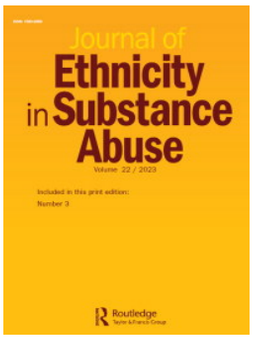

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Oral health and smoking in Bandare-Kong cohort study: a cross-sectional population-based study (findings from PERSIAN cohort study)

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ABSTRACT

Considering the harmful effects of smoking on oral and dental health, our aim was to investigate the oral and dental health status of people in the city of Bandare-Kong, Iran, and its relationship to smoking. This cross-sectional population-based study used baseline data from the Bandare-Kong Cohort Study. A total of 4063 participants aged 35–70 years were included in this study. Using Stata17 software, negative binomial regression was employed to identify factors related to the decayed, missing, and filled teeth (DMFT) index. The association between smoking status and DMFT was assessed by the adjusted incidence rate ratio (IRR). Of the 4063 participants, 987 (24.29%) used cigarettes, hookahs, or both. The mean ± standard error (SE) DMFT index in all subjects was 11.08 ± 0.15; it was 14.17 ± 0.53 for cigarette smokers and 12.39 ± 0.37 for hookah users ($p < 0.001$). After adjusting for other variables, the rate of DMFT for cigarette smokers was 0.33 (IRR: 1.33; 95% confidence interval [CI]: 1.22, 1.44), which was higher than for those who did not use cigarettes. The rate of DMFT for those who used cigarettes, hookahs, or both was 0.11 (IRR: 1.11; 95% CI: 1.05, 1.18), which was also higher than for those who did not smoke. Cigarette smoking is a risk factor for oral health complaints. Although the rate of DMFT was increased in hookah smokers, it was not a predictor of dental problems. However, we suggest that hookah use be included in educational policies to control oral and dental diseases.

Abbreviations: DMFT: decayed, missing, and filled teeth

KEYWORDS

DMFT index; oral health; cigarette smoking; hookah; Iran

Introduction

The epidemiology of smoking and its thousands of effects on human health have been studied extensively around the world. It is estimated that smoking causes 1 in 10 deaths worldwide (WHO, 2023). Also, although

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the rate of smoking among men remains high, the increase in smoking among women has raised concerns (WHO, 2023). Tobacco accounted for 8·71 million deaths (Murray et al., 2020). Currently, the prevalence of tobacco use in Iran is 25.2% in men and 4% in women (Riazi-Isfahani et al., 2022). The prevalence of smoking is higher in the south of Iran (Danaei et al., 2017; Nemati et al., 2017).

For many years, it was believed that smoking was the only cause of lung diseases, cancers, and cardiovascular diseases (Gallucci et al., 2020; Jeon et al., 2018). Scientists believed that smoking alone did not cause periodontal diseases but should be considered an aggravating factor, as the only difference between smokers and nonsmokers was the amount of plaque in their mouths. But studies in the last two decades have shown that smoking has a great effect on periodontal diseases and is one of the factors that can cause them (Sagtani et al., 2020; Zhang et al., 2019).

According to the World Dental Federation, "oral health is multifaceted and includes the ability to speak, smile, smell, taste, touch, chew, swallow, and convey a range of emotions through facial expressions with confidence and without pain, discomfort, and disease of the craniofacial complex" (Glick et al., 2016). Oral health is an essential aspect of overall health and well-being. The decayed, missing, and filled teeth (DMFT) index is a universal tool to assess oral and dental problems, and it is used to evaluate and monitor oral health interventions in a community (Moradi et al., 2020). Considering that the average number of DMFT is 18 for Iranian adults (Najafi et al., 2020), the oral health status of that population is not good (Moradi et al., 2020).

Previous studies indicated that tobacco smoking can have adverse effects on oral health, including tooth discoloration, periodontitis leading to tooth loss, impaired connective tissue repair, and even oral cancer (Akinkugbe, 2019; Bezerra et al., 2018; Carson & Burns, 2016; Csikar et al., 2016; Dye et al., 2006; Millar & Locker, 2007; Tanaka et al., 2005). Despite the increasing use of hookahs among some communities, few studies have included hookahs, with most focusing on cigarettes (Hadzic et al., 2020; Javed et al., 2016). In addition, these researchers studied special populations such as students (Hadzic et al., 2020) or males (Javed et al., 2016). The different geographic regions in Iran have different risk factors due to variations in culture and lifestyle (Moradinazar et al., 2020; Zahirian Moghadam et al., 2021), so the need to conduct separate studies in each region is undeniable. Given the special cultural and climatic characteristics of southern Iran, together with the popularity of hookah use among both men and women in Hormozgan province (Dadipoor et al., 2019; Ghanbarnejad et al., 2012), the effects of tobacco smoking via both cigarettes and hookahs must be investigated in this context. This study was conducted with the aim of determining the oral and dental health status of adults aged 35–70 living in the city of Bandare-Kong, Iran, and its

relationship to smoking. Bandare-Kong is an ancient port located at the southernmost point of Iran. It stands five meters above sea level and experiences hot summers and mild winters.

Materials and methods

Study design

This cross-sectional population-based study was conducted using baseline data from the Bandare-Kong Non-Communicable Diseases (BKNCD) Cohort Study, which was part of the Prospective Epidemiological Research Studies in Iran (PERSIAN) (http://persiancohort.com). Launched in 2016, the BKNCD study's purpose was to assess the prevalence and tackle the rising incidence of noncommunicable diseases in Iran and identify the risk factors associated with them. Details were published in the cohort study profile (Nejatizadeh et al., 2022).

This study was approved by the Ethical Review Board of Hormozgan University of Medical Sciences at No. IR.HUMS.REC.1401.170.

Study population

A total of 4063 participants aged 35–70 years were included in this study (Fig. 1). Sample collection was based on health center statistics and urban-rural divisions. In addition to informed consent and willingness to take part in the study, the criteria for participation were age 35 to 75 years, residence in Bandare-Kong for at least one year and nine months, and Iranian citizenship. Exclusion criteria included lack of interest and mental or physical disability (Nejatizadeh et al., 2022).

Data collection

Face-to-face interviews by highly qualified and trained interviewers were conducted using a questionnaire that covered demographics, lifestyle variables, eating habits, physical activity, and medical history.

A wealth score index (WSI) was estimated by multiple correspondence analysis (MCA) of the following variables: access to a freezer, access to a washing machine, access to a dishwasher, access to a computer, access to the internet, access to a motorcycle, access to a car (no access, access to a car with a price <50 million tomans, or access to a car with a price >50 million tomans), access to a vacuum cleaner, color TV type (no color TV, regular color TV, or plasma color TV), owning a mobile phone, owning a personal computer (PC) or laptop, and international trips in a lifetime (never, only pilgrimage, both pilgrimage and nonpilgrimage trips).

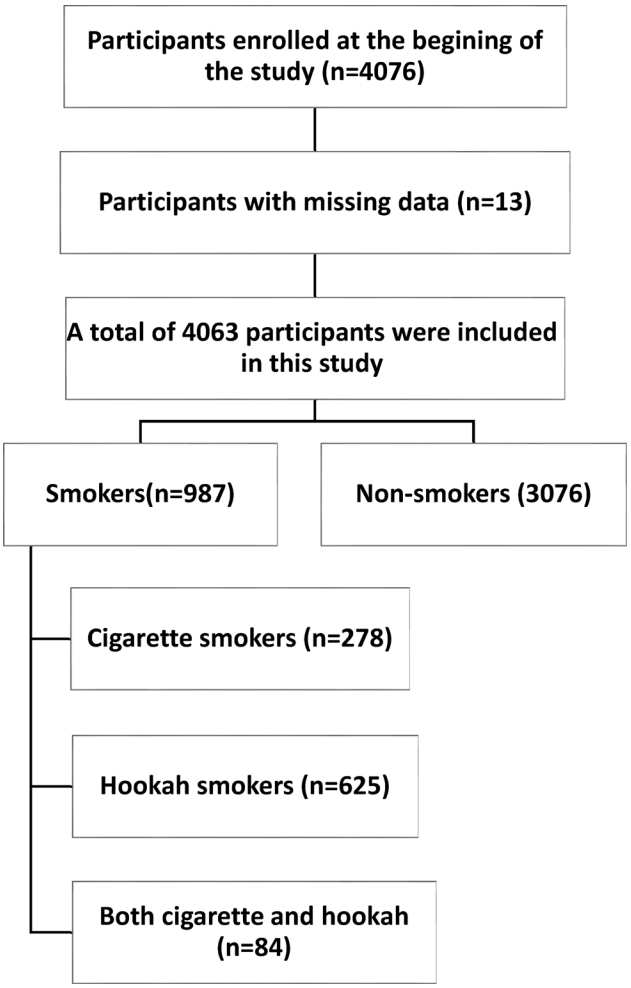

Figure 1. Flowchart of the sampling procedure.

Physical activity was estimated by calculating a metabolic equivalent of task (MET) for a number of activities for 24 hours to achieve an overall score. The activities included nighttime sleep; daytime sleep (naps); resting or lying in bed awake; watching TV or movies on a laptop or PC or listening to music; reading books, magazines, or newspapers; working while seated; eating; sitting in a meeting, party, or conference; driving a motorcycle, vehicle, or agricultural or road construction machinery; cooking; washing the dishes and similar activities while standing; house cleaning; washing clothes; sweeping floors and other light housework; walking; going down the stairs; brisk walking; light aerobic exercise; bicycling to work or for pleasure; heavy labor; agricultural activities; and professional sports activities. Participants were then divided into two groups: those with low physical activity and those with vigorous physical activity.

Participants' oral health status was assessed by the number of times they brushed their teeth, total number of natural teeth (not counting implants), number of decayed teeth (a tooth both filled and decayed was recorded as decayed), number of missing teeth (only teeth pulled as a result of decay were counted; congenitally missing teeth and teeth absent for other reasons, such as trauma, were not counted), number of teeth filled, existence of lesions inside the mouth, and whether participants flossed, had dentures, and used mouthwash. The DMFT index is the sum of the number of permanent teeth that are decayed, missing (due to caries), and filled. In this study, the overall DMFT index and its components (D, M, and F teeth) were dependent variables. Smoking was considered as background experience of smoking and current smoking separately for each waterpipe and cigarette.

Statistical analysis

Continuous variables were reported using means (standard deviation) or medians (interquartile range), and categorical variables were reported by number and percent. T-tests were used to determine whether the means of the two groups were equal; also, Mood's median test (a nonparametric test) was used to test the equality of medians from the two groups. An association between two categorical variables was determined by chi-square test.

Negative binomial regression was used to identify factors related to the DMFT index in three separate groups of cigarette users, hookah users, and nonsmokers. First, simple negative binomial regression was used to estimate the crude incidence rate ratio (IRR); then independent variables with p-values less than 0.25 were included in the multivariable negative binomial model. Finally, an association between smoking status and DMFT was assessed by an adjusted IRR. All analyses were carried out using Stata17 software, and $p < 0.05$ was considered statistically significant.

Results

A total of 4063 people aged 35–70 years, with an average age of 48.00 ± 9.00 years, participated in this study. Most were in the 35–44 age group (41.57%), and the majority of participants were female (57.45%). Among the participants, 987 (24.29%) used cigarettes, hookahs, or both; 2433 (59.88%) were illiterate or had only an elementary education; 3445 (84.79%) lived in urban areas; and 38.33% had a low wealth score. In addition, 1004 participants (24.89%) consumed a high amount of sugary substances each day, 634 (15.63%) had diabetes, and 323 (7.96%) had

Table 1. Participants' characteristics by smoking status.

		Cigarette			Hookah		
Variable	Total ($n=4063$)	Smoker ($n=362$)	Nonsmoker ($n=3701$)	p-Value	User ($n=709$)	Nonuser ($n=3354$)	p-Value
Quantitative variables are reported by mean (SD) or median (IQR)							
Age (years)	48 (9)	49 (8)	48 (10)	0.202	51 (10)	48 (9)	<0.001
Education (years)	5 (7)	5 (5)	5 (7)	0.013	4 (7)	5 (8)	<0.001
BMI (kg/m^2)	26.94 (5.01)	24.97 (0.25)	27.13 (0.08)	<0.001	26.54 (0.19)	27.03 (0.09)	0.018
Categorical variables are reported by number (%)							
Gender							
Male	1729 (42.55)	356 (8.76)	1373 (33.79)	<0.001	393 (9.76)	1318 (32.74)	<0.001
Female	2334 (57.45)	6 (0.15)	2328 (57.30)		316 (7.85)	1999 (49.65)	
Age (years)							
35–44	1689 (41.57)	122 (3.00)	1567 (38.57)	<0.001	232 (5.76)	1439 (35.74)	<0.001
45–54	1246 (30.67)	141 (3.47)	1105 (27.20)		197 (4.89)	1040 (25.83)	
55–64	881 (21.68)	89 (2.19)	792 (19.49)		206 (5.12)	670 (16.64)	
≥65	247 (6.08)	10 (0.25)	237 (5.83)		74 (1.84)	168 (4.17)	
Level of Education (years)							
≤5	2433 (59.88)	187 (4.60)	2246 (55.28)	<0.001	492 (12.22)	1926 (47.84)	<0.001
6–12	1289 (31.73)	155 (3.81)	1134 (27.91)		202 (5.02)	1069 (26.55)	
≥13	341 (8.39)	20 (0.49)	321 (7.90)		15 (0.37)	322 (8.00)	
Marital Status							
Never married	98 (2.41)	3 (0.07)	95 (2.34)	<0.001	8 (0.20)	85 (2.11)	<0.001
Married	3635 (89.47)	355 (8.74)	3280 (80.73)		608 (15.10)	2997 (74.44)	
Widow/divorced	330 (8.12)	4 (0.10)	326 (8.02)		93 (2.31)	235 (5.84)	
Residence							
Urban	3445 (84.79)	326 (8.02)	3119 (76.77)	0.003	579 (14.38)	2832 (70.34)	0.013
Rural	618 (15.21)	36 (0.89)	582 (14.32)		130 (3.23)	485 (12.05)	
BMI							
<25	1471 (36.46)	190 (4.71)	1281 (31.75)	<0.001	286 (7.14)	1170 (29.23)	0.007
≥25	2564 (63.54)	166 (4.11)	2398 (59.43)		415 (10.37)	2132 (53.26)	
Wealth Score Index							
Low	1543 (38.33)	138 (3.43)	1405 (34.90)	0.969	336 (8.39)	1201 (30.00)	<0.001
Middle	840 (20.86)	76 (1.89)	764 (18.98)		133 (3.32)	703 (17.56)	
High	1643 (40.81)	144 (3.58)	1499 (37.23)		235 (5.87)	1396 (34.87)	
Physical Activity							
Low	2032 (50.02)	183 (4.51)	1849 (45.52)	0.833	382 (9.49)	1625 (40.37)	0.018
Vigorous	2030 (49.98)	179 (4.41)	1851 (45.57)		327 (8.12)	1691 (42.01)	
Daily Consumption of Sugary Substances							
Low	1009 (25.01)	41 (1.02)	968 (24.00)	<0.001	140 (3.50)	859 (21.46)	<0.001
Moderate	2021 (50.10)	157 (3.89)	1864 (46.21)		346 (8.65)	1662 (41.53)	
High	1004 (24.89)	161 (3.99)	843 (20.90)		219 (5.47)	776 (19.39)	
Diabetes History							
No	3422 (84.37)	324 (7.99)	3098 (76.38)	0.005	575 (14.28)	2825 (70.17)	0.007
Yes	634 (15.63)	38 (0.94)	596 (14.69)		134 (3.33)	492 (12.22)	
Cardiac Ischemic Disease							
No	3733 (92.04)	332 (8.19)	3401 (83.85)	0.812	633 (15.72)	3076 (76.40)	0.002
Yes	323 (7.96)	30 (0.74)	293 (7.22)		76 (1.89)	241 (5.99)	
Mental Problems							
No	3887 (95.83)	349 (8.60)	3538 (87.23)	0.566	669 (16.62)	3191 (79.26)	0.025
Yes	169 (4.17)	13 (0.32)	156 (3.85)		40 (0.99)	126 (3.13)	

SD: standard deviation; IQR: interquartile range; BMI: body mass index.

Age and BMI were reported by mean (SD), while education was reported by median (IQR). Mental problems include depression, psychiatric disorder, learning disability, and amnesia. T-test was used to compare age and BMI means between the two groups; Mood's median test was used to compare the median education between the two groups; the association between two categorical variables was determined by chi-square test.

cardiac ischemic disease. Table 1 shows the participants' characteristics. Figure 2 shows the relationship between DMFT and smoking based on gender and place of residence.

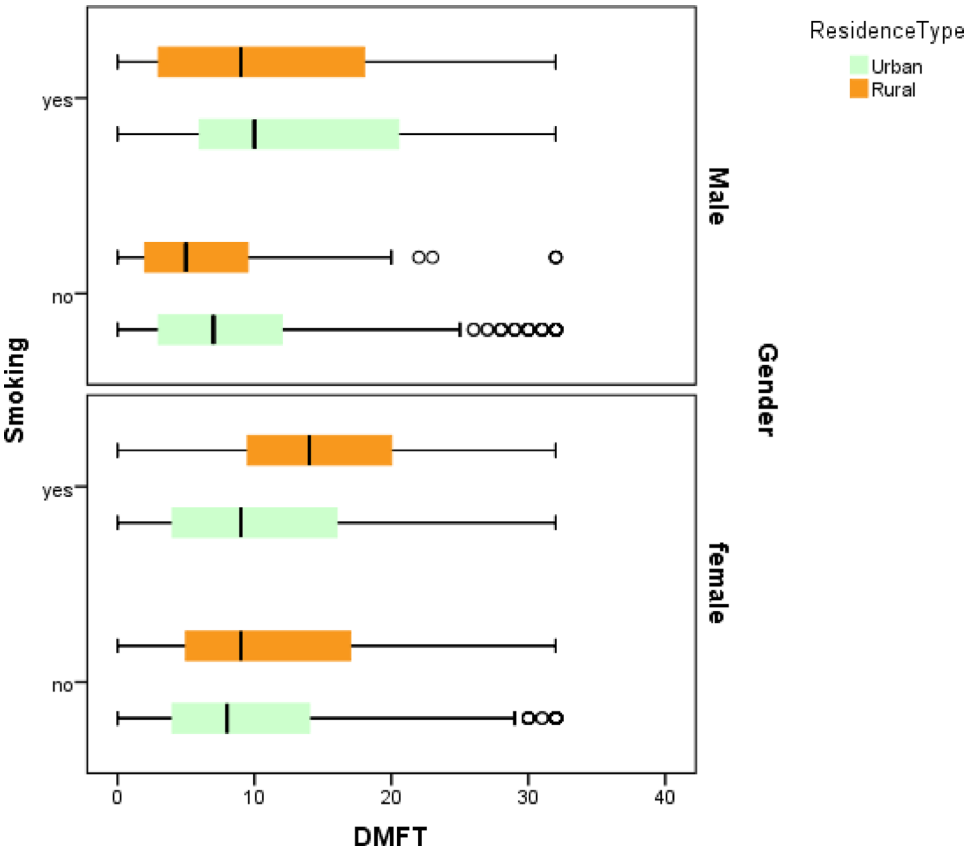

Figure 2. DMFT and smoking based on gender and place of residence.

Based on the results shown in Table 2, the mean ± standard error (SE) DMFT index in all subjects was 11.08 ± 0.15, and the mean (SE) number of decayed, missing, and filled teeth was 2.94 ± 0.05, 6.44 ± 0.14, and 1.70 ± 0.04, respectively. The median (interquartile range [IQR]) scores for DMFT, number of decayed teeth, number of missing teeth, and number of filled teeth in all individuals (with and without dentures) were 8 (11), 2 (3), 3 (5), and 0 (3), respectively. The median (IQR) scores for DMFT in cigarette users and hookah users were higher than in nonusers: 10 (15) for cigarette users, 10 (13) for hookah users, and 8 (10) for nonusers ($p < 0.001$). Overall, 1082 participants (26.65%) had DMFT scores of 0 to 4 (54 people [1.33%] were cigarette users, 172 [4.24%] were hookah users, and the rest were nonsmokers). In addition, 1214 participants (29.90%) had at least four decayed teeth (152 people [3.74%] were cigarette users, 257 [6.33%] were hookah users, and the rest were nonsmokers), and 2703 participants (66.50%) had at least two missing teeth (299 people [7.37%] were cigarette users, 520 [12.81%] were hookah users, and the rest were nonsmokers). About half the participants (2102 people

Table 2. Participants' oral health information by smoking status.

Variable	Total ($n=4063$)	Cigarette			Hookah		
		Smoker ($n=362$)	Nonsmoker ($n=3701$)	p-Value	User ($n=709$)	Nonuser ($n=3354$)	p-Value
Quantitative variables are reported by mean (standard error of mean)							
DMFT	11.08 (0.15)	14.17 (0.53)	10.78 (0.15)	<0.001	12.39 (0.37)	10.80 (0.16)	<0.001
Number of teeth	25.19 (0.14)	22.42 (0.55)	25.46 (0.15)	<0.001	23.71 (0.37)	25.50 (0.16)	<0.001
Number of missing teeth	6.44 (0.14)	9.26 (0.55)	6.17 (0.15)	<0.001	7.86 (0.37)	6.14 (0.16)	<0.001
Number of decayed teeth	2.94 (0.05)	3.77 (0.19)	2.85 (0.05)	<0.001	3.42 (0.14)	2.83 (0.05)	<0.001
Number of filled teeth	1.70 (0.04)	1.14 (0.10)	1.76 (0.04)	<0.001	1.11 (0.08)	1.83 (0.04)	<0.001
Quantitative variables are reported by median (IQR)							
DMFT	8 (11)	10 (15)	8 (10)	<0.001	10 (13)	8 (10)	<0.001
Number of teeth	29 (6)	27 (12)	29 (6)	<0.001	28 (8)	29 (5)	<0.001
Number of missing teeth	3 (5)	4 (12)	2 (5)	<0.001	4 (8)	2 (5)	<0.001
Number of decayed teeth	2 (3)	3 (5)	2 (3)	<0.001	2 (4)	2 (3)	<0.001
Number of filled teeth	0 (3)	0 (2)	0 (3)	<0.001	0 (1)	1 (3)	<0.001
Categorical variables are reported by number (%)							
DMFT							
0–4	1082 (26.65)	54 (1.33)	1028 (25.32)	<0.001	172 (4.24)	910 (22.41)	<0.001
5–8	1009 (24.85)	83 (2.04)	926 (22.81)		145 (3.57)	864 (21.28)	
9–15	1025 (25.25)	94 (2.32)	931 (22.93)		180 (4.43)	845 (20.81)	
≥16	944 (23.25)	131 (3.23)	813 (20.02)		212 (5.22)	732 (18.03)	
Number of missing teeth							
0–1	1360 (33.50)	63 (1.55)	1297 (31.95)	<0.001	189 (4.66)	1171 (28.84)	<0.001
2–3	1017 (25.05)	86 (2.12)	931 (22.93)		158 (3.89)	859 (21.16)	
4–6	706 (17.39)	80 (1.97)	626 (15.42)		140 (3.45)	566 (13.94)	
≥7	977 (24.06)	133 (3.28)	844 (20.79)		222 (5.47)	755 (18.60)	
Number of decayed teeth							
0–1	1459 (35.94)	97 (2.39)	1362 (33.55)	<0.001	228 (5.62)	1231 (30.32)	<0.001
2–3	1387 (34.16)	113 (2.78)	1274 (31.38)		224 (5.52)	1163 (28.65)	
≥4	1214 (29.90)	152 (3.74)	1062 (26.16)		257 (6.33)	957 (23.57)	
Number of filled teeth							
0	2102 (51.77)	235 (5.79)	1867 (45.99)	<0.001	470 (11.58)	1632 (40.20)	<0.001
1–2	891 (21.95)	61 (1.50)	830 (20.44)		115 (2.83)	776 (19.11)	
≥3	1067 (26.28)	66 (1.63)	1001 (24.66)		124 (3.05)	943 (23.23)	
Frequency of tooth brushing							
Never	464 (11.43)	66 (1.63)	398 (9.80)	<0.001	116 (2.86)	348 (8.57)	<0.001
Once a day	1655 (40.76)	145 (3.57)	1510 (37.19)		256 (6.31)	1399 (34.46)	
2 times a day	1222 (30.10)	54 (1.33)	1168 (28.77)		169 (4.16)	1053 (25.94)	
3 times a day	238 (5.86)	7 (0.17)	231 (5.69)		36 (0.89)	202 (4.98)	
Other (less than daily)	481 (11.85)	90 (2.22)	391 (9.63)		132 (3.25)	349 (8.60)	
Oral lesion	16 (0.39)	2 (0.05)	14 (0.34)	0.614	4 (0.10)	12 (0.30)	0.426
Dentures	308 (7.59)	33 (0.81)	275 (6.77)	0.249	61 (1.50)	247 (6.08)	0.260
Flossing	263 (6.48)	26 (0.64)	237 (5.84)	0.568	34 (0.84)	229 (5.64)	0.045
Mouthwash use	101(2.49)	13(0.32)	88(2.17)	0.158	10(0.25)	91(2.24)	0.043

IQR: interquartile range.

The independent samples t-test was used to test the equality of means from the two populations; Mood's median test was used to compare the median education between the two groups; the association between two categorical variables was determined by chi-square test.

[51.77%]) had no filled teeth (235 [5.79%] were cigarette users, 470 [11.58%] were hookah users, and the rest were nonsmokers).

In general, 1655 participants (40.76%) brushed their teeth once a day (145 people [3.57%] were cigarette users, 256 [6.31%] were hookah users,

and the rest were nonsmokers). There was no statistical difference in the prevalence of oral lesions and dentures in cigarette users, hookah users, and their nonsmoking counterparts ($p > 0.05$). There was no statistical difference in the prevalence of using dental floss and mouthwash in cigarette smokers and their nonsmoking counterparts ($p > 0.05$), but the prevalence of using dental floss and mouthwash was lower among hookah users than others ($p < 0.05$).

Based on Table 3, increased DMFT rates were associated with cigarette use, older age, being married, and higher consumption of sugary substances per day. People with a body mass index (BMI) ≥ 25 and people with middle wealth scores had lower rates of DMFT than those with a BMI < 25 and those with low wealth scores, respectively. Also, among people who used hookahs, older age and higher consumption of sugary substances per day were associated with increased DMFT rates. Moreover, the findings in Table 3 show that for nonsmokers, older age and higher consumption of sugary substances per day were associated with increased DMFT rates. In addition, after adjusting for other variables, people with 6 to 12 years of education had lower rates of DMFT than those with ≤5 years of education, as did people who used dental floss compared with those who did not.

Holding other variables constant in model 1 (Table 4), the rates of DMFT, missing teeth, and decayed teeth for cigarette smokers were 0.33 (IRR: 1.33;

Table 3. Negative binominal regression analysis to determine factors associated with DMFT.

	Cigarette ($n = 362$)	Hookah ($n = 709$)	Nonsmoker ($n = 3076$)
Variable	Adjusted IRR (95% CI) [p-value]	Adjusted IRR (95% CI) [p-value]	Adjusted IRR (95% CI) [p-value]
Age (reference: 35–44 years)			
45–54 years	1.41 (1.19,1.67) [<0.001]	1.44 (1.23,1.68) [<0.001]	1.39 (1.29,1.49) [<0.001]
55–64 years	1.77 (1.45,2.16) [<0.001]	1.99 (1.67,2.34) [<0.001]	2.26 (2.08,2.46) [<0.001]
≥65 years	2.51 (1.58,3.98) [<0.001]	2.63 (2.11,3.27) [<0.001]	2.95 (2.59,3.36)[<0.001]
Education (reference: ≤5 years)			
6–12 years	0.95 (0.81,1.11) [0.532]	0.87 (0.76,1.01) [0.076]	0.89 (0.83,0.95) [0.001]
≥13 years	1.07 (0.76,1.50) [0.691]	1.09 (0.74,1.61) [0.649]	0.96 (0.86,1.06) [0.433]
Marital Status (reference: single)			
Married	5.96 (2.02,17.570[0.001]	1.08 (0.62,1.85) [0.788]	1.05 (0.88,1.25) [0.598]
Widow/divorced	3.44 (0.95,12.52) [0.061]	1.26 (0.72,2.21) [0.423]	1.07 (0.87,1.30) [0.518]
BMI (reference: <25)			
≥25	0.80 (0.69,0.93) [0.003]	0.92 (0.82,1.03) [0.148]	0.99 (0.93,1.05) [0.721]
Wealth Score Index (reference: low)			
Middle	0.76 (0.62,0.93) [0.008]	1.08 (0.93,1.26) [0.312]	1.01 (0.93,1.08) [0.863]
High	0.86 (0.72,1.02) [0.088]	0.90 (0.79,1.03) [0.131]	1.02 (0.95,1.09) [0.568]
Daily Consumption of Sugary Substances (reference: low)			
Moderate	1.07 (0.84,1.38) [0.565]	1.15 (0.99,1.34) [0.059]	1.03 (0.96,1.09) [0.435]
High	1.40 (1.08,1.810) [0.010]	1.28 (1.08,1.51) [0.003]	1.15 (1.06,1.24) [0.001]
Diabetes History	089 (0.69,1.15) [0.377]	0.98 (0.85,1.14) [0.829]	1.08 (0.99,1.17) [0.051]
Cardiac Ischemic Disease	1.03 (0.79,1.34) [0.811]	1.11 (0.92,1.34) [0.262]	1.04 (0.94,1.16) [0.444]
Flossing	0.73 (0.53,1.01) [0.054]	0.87 (0.66,1.15) [0.338]	0.84 (0.75,0.95) [0.004]
Mouthwash Use	1.51 (0.99,2.31) [0.057]	1.04 (0.64,1.68) [0.873]	1.07 (0.89,1.28) [0.468]

IRR: incidence rate ratio; CI: confidence interval.
The reference category for diabetes, cardiac ischemic disease, flossing, and mouthwash use is "No."

Table 4. Association between smoking status and DMFT.

	DMFT		Missing teeth		Decayed teeth		Filled teeth	
Variable	Adj IRR (95% CI)	*p*-Value	Adj IRR (95% CI)	*p*-Value	Adj IRR (95% CI)	*p*-Value	Adj IRR (95%CI)	*p*-Value
Cigarette (reference category: nonsmoker): Model 1								
Smoker	1.33 (1.22,1.44)	<0.001	1.73 (1.52,1.96)	<0.001	1.32 (1.18,1.48)	<0.001	0.60 (0.50,0.73)	<0.001
Hookah (reference category: nonuser): Model 2								
User	0.98 (0.92,1.05)	0.614	1.02 (0.93,1.12)	0.671	1.13 (1.04,1.23)	0.004	0.72 (0.63,0.83)	<0.001
Cigarette, hookah, or both (reference category: nonuser): Model 3								
User	1.11 (1.05,1.18)	<0.001	1.29 (1.18,1.40)	<0.001	1.23 (1.14,1.33)	<0.001	0.63 (0.56,0.71)	<0.001

Adj IRR: adjusted incidence rate ratio; CI: confidence interval.

Model 1 is adjusted for age, education, marital status, BMI, wealth score index, daily consumption of sugary substances, diabetes, cardiac ischemic disease, flossing, mouthwash use, and hookah use. Model 2 is adjusted for cigarette use and model 1 factors, except hookah use. Model 3 is adjusted for model 1 factors, except hookah use.

95% CI: 1.22, 1.44), 0.73 (IRR: 1.73; 95% CI: 1.52, 1.96), and 0.32 (IRR: 1.32; 95% CI: 1.18, 1.48), respectively—higher than the rates for those who did not use cigarettes. But those who used cigarettes had lower rates of filled teeth than their counterparts (IRR: 0.60; 95% CI: 0.50, 0.73).

Based on model 2 (Table 4), the rate of decayed teeth for those who used hookahs was 0.13 (IRR: 1.13; 95% CI: 1.04, 1.23)—higher than for those who did not use hookahs. Also, the rate of filled teeth for hookah users was 0.28 (IRR: 0.72; 95% CI: 0.63, 0.83)—lower than for nonusers.

After adjusting for other variables in model 3 (Table 4), the rates of DMFT, missing teeth, and decayed teeth for those who used cigarettes, hookahs, or both were 0.11 (IRR: 1.11; 95% CI: 1.05, 1.18), 0.29 (IRR: 1.29; 95% CI: 1.18, 1.40), and 0.23 (IRR: 1.23; 95% CI: 1.14, 1.33), respectively—higher than for nonsmokers. However, the rate of filled teeth for those who used cigarettes, hookahs, or both was 0.37 (IRR: 0.63; 95% CI: 0.56, 0.71)—lower than for their nonsmoking counterparts.

Discussion

Considering the harmful effects of smoking on oral and dental health, this study was conducted with the aim of investigating the oral and dental health status of adults aged 35–70 years in Bandare-Kong, Iran, and its relationship to smoking. Our results indicate that smoking has a negative effect on oral health and is one of the main risk factors for increased rates of DMFT.

The findings of the present study demonstrated a significant association between smoking and increased rates of DMFT; this was confirmed by Leite et al. (2018). The DMFT index for those who used cigarettes and both cigarettes and hookahs was higher than for others. Based on this finding, it can be stated that smoking and the use of substances containing

tobacco have potential effects on the development of tooth caries. The mean DMFT index in this study (11.08) was different from that in similar studies conducted in other parts of Iran and elsewhere: it was 18.06 in the Persian Kharameh Cohort Study (Johari et al., 2021), 7.33 in Kurdistan (Moradi et al., 2020), and 21.27 in Azerbaijan (Hadilou et al., 2022). The DMFT index in Pakistan was similar to our findings (Ahmed et al., 2023). Additionally, international studies reported both lower (Tanık, 2019) and higher (Almazrooei et al., 2020; Skalerica et al., 2020) DMFT index numbers than ours. This difference in the mean DMFT index could be attributable to economic, cultural, and social differences, as well as age, genetics, diet, daily oral hygiene, and access to oral health services.

In this study, after adjusting for other variables, the rates of missing and decayed teeth for those who used cigarettes, hookahs, or both were higher than for nonsmokers, while the rate of filled teeth was lower. Perhaps the reason is smokers' generally unhealthy lifestyle, so that in addition to using harmful substances such as tobacco, they avoid oral health treatment. Similar studies confirm this finding (Johari et al., 2021; Najafi et al., 2020).

In line with our results, Javed et al. (2016) in Saudi Arabia found that cigarette smokers or hookah smokers had more missing teeth and poorer periodontal health than those who never smoked. Another study in Japan reported that children whose mothers smoked six or more cigarettes per day were more likely to present with missing teeth than children whose mothers did not smoke, after adjusting for possible confounders (Nakagawa Kang et al., 2019). Therefore, health organizations should inform the public about the potential adverse effects of smoking on tooth-related complaints.

In the present study, for all people (both smokers and nonsmokers), being older and consuming lots of sweets caused an increase in the DMFT index. In line with our findings, prior studies indicated that increasing age (Akarsu & Karademir, 2020; Tanık, 2019) and consuming more candies, chocolate, sweets, and sweetened juices (Ibrahim, 2021) led to an increase in the mean DMFT index. In a study in Saudi Arabia, the DMFT index increased with increasing age (Ahmed et al., 2023). A decrease in older people's physical, social, and economic well-being might explain this result. Therefore, important changes in community dental behavior and dietary habits should be implemented.

In addition, among people who smoked cigarettes, the mean DMFT index in individuals with a BMI < 25 was greater than that of people with a higher BMI, consistent with the results of similar studies in Iran (Johari et al., 2021) and South Korea (Song et al., 2017). However, in contrast to our results, in a cross-sectional study in a Turkish population, there was no difference in the DMFT index between those of normal weight and those who were overweight (Akarsu & Karademir, 2020). Based on a

systematic review, one possible explanation of these contradictory results is that both BMI and DMFT index are multifactorial variables (Alshehri et al., 2020); therefore, the relationship between BMI and DMFT is complex and should be the subject of additional prospective studies in different contexts.

Also, among people who used cigarettes, a low wealth score, indicating a low economic and social level, caused an increase in the DMFT index. In line with this finding, other studies reported that socioeconomic status was a factor influencing the DMFT index (Costacurta et al., 2020; Moradi et al., 2020). Najafi et al. (2020) reported that the incidence of DMFT is high among adults experiencing socioeconomic deprivation and recommended a focus on dental caries in that group.

Based on these results, we can conclude that people living in poor economic and social situations are unable to pay for dental hygiene products and do not have access to oral health facilities, making a higher rate of DMFT more likely. Thus, we suggest early preventive interventions and the provision of appropriate and effective access to oral health care for those with a low socioeconomic status.

Strengths, limitations, and future research

The strengths of this study include the wide range of variables and large sample size. However, because it was a cross-sectional analysis of a prospective cohort study that reported baseline measurements, the cause-and-effect relationship between the variables may not be properly identified. We believe that by advancing this cohort study and combining it with data from other cohort studies being conducted simultaneously in different regions of Iran, future studies will be better able to discuss the cause-and-effect relationships between variables and, at the same time, will have better generalizability.

On the downside, the data were collected in the form of self-reporting (a valid PERSIAN cohort questionnaire and interviews), which can lead to reporting or response bias. In addition, the studied population consisted of people older than 35 years, limiting the generalizability of our results to other age groups. To generalize the results to the entire population of Iran, more comprehensive studies that include all age groups should be conducted, especially among adolescents and young adults, who constitute a large proportion of tobacco users in Iran.

Conclusion

This study has shown that cigarette smoking is a risk factor for oral health complaints. Smoking both hookahs and cigarettes led to an increased DMFT index. In our research, although the rate of DMFT was increased

in hookah smokers, it was not a predictor of dental problems; however, hookah use should be included in educational policies to control oral and dental diseases. Encouraging people to adopt a healthy smoke-free lifestyle and providing smoking cessation facilities can help reduce the risk of oral and dental diseases and improve an individual's response to treatment.

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Ethical approval and consent to participate

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of Hormozgan University of Medical Sciences (ethical code IR.HUMS.REC.1401.170). Written informed consent was obtained from all subjects involved in the study.

Consent for publication

Not applicable

Author contributions

SR contributed to the concept and design and wrote the manuscript. SR, SD, and HESK contributed to data analysis, statistical analysis, design, and manuscript preparation. NS contributed to the literature search, manuscript editing, and manuscript review. All authors reviewed and approved the manuscript.

Disclosure statement

The authors declare that they have no competing interests.

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Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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