



PERIODONTAL STATUS IN ADULTS EXPOSED TO SMOKED TOBACCO (CONVENTIONAL CIGARETTE VS. E-CIGARETTE): A SINGLE-CENTRE STUDY

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Abstract

Background: The increased trend of e-cigarettes among young adults has become a popular alternative to traditional cigarette smoking. Proponents believed it to be a safer alternative to smoking, citing lower exposure to many of the poisonous compounds found in tobacco smoke. However, the influence of e-cigarettes on oral health has gained increased interest among researchers and dental practitioners.

Objectives: To assess the frequency of cigarette and e-cigarette smokers and to evaluate their association with periodontitis.

Methods: An analytical cross-sectional study was conducted among 360 participants aged between 18 and 60 who visited the dental OPD of a public sector university. A validated questionnaire was administered to record demographic details, oral hygiene practices, and consumption practices of cigarettes and e-cigarettes. The periodontal assessment was done using CPI and CAL indices. The association of periodontal status among the groups was reported using Pearson's chi-square test, while logistic regression was performed for multivariate analysis.

Results: Participants with periodontitis reported more consumption of cigarettes, while participants with generalized chronic periodontitis reported more consumption of e-cigarettes. There was a significant association between the status of periodontitis and the type of smoker ($p < 0.001$). The multivariate logistic regression analysis showed that e-cigarette smokers (OR=5.42), primary education (OR=4.29), graduates (OR=4.30), good oral hygiene (OR=0.04), fair oral hygiene (OR=0.05), and use of fluoridated tooth paste (OR=0.45) were significant risk factors for generalized periodontitis.

Conclusion: Compared to conventional cigarette smokers, e-cigarette smokers have a profound detrimental effect on periodontium, measured by periodontal parameters (CAL & PD).

Keywords: cigarette smoking; e-cigarette smoking; periodontitis, vaping, periodontal health, periodontal pocket.

Introduction

Periodontitis is polymicrobial in origin and chronic inflammatory disease that progressively destroys the tooth-supporting apparatus. Smoking is enumerated as a significant and primary risk factor affecting periodontal health.¹ Smoking causes changes in the host immunological response and the microbiota of the oral cavity, making the oral tissue more prone to infection. It has been identified from the literature that more severe periodontal diseases exist with increased bone attachment loss, the recession of gingiva, and the formation of pockets in smokers when compared to non-smokers.² The dose-response relationship has been detected between the number of cigarettes smoked per day and the odds of periodontal disease.³

The massive rise in the use of e-cigarettes by adults and teenagers globally is alarmingly high and at concerning levels, especially in the low and middle-income countries (LMICs). In contemporary years, former and novel tobacco users have shifted to alternatives substitutes such as vaporizers, vape and e-pens, e-hookahs, pipes, and cigars, which are categorized as electronic nicotine delivery systems (ENDS). ENDS are considered as tobacco products that are not combustible and are usually recharged via USB ports.⁴ With every inhalation puff, e-cigarettes evaporate "e-liquid" inside a heating chamber, exposing the user to nicotine mixed with a base (often propylene glycol), concentrating flavorings along with chemicals that put the user at risk for addiction and other negative consequences of systemic and oral health. The e-liquid is available in a variety of flavors with significantly varying nicotine concentrations contingent on the brand and taste selected. These flavorings of the ENDS products had different toxicity of the aerosol.

Pakistan has reported 6.2% e-cigarette users which higher than other South Asian countries; India and Bangladesh constitute the small proportion of 0.02%, and 0.2% respectively.⁵ The youth in Pakistan are particularly susceptible to the appeal of e-cigarette, as it is often marketed as a trendy and socially acceptable activity.⁶ Considering e-cigarette as innocuous alternative to cigarette smoking, e-cigarette now emerged as the solution to the problem of the general population especially adults and teenagers. Numerous studies have shown that e-cigarettes are less harmful than traditional cigarettes, which have well-established deleterious effects on every bodily system in the body. They cut the environmental hazards by producing a lesser amount of passive smoke. It is shown that the vapors from e-cigarette has no inflammatory and cytotoxic effects when inhaled. The adverse marketing practices which claim that e-cigarettes assist people in quitting smoking make the case for increasing demand for it.⁷

However, the number of the cigarette smoked decreases while switching to e-cigarettes, but complete withdrawal is not achieved, and there is still a significant chance of acquiring smoking-related disorders, especially oral diseases. The literature reported nicotine as a known gateway drug leading to the more serious addiction than other addictive substances, and this can be an alarming scenario with the emerging use of e-cigarettes, which can become a new direction toward nicotine addiction in the population.⁸ The aerosol from e-cigarettes contains volatile organic chemicals, metals, aldehydes, and nitrosamines that are unique to tobacco. These substances may change the oral flora and negatively impact dental health. A disturbance of the oral microbiome, specifically with regard to commensal bacteria, may result in dysbiosis and a rise in pathobionts, both of which may cause detrimental effects of the mouth, including periodontal disease. Concentrating on a link between vaping and oral health, a new study examined the relationship between vaping and oral health and found that exposure to e-cigarettes causes carbonyl stress, which raises cyclooxygenase 2 and prostaglandin E2 levels in epithelium of human gingiva when compared to control.⁹ Numerous studies evaluated the effect of vaping on periodontium and establishes that higher levels of plaque index, periodontal pocket depth, clinical attachment loss, and marginal bone loss was observed in vaping groups compared to non-smokers.⁹⁻¹²

Nevertheless, these contradicting evidences reported from literature and paucity of data from our population along with high rise of e-cigarette user highlights the need to conduct a study to assess the frequency of cigarette and e-cigarette smokers and to evaluate its association with type of periodontitis.

Methods

Study type:

An analytical cross-sectional study.

Study setting:

Dow University of Health Sciences

Enrolment of the Participants:

A total of 360 participants aged above 18 years were enrolled in this analytical cross-sectional study. The ones who had more than 6 natural teeth been included in the study. The individuals who were non-cooperative or who had their periodontal treatment during last three months before the study were excluded.

Sample Size Estimation:

The sample size is calculated using Open Epi software. With 95% confidence interval, 80% power, and 5% level of significance, the calculated sample size was 313.¹³ However, the sample size was increased by 15%, so the total sample size was 360. This was done in order to overcome any missing data and to accommodate equal number of participants in all the three groups.

Data Collection Method:

The participants were approached via non-probability convenient sampling technique till the required sample size was achieved. Written consent was sought from all the respondents. A validated questionnaire comprising information about the respondent's demographic details, oral hygiene practices, and cigarette or e-cigarette consumption details was administered by the examiner. To verify the construct validity back translation method was used. To assure that there was clear understanding of the questions asked, the questionnaire was constructed in English and translated into local language (Urdu) and then back to English.

Participants were divided into three groups: Cigarette Smokers, E-cigarette Smokers and Non-smokers (who never consumed any form of tobacco). CPI and OHI-S indices was used to assess periodontal parameters and oral hygiene respectively. The case definition of periodontitis was measured at minimum 1 site with probing pocket depth (PPD) ≥ 4 mm or 2 sites on different teeth with periodontal clinical attachment level (CAL) ≥ 4 mm ; generalized chronic periodontitis (minimum 30% site with CAL ≥ 4 mm); minimum five sites with CAL ≥ 6 mm.¹⁴

All examinations were done in the dental OPD with seated in an upright chair using mouth mirrors, and periodontal probes. Examiner was calibrated for examination. Inter examiner reliability was reported to be almost in perfect agreement (Kappa statistics = 0.84).

Statistical Analysis:

The collected data was analyzed by using IBM SPSS Statistics 27. Continuous variable (age) was expressed using median and interquartile as the data of age was not normally distributed. Categorical variables were measured by frequency and percentages. Pearson's Chi-square test was used to find the association of periodontitis among three study groups. Further, the univariate and multivariate binary logistic regression analyses were applied to see the effect of covariates on two smoker groups (E-cigarette verses Cigarette). A value of $p < 0.05$ was considered statistically significant.

Results

A total of 360 participants were included in the study. There were equal proportions (n=120, 33.3%) of all three study groups: cigarette smokers, E-cigarette smokers, and non-smokers. Further, this study population contained (n=115, 31.9%) periodontitis, (n=130, 36.2%) generalized chronic periodontitis, and (n=115, 31.9%) in no periodontitis. Figure 1 illustrates the frequency distribution of periodontitis status of participants according to smokers groups. Participants with periodontitis reported more

consumption of cigarette (n=81, 22.50%) while participants with generalized chronic periodontitis reported more consumption of e-cigarette (n=89, 24.72%).

The median age of the participants was 31 (IQR 17) years. Most of the participants were male in the study group (n=227, 63.1%). Most of the participants had fair (n=153, 42.5%) and poor (n=152, 42.2%) oral hygiene status (OHS). All demographic variables age, gender, marital status, educational status, and occupation were significantly associated with periodontitis status ($p < 0.001$). The oral hygiene status (OHS) and smokers groups were also found to be statistically significant ($p < 0.001$) (Table 1).

Majority of the participants reported tooth brushing (n=348, 96.7%), once daily cleaning teeth (n=200, 55.6%) and use of fluoridated toothpaste (n=301, 83.6%) but not used of mouthwash (n=275, 76.4%), dental floss (n=337, 93.6%), and professional cleaning (n=248, 68.9%). There was significant association of frequency of cleaning teeth, use of fluoridated toothpaste, mouthwash, dental floss, and professional cleaning with periodontitis status ($p < 0.05$) (Table 2).

For logistic regression analysis, non-smokers group and no periodontitis group was excluded. The univariate and multivariate binary logistic regression analysis was performed to see the effects of covariates on generalized chronic periodontitis verses periodontitis. The univariate analysis showed that E-cigarette smokers (OR=5.96, 95% CI= 3.40, 10.40; $p < 0.001$), marital status (OR=2.83, 95% CI= 1.60, 5.02; $p < 0.001$), secondary education (OR=4.29, 95% CI= 1.93, 9.52; $p < 0.001$), good oral hygiene (OR=0.02, 95% CI= 0.003, 0.18; $p < 0.001$), fair oral hygiene (OR=0.07, 95% CI= 0.04, 0.14; $p < 0.001$), use of fluoridated tooth paste (OR=0.18, 95% CI= 0.07, 0.40; $p < 0.001$), and use of mouth wash (OR=0.27, 95% CI= 0.14, 0.52; $p < 0.001$) were significantly associated with generalized periodontitis. The multivariate analysis showed that E-cigarette smokers (OR=5.42, 95% CI= 2.52, 11.69; $p < 0.001$), primary education (OR=4.29, 95% CI= 1.18, 15.51; $p = 0.027$), graduates (OR=4.30, 95% CI= 1.44, 12.83; $p = 0.009$), good oral hygiene (OR=0.04, 95% CI= 0.004, 0.32; $p = 0.003$), fair oral hygiene (OR=0.05, 95% CI= 0.02, 0.12; $p < 0.001$), and use of fluoridated tooth paste (OR=0.45, 95% CI= 0.16, 1.30; $p=0.014$) were significant risk factors of generalized periodontitis (Table 3).

Discussion

The target of having a generation free of tobacco use is troubled by the growing frequency of e-cigarette usage among youth. This study deals current statistics on the prevalence of e-cigarette use and its effect on periodontitis along with the conventional cigarette smoking, which may be used as a starting point for monitoring and assessment initiatives in our population.

In our study, the prevalence of generalized chronic periodontitis was found higher in the group who used e-cigarette than conventional cigarette smokers. Other studies have related parallel findings that individuals using e-cigarette have more chances of worsening of periodontal status. A study led by Jeong W et al.¹⁵ was in agreement with the outcomes of our study reporting a significant association between conventional cigarette and e-cigarette smoking with periodontitis. In the current study, we look more into severity of the periodontal diseases and reported that e-cigarette smokers had more chances of having generalized chronic periodontitis as compared to periodontitis in relation to conventional cigarette smokers (OR=5.96). These outcomes stipulate that quitting either type of cigarette smoking offers a substantial benefit to periodontal health. On the contrary with the literature, our study does not suggest the e-cigarette can be used as an alternative to conventional cigarette smoking cessation strategy.¹⁶

One of limitation is that when compared, conventional cigarette smokers which switched to e-cigarette smoking might demonstrate the higher probability and high degree of the periodontal disease, which were not recorded in the current study.

In the present study, the level of education was significantly associated with generalized chronic periodontitis. The probability of high level of education of the study participants having generalized chronic periodontitis was significantly high (OR=4.30). Nonetheless, a study from Hamburg City, Germany presented a significant association between low level of education and periodontitis, even

after adjusting for co-variables (OR=1.33, p-value < 0.001).¹⁷ Similarly, the National Health and Nutrition Examination Survey III (NHANES III) revealed low level of schooling had a higher risk of developing periodontitis which are not in agreement with the result of our study.¹⁸

This finding may be explained by the fact that majority of the study participants were university graduate (55%) among which e-cigarette users were 30% and participants with generalized chronic periodontitis were more frequent e-cigarette users, referring to e-cigarette as a social symbol and its increasing acceptance among general population. Contradictory trend among study participants with postgraduate level of education was observed in the research from China, reporting the likelihood of using of e-cigarette decreased with increasing educational attainment.¹⁹ These outcomes highlight the lack of regulations of e-cigarette use, advertising malpractice and unrestricted practices that appeal the youth and promote the use of e-cigarette despite of trepidations about the potential for nicotine addiction and the long-term effects on health.

From our perspective, no other study aimed to find effect of conventional cigarette and e-cigarette smokers on types of periodontitis. The data for this study was collected from general OPD rather than targeting e-cigarette shops or any online websites dedicated to e-cigarette, hence avoiding selection bias.

One of the limitations of the research was no female participants reported use of conventional cigarette, which might be attributed to cultural prejudices that prevented women from participating or caused fewer or no women to smoke conventional cigarette. However, the ratio of male to female conventional cigarette smokers was consistent with the overall trend seen in Pakistan.²⁰ But the alarming concern of the finding present the exponentially increase use of e-cigarette among females refer to upsurge in popularity of e-cigarettes therefore females do not find such taboo against using e-cigarette in contrast to cigarette smoking. Moreover, the females who were university graduate reported high consumption of e-cigarette. Again, this indicated the growing trend of e-cigarettes particularly among the youth of Pakistan.

The findings of this research are relevant as Pakistan have high tobacco-related health burden and inadequate resources to offer tobacco cessation. It is important for the government of Pakistan to enforce regulations to address the concerns related to the use of e-cigarette and protect the community from the potential harm.

Conclusion

Smoking in either form was found to affect the periodontal status. Increased generalized chronic periodontitis was observed among e-cigarette smokers whereas, cigarette smokers had increased periodontitis.

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Conflict of Interest

All authors acknowledged no conflict of interest.

Ethical Approval

This protocol was approved by Institutional Review Board (IRB) of Dow University of Health Sciences (DUHS) (**IRB-2825/DUHS/Approval/2022/24**).

Authors Contributions

SA and SM conceived and designed the study. JU collected the data. HFW and SA did statistical analysis and interpretation of the data. SM and MU drafted the manuscript. SS critically reviewed the manuscript.

All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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List of Abbreviations

- CPI Community Periodontal Index
- OHI-S Oral Hygiene Index-Simplified
- LMICs Low and Middle Income Countries
- ENDs Electronic Nicotine Delivery systems
- CAL Clinical Attachment Loss
- PPD Periodontal Pocket Depth
- OHS Oral hygiene Status
- OPD Outpatient department

Legends of Figure and Tables

Figure 1: Frequency distribution of periodontitis status according to smokers groups.

Table 1: Demographic characteristics of participants according to periodontitis status.

Table 2: Oral hygiene characteristics according to periodontitis status (n=360).

Table 3. Univariate and multivariate analysis of participant’s characteristics according to periodontitis (generalized chronic periodontitis vs. periodontitis)

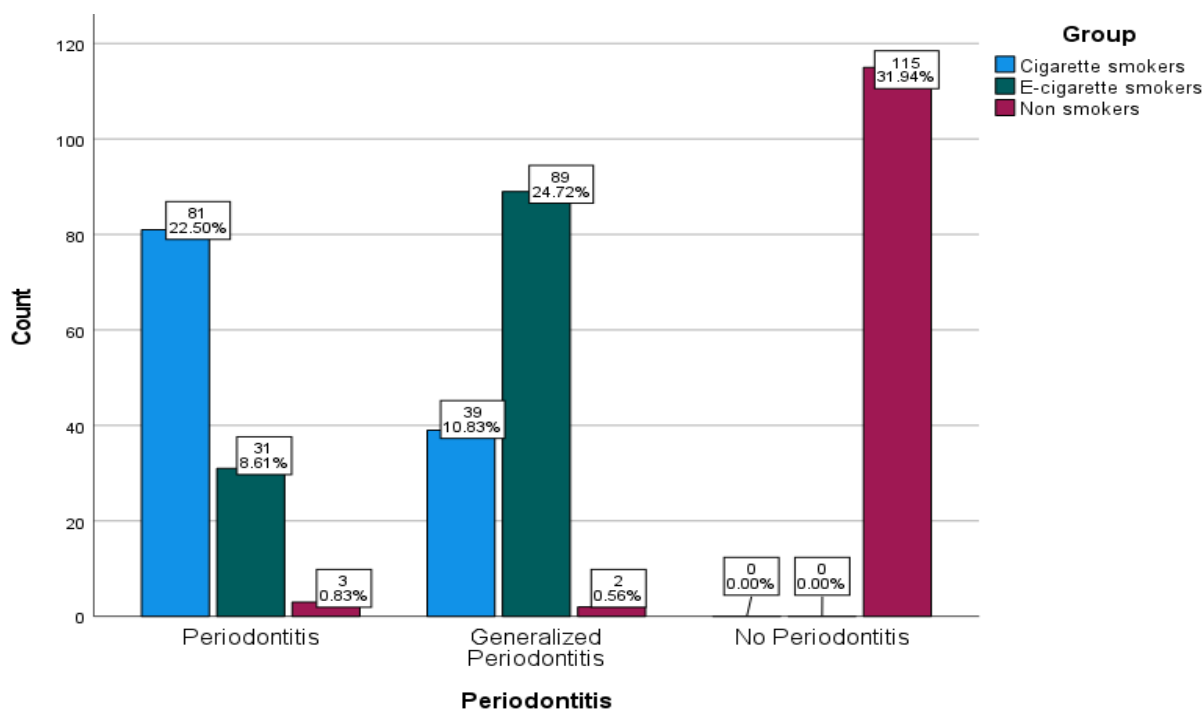


Figure 1: Frequency distribution of periodontitis status according to smokers groups

Table 1: Demographic characteristics of participants according to periodontitis status						
Characteristics		Total	Periodontitis	Generalized Chronic Periodontitis	No Periodontitis	p-value
		(n=360)	(n=115)	(n=130)	(n=115)	
		Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	
Age (years)		31 (17)	29 (12) ^{ab,ac}	39 (13) ^{ab,bc}	24 (13) ^{ac,bc}	< 0.001*
		n (%)	n (%)	n (%)	n (%)	
Gender						
	Male	227 (63.1)	94 (81.7)	94 (72.3)	39 (33.9)	< 0.001*
	Female	133 (36.9)	21 (18.3)	36 (27.7)	76 (66.1)	
Marital Status						
	Married	218 (60.6)	68 (59.1)	102 (78.5)	48 (41.7)	< 0.001*
	Unmarried	142 (39.4)	47 (40.9)	28 (21.5)	67 (58.3)	
Educational Status						
	Illiterate	48 (13.3)	13 (11.3)	24 (18.5)	11 (9.6)	< 0.001*
	Primary	55 (15.3)	11 (9.6)	31 (23.8)	13 (11.3)	
	Intermediate	59 (16.4)	17 (14.8)	22 (16.9)	20 (17.4)	
	University	198 (55)	74 (64.3)	53 (40.8)	71 (61.7)	
Occupation						
	No employment	152 (42.2)	34 (29.6)	38 (29.2)	80 (69.6)	< 0.001*
	Government job	41 (11.4)	18 (15.7)	19 (14.6)	4 (3.5)	
	Private job	128 (35.6)	45 (39.1)	64 (49.2)	19 (16.5)	
	Self-employment	39 (10.8)	18 (15.7)	9 (6.9)	12 (10.4)	
Oral hygiene status						
	Good	55 (15.3)	13 (11.3)	3 (2.3)	39 (33.9)	< 0.001*
	Fair	153 (42.5)	68 (59.1)	16 (12.3)	69 (60)	
	Poor	152 (42.2)	34 (29.6)	111 (85.4)	7 (6.1)	
Groups						
	Cigarette smokers	120 (33.3)	81 (70.4)	39 (30)	0 (0)	< 0.001*
	E-cigarette smokers	120 (33.3)	31 (27)	89 (68.5)	0 (0)	

	Non-smokers	120 (33.3)	3 (2.6)	2 (1.5)	115 (100)
*p-value calculated by using Kruskal Walli's test for continuous variable (Age) and post hoc analysis by Bonferroni correction & χ^2 for categorical variables					
^a Periodontitis, ^b Generalized Chronic Periodontitis, ^c No periodontitis represents significance of multiple comparison by the Bonferroni correction					

Table 2: Oral hygiene characteristics according to periodontitis status (n=360)

Characteristics		Total (n=360)	Periodontitis (n=115)	Generalized Chronic Periodontitis (n=130)	No Periodontitis (n=115)	p- value
Means of cleaning						
	Tooth brushing	348(96.7)	112(97.4)	124(95.4)	112(97.4)	0.595
	Miswak	12(3.3)	3(2.6)	6(4.6)	3(2.6)	
Frequency of cleaning teeth						
	Once	200(55.6)	74 (64.3)	81(62.3)	45(39.1)	< 0.001
	Twice	160(44.4)	41(35.7)	49(37.7)	70(60.9)	
Use of fluoridated toothpaste						
	Yes	301(83.6)	107(93)	96(73.8)	98(85.2)	< 0.001
	No	59(16.4)	8(7)	34(26.2)	17(14.8)	
Use of mouthwash						
	Yes	85(23.6)	41(35.7)	17(13.1)	27(23.5)	< 0.001
	No	275(76.4)	74(64.3)	113(86.9)	88(76.5)	
Use of dental floss						
	Yes	23(6.4)	2(1.7)	9(6.9)	12(10.4)	0.025
	No	337(93.6)	113(98.3)	121(93.1)	103(89.6)	
Professional cleaning						
	Yes	112(31.1)	45 (39.1)	39(30)	28(24.3)	0.049
	No	248(68.9)	70(60.9)	91(70)	87(75.7)	

p-value calculated by using χ^2 for categorical variables

Table 3. Univariate and multivariate analysis of participants characteristics according to periodontitis (generalized chronic periodontitis vs. periodontitis)

Variables	Univariate Analysis				Multivariate Analysis	
	Crude OR CI)	OR (95% CI)	p-value	Adjusted OR CI)	OR (95% CI)	P- value
Smoker groups						
	Cigarette smokers	1		1		

E-cigarette smokers	5.96 (3.40-10.40)	< 0.001*	5.42 (2.52-11.69)	< 0.001*
Marital Status				
Unmarried	1		1	
Married	2.83 (1.60-5.02)	< 0.001*	1.43 (0.59-3.45)	0.423
Educational Status				
Illiterate	1		1	
Primary	2.55 (1.19-5.48)	0.160	4.29 (1.18-15.51)	0.027*
Secondary	4.29 (1.93-9.52)	< 0.001*	1.98 (0.58-6.73)	0.271
University	1.71 (0.82-3.55)	0.151	4.30 (1.44-12.83)	0.009*
Gender				
Female	1			
Male	0.52 (0.27-1.00)	0.510		
OHI				
Poor	1		1	
Good	0.02 (0.003-0.18)	< 0.001*	0.04 (0.004-0.32)	0.003*
Fair	0.07 (0.04-0.14)	< 0.001*	0.05 (0.02-0.12)	< 0.001*
Occupation				
Nil	1			
Govt. job	0.90 (0.40-2.03)	0.810		
Private job	1.22 (0.66-2.26)	0.510		
Self - employed	0.43 (0.16-1.09)	0.070		
Use of fluoridated tooth paste				
No	1		1	
Yes	0.18 (0.07-0.40)	< 0.001*	0.45 (0.16-1.30)	0.014*
Use of mouth wash				
No	1		1	
Yes	0.27 (0.14-0.52)	< 0.001*	0.57 (0.23-1.44)	0.230
Use of dental floss				
No	1			
Yes	4.16 (0.87-19.67)	0.070		

Professional cleaning

No	1	
Yes	0.67 (0.39-1.15)	0.150

Means of Cleaning

Miswak	1	
Tooth brushing	0.56 (0.13-2.29)	0.420

*Univariate and multivariate binary logistic regression was applied for crude and adjusted odd ratios (ORs)