % of cases compared to 100 % of controls, demonstrating a statistically significant difference ($p = 0.04$). Similarly, flossing was practiced by only 4.29 % of cases, whereas 13.57 % of controls reported flossing, indicating a significant association ($p = 0.006$).

Most of the participants brushed their teeth once daily (89.6 %) (91.4 % of cases and 87.9 % of controls). Brushing twice a day was slightly more common among controls (10.7 %) than cases (8.6 %) ($p = 0.29$). A small percentage of controls (1.43 %) did not brush at all, while all cases brushed their teeth at least once per day (Table 1).

The most common systemic diseases among cases include diabetes (37.9 %), followed by cardiovascular diseases (28.6 %) and thyroid disorders (15 %). Other conditions, including obesity (7.1 %), respiratory infections (5.8 %), and neurological/psychological problems (4.2 %) were less frequent. Notably, no cases of cancer or stroke were reported in this study population.

Additionally, 11.4 % of cases had other systemic diseases which included autoimmune (e.g: Myasthenia Gravis, Sjogren's Syndrome, Psoriasis, Rheumatoid Arthritis etc) and infectious diseases (HIV/AIDS, Tuberculosis, Pneumonia etc) (Table 2).

Overall, 68.6 % of study participants experienced missing teeth. A higher percentage of cases (87.1 %) had greater number of missing teeth compared to controls (50 %) and the difference was statistically significant ($p = 0.0001$). The overall mean number of missing teeth in the total study population was 1.00 ± 1.94. Cases had significantly higher mean number of missing teeth (1.56 ± 2.54) compared to controls (0.44 ± 1.34) ($p = 0.0001$) (Table 3).

Overall, more than half of the study participants (62.1 %) had a Tooth Loss Index Score 0, indicating no tooth loss due to caries or periodontal disease. None of the study participants had a Tooth Loss Index Score 5 (completely edentulous). A statistically significant difference ($p = 0.0001$) was observed among cases and controls based on Tooth Loss Index Scores. Only 40 % of cases had Tooth Loss Index Score 0 (no tooth loss due to caries or periodontal disease), compared to 84.29

Table 1
Comparison of cases and controls based on demographic characteristics.

Demographic characteristics	n (%)		p-value	n (%)
	Cases	Controls		Total
Age group				
18–25yrs	14 (10)	14 (10)	1.00	28 (10)
26–35yrs	41 (29.2)	41 (29.2)		82 (29.2)
36–45yrs	60 (43)	60 (43)		120 (42.9)
46–55yrs	13 (9.2)	13 (9.2)		26 (9.3)
≥56yrs	12 (8.6)	12 (8.6)		24 (8.6)
Gender				
Male	74 (52.9)	74 (52.9)	0.63	148 (52.9)
Female	66 (47.1)	66 (47.1)		132 (47.1)
Education				
No formal education	44 (31.4)	40 (28.6)	**0.01***	84 (30)
Up to primary school	24 (17.1)	9 (6.4)		33 (11.8)
Middle school to higher secondary	33 (23.6)	48 (34.2)		81 (29)
Diploma, Graduate and above	39 (27.9)	43 (30.8)		82 (29.2)
Alcohol consumption				
Yes	41 (29.3)	21 (15)	**0.01***	62 (22.1)
No	83 (59.3)	101 (72.1)		184 (65.8)
Occasionally	16 (11.4)	18 (12.9)		34 (12.1)
Cigarette smoking				
Non-smoker	85 (60.8)	107 (76.4)	**0.01***	192 (68.6)
Ex-smoker	6 (4.2)	6 (4.3)		12 (4.3)
Current smoker	49 (35)	27 (19.3)		72 (27.1)
Tooth brushing				
Yes	136 (97.1)	140 (100)	**0.04***	276 (98.6)
No	4 (2.9)	0 (0)		4 (1.4)
Flossing				
Yes	6 (4.3)	19 (13.6)	**0.006***	25 (8.9)
No	134 (95.7)	121 (86.4)		255 (91.1)
Tooth brushing frequency				
None	0 (0)	2 (1.4)	0.29	2 (0.7)
1	128 (91.4)	123 (87.9)		251 (89.6)
2	12 (8.6)	15 (10.7)		27 (9.7)
Total	**140 (100)**	**140 (100)**		**280 (100)**

*$p \leq 0.05$ is considered statistically significant.

Table 2
Frequency distribution of chronic systemic diseases among cases.

Systemic diseases	n (%)
Diabetes	53 (37.9)
Cardiovascular diseases	40 (28.6)
Thyroid disorder	21 (15)
Obesity	10 (7.1)
Respiratory infections	8 (5.8)
Neurological and psychological problems	6 (4.2)
Bone/Joint diseases	2 (1.4)
Renal disease	2 (1.4)
Gastrointestinal Problems	2 (1.4)
Cancer	0 (0)
Stroke	0 (0)
Others[a]	16 (11.4)

[a] Other diseases include Autoimmune diseases & Infectious diseases.

Table 3
Comparison among cases and controls based on number of missing teeth.

Group	Participants with missing teeth n (%)	Mean number of missing teeth±SD	p-value
Cases	122 (87.1)	1.56 ± 2.54	**0.0001***
Controls	70 (50)	0.44 ± 1.34	
Total	**192 (68.6)**	**1.00 ± 1.94**	

% of controls. Furthermore, for sequential scores (Scores 1–4), the number of cases was consistently higher than controls (Table 4).

Overall, mean Tooth Loss Index score for the study population was 0.53 ± 0.74. and was significantly higher among cases (0.91 ± 1.12) compared to controls (0.16 ± 0.37) (p = 0.0001) (Table 5).

Table 4
Comparison of cases and controls based on tooth loss index scores.

Tooth Loss Index Scores	Tooth loss Index	n (%)		p-value	n (%)
		Cases	Controls		Total
Score 0	No tooth loss due to caries or Periodontal disease	56 (40)	118 (84.2)	**0.0001***	174 (62.1)
Score 1	Loss of 1–4 permanent first molar	66 (47.1)	22 (15.8)		88 (31.4)
Score 2	Loss of up to 12 posterior teeth, excluding first permanent molars	4 (2.9)	0 (0)		4 (1.4)
Score 3	Loss of up to 12 teeth including an anterior tooth	2 (1.4)	0 (0)		2 (0.8)
Score 4	Loss of more than 12 teeth	12 (8.6)	0 (0)		12 (4.3)
Score 5	Edentulous	0 (0)	0 (0)		0 (0)
Total		**140 (100)**	**140 (100)**		**280 (100)**

*$p \leq 0.05$ is considered statistically significant.

Though middle age group [26–35 (OR = 1.17) and 36–45 (OR = 1.03)] and females (OR = 1.12) had higher odds of Tooth Loss Index scores, association was not statistically significant. However, education played a significant role, wherein cases without formal education had 2.5 times higher odds of experiencing increased Tooth Loss Index scores (p = 0.03) compared to those with higher levels of education.

Alcohol consumption and smoking were strongly associated with tooth loss index scores among cases. Individuals who consumed alcohol had significantly higher odds of increased Tooth Loss Index Scores (OR = 1.27, p = 0.0001) compared to non-alcoholics. Likewise, both ex-smokers (OR = 1.26, p = 0.03) and current smokers (OR = 1.62, p = 0.002) had significantly greater odds of higher Tooth Loss Index scores compared to non-smokers.

In contrast, oral hygiene behaviours, including tooth brushing, flossing and tooth brushing frequency were not significantly associated with Tooth Loss Index scores among cases.

Compared to controls, cases were nearly four times more likely to experience significant Tooth Loss Index score. (OR = 3.82, p = 0.0001) (Table 6).

A strong positive correlation was observed among cases (r = 0.82, p = 0.0001), suggesting a significant relationship between systemic diseases and increased tooth loss index. In contrast, controls exhibited a weaker yet statistically significant correlation (r = 0.41, p = 0.0001) (Table 7)

4. Discussion

The present study highlighted that individuals with systemic diseases (Cases) experience a significantly higher rate of tooth loss compared to controls, suggesting that systemic conditions show a strong association

Table 5
Comparison of cases and controls based on mean tooth loss index score.

Group	Mean	p-value
Cases	0.91 ± 1.12	**0.0001***
Controls	0.16 ± 0.37	
Total	**0.53 ± 0.74**	

*$p \leq 0.05$ is considered statistically significant.

Table 6
Multiple Logistic Regression Analysis Among Cases based on Tooth Loss Index Scores (Score 1–4).

Variables	OR	95 % CI for OR		p-value
		Lower	Upper	
Age groups				
18–25yrs	**Ref.**			
26–35yrs	1.17	0.64	2.16	0.61
36–45yrs	1.03	0.59	1.80	0.91
46–55yrs	0.92	0.40	2.13	0.84
≥56yrs	0.88	0.37	2.10	0.78
Gender				
Male	**Ref.**			
Female	1.12	0.71	1.77	0.63
Education				
No formal education	2.50	1.06	5.92	**0.03***
Up to primary school	0.61	0.34	1.12	0.11
Middle school to Higher Secondary	0.80	0.45	1.43	0.44
Diploma, Graduate and above	**Ref.**			
Alcohol consumption				
Yes	1.27	0.49	3.28	**0.0001***
No	**Ref.**			
Occasionally	0.71	0.31	1.63	0.41
Cigarette smoking				
Non-smoker	**Ref.**			
Ex-smoker	1.26	0.36	4.44	**0.03***
Current smoker	1.62	0.67	3.91	**0.002***
Tooth brushing				
Yes	**Ref.**			
No	0.00	0.00	–	0.99
Flossing				
Yes	**Ref.**			
No	1.11	0.87	1.42	0.41
Tooth brushing frequency				
None	0.00	0.00	–	0.99
1	1.04	0.81	1.33	0.75
2	**Ref.**			
Systemic diseases				
Cases	3.82	2.39	6.11	**0.001***
Controls	**Ref.**			

*$p \leq 0.05$ is considered statistically significant.
Ref.: Reference category used for comparison in logistic regression analysis. Odds ratios for other categories are calculated relative to this reference group.

Table 7
Correlation of tooth loss index scores (score 1–4) with cases and controls.

Groups	n	r-value	p-value
Cases	140	0.82	**0.0001***
Controls	140	0.41	**0.0001***
Total	280	0.79	**0.0001***

*$p \leq 0.05$ is considered statistically significant.

oral health deterioration. This relationship reinforces the importance of considering oral health as an integral part of managing chronic systemic conditions.

In this study, the adults aged 18 years and above were selected as to ensure a comprehensive assessment of tooth loss across different age groups while maintaining relevance to systemic diseases. Many systemic diseases, such as diabetes, cardiovascular diseases, and thyroid disorders, typically manifest in adulthood, making this population more relevant for studying their association with oral health. Including younger adults also provides insights into early-onset tooth loss related to lifestyle factors, such as smoking and alcohol consumption, which can contribute to periodontal disease progression. This broad age range ensures that findings are applicable across different life stages and allows for early identification of risk factors contributing to long-term dental deterioration.

Tooth Loss Index (TLI) by Batista MJ[6] was chosen for this study as it provides a standardized and validated method to assess tooth loss systematically. This index categorizes tooth loss beyond a simple count, allowing for a comprehensive evaluation of missing teeth.

Educational status emerged as significant predictor of tooth loss in the present study. Similarly, study conducted by Vettore et al.[11] reported that individuals with lower educational levels are more likely to exhibit increased risk of periodontal disease. This finding could be due to limited oral health knowledge, reduced access to dental care, and poor lifestyle choices. Inadequate awareness regarding appropriate oral hygiene practices and the importance of preventive care can lead to delayed diagnosis and management of dental conditions, thereby increasing the likelihood of tooth loss. Furthermore, financial constraints and lower health literacy commonly associated with lower educational levels may result in infrequent dental visits, where tooth extraction is often preferred over restorative interventions due to cost and accessibility issues[12].

The study also identified significant associations between alcohol consumption and smoking, with elevated Tooth Loss Index Scores. This finding aligns with the observations of Rooban et al.,[13] where a positive association between alcohol use and subsequent tooth loss was reported. Chronic alcohol intake may adversely affect oral hygiene practices and contribute to xerostomia (dry mouth), thereby reducing salivary flow—a key factor in acid neutralization and inhibition of bacterial proliferation. Moreover, alcohol acts as a pro-inflammatory agent, intensifying both systemic and periodontal inflammation, which can accelerate the destruction of periodontal tissues and alveolar bone, ultimately leading to tooth loss.[14]

Similarly, both ex-smokers and current smokers demonstrated significantly higher odds of elevated Tooth Loss Index scores. This observation is consistent with the findings of Leite et al.[14], who reported that smoking contributes to accelerated periodontal destruction, ultimately resulting in increased tooth loss over time. Tobacco use compromises gingival blood flow, impairs host immune responses, and promotes alveolar bone resorption, all of which contribute to heightened tooth mobility and eventual tooth loss.[15] Notably, even after smoking cessation, the detrimental effects on periodontal structures may persist. Former smokers may continue to experience progressive oral health decline due to residual inflammation and persistent alterations in the oral microbiome. Furthermore, smoking fosters an environment conducive to the proliferation of pathogenic bacterial species, thereby exacerbating the risk of periodontal disease.[16]

Interestingly, oral hygiene behaviours, including tooth brushing, flossing, and brushing frequency, were not significantly associated with Tooth Loss Index scores. While previous studies such as Kaira et al.[17] emphasized the role of oral hygiene in reducing the risk of periodontal disease and tooth loss, the present study suggests that systemic factors and lifestyle behaviours may have a more pronounced effect on tooth loss. This observation is further supported by the findings of Albandar and Rams,[18] indicating that although oral hygiene contributes to periodontal health, systemic conditions and behavioural risk factors exert a stronger influence on disease progression and tooth loss. Because nearly all participants brushed once daily, there was limited variability, reducing the chance of detecting an association. Future studies with more detailed assessment of oral hygiene behaviours are required.

A study by Chapple et al.[19] found that individuals with systemic diseases such as diabetes and cardiovascular diseases exhibit a higher prevalence of periodontal disease, leading to greater tooth loss. Similarly, Taylor et al.[20] highlighted the bidirectional relationship between diabetes and periodontal disease, where uncontrolled diabetes exacerbates periodontal breakdown, resulting in a higher number of missing teeth. Our study further supports this association by revealing that individuals with systemic diseases (cases) were nearly four times more likely to experience greater tooth loss (OR = 3.82, p = 0.0001).

Systemic diseases may influence tooth loss by exacerbating periodontal disease, impairing immune response, and altering oral microbiota. Conditions like diabetes increase pro-inflammatory cytokines and impair wound healing, accelerating periodontal breakdown.[21]

Cardiovascular diseases and autoimmune disorders promote chronic inflammation, leading to alveolar bone loss. Additionally, xerostomia (dry mouth) caused by thyroid disorders and medications reduces saliva's protective role, increasing the risk of caries and periodontal disease.

The correlation analysis among cases and controls with tooth loss index scores in this study reinforces the significant relationship between systemic diseases (Cases) and tooth loss. A strong positive correlation was observed among cases, further emphasizing the role of systemic health in oral disease progression. The weaker correlation observed among controls suggests that while tooth loss does occur in individuals without systemic diseases, its severity is comparatively lower. These findings are consistent with those of Holm,[22] who reported that systemic conditions accelerate oral health deterioration, leading to more pronounced tooth loss in affected individuals.

As this is a case-control design, causation cannot be inferred. Reverse causality is also possible, where long-standing poor oral health may contribute to systemic inflammation.

The study's strengths include its age and gender-matched case-control design, which minimizes confounding, and the comprehensive assessment of tooth loss using both Tooth Loss Index (TLI) scores and the number of missing teeth. By analyzing systemic diseases, lifestyle factors, and education levels, the study provides a holistic understanding of factors influencing tooth loss. Additionally, the findings are statistically significant and hold clinical and public health relevance, emphasizing the importance of oral health education and preventive care.

However, the study has limitations, including self-reported data on habits like smoking and alcohol consumption, which may introduce recall bias. Data on dietary habits, socioeconomic status, frequency of dental visits, and genetic predispositions were not collected, and these unmeasured confounders may have influenced the findings. Systemic diseases were grouped into a single category (cases), which does not allow identification of disease-specific effects. This grouping was necessitated by the small number of participants within individual disease categories. Some logistic regression estimates showed wide confidence intervals, indicating limited statistical precision. These results should be interpreted cautiously, and future studies with larger sample sizes are needed to obtain more stable estimates. Despite these limitations, the study provides valuable insights, highlighting the need for further longitudinal research to establish causal relationships.

5. Conclusion

The present study demonstrated a significantly higher odds of tooth loss among adults with systemic diseases compared to healthy controls. Factors such as low education, alcohol consumption, and smoking were significant predictors associated with increased tooth loss, while oral hygiene practices showed no significant association. The findings emphasize the need for integrated oral health strategies targeting individuals with systemic conditions to promote early prevention and reduce the burden of tooth loss.

Funding information

This research did not receive any specific grant from funding agencies in public, commercial, or not to profit sectors.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

I would sincerely thank the Department of Public Health Dentistry, Government Dental College and Hospital, Hyderabad, for providing the facilities and support to conduct this research. We are grateful to the faculty and postgraduate colleagues for their valuable guidance and assistance during data collection.

We also acknowledge the cooperation of all study participants.

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