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Prevalence and Predictors of Dental Fluorosis among the Yemeni Adult Population Living in Riyadh, Saudi Arabia - A Cross-Sectional Study

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Abstract

Dental fluorosis is one of the dental public health problems in many global populations especially those with high levels of fluoride in drinking water. It was noted that Yemeni population have increased obvious fluorosis. This could be because of the early childhood exposure to fluoride from the drinking water in their origin. Also, the increased risk of dental fluorosis is possibly because of exposure to fluoride above optimum level, and further use of fluoride containing anti-cariogenic agents that include, toothpaste, mouthwash, fluoride containing chewing gum, and diet enriched with fluoride such as consumption of fish as well as frequency of tea intake. These can be seriously considered as primary determinants that may be a risk factor for dental fluorosis.

Keywords: Dental fluorosis; Endemic fluorosis areas; Fluoride; Dental caries

Introduction

Dental Caries is a common disease; people of all age groups are vulnerable to this disease. Caries is a prime reason for tooth pain and tooth loss. It can be detected, contained, and reversed during its premature stage by proper care. Caries is not a self-controlling disease; it spreads and progresses until it destroys the tooth completely if intervention measures are not instituted [1,2]. It is defined as the localized destruction of the tooth's hard tissues by the action of acidic by-products produced by the oral bacteria as a result of the fermentation of dietary carbohydrates. The demineralization of the teeth due to the pathogenic factors initiates caries on the specific "anatomical predilection" sites on the teeth [3].

According to the World Health Organization, 2.3 billion people on the entire planet suffer from permanent teeth caries, among them, 530 million children suffer from caries in the deciduous teeth [4]. In the middle and low-income nations, the prevalence of dental caries is increasing [5]. A meta-analysis conducted with 164 studies regarding the prevalence of caries in primary and permanent teeth of children from 1995 to 2019 found that the prevalence of caries in the primary teeth was 46.2% out of 80,405 children included in the studies while 53.8% out of 1,454,871 adults in the studies suffered from caries in the permeant teeth [6].

In order to keep the teeth safe from demineralization, fluoride can play an important role. As fluoride comes in contact with the teeth through the use of toothpaste, mouthwashes, etc., it converts the hydroxyapatite of enamel to fluorapatite by replacing the hydroxyl ion with fluoride. This fluorapatite is harder to demineralize, and it keeps the teeth safe. According to Iheozor-Ejiofor et al. [7] by providing fluoride to the teeth through drinking water, 35% reduction in decay was found in deciduous teeth while 26% reduction for permanent teeth. Another study claims that fluoride gel treatment at least once a year can cause a 28% reduction in tooth decay [8]. A study by Marinho et al. [9] found that the daily or weekly use of fluoridated mouthwashes can reduce the chance of tooth decay by 27%. In addition to this, Walsh et al. [10] conducted a study regarding the use of different concentrations of fluoride and its effects on the reduction of tooth decay. They found that the concentration between 0.1% to 0.125% can produce a 23% reduction in tooth decay, while the concentration between 0.24% to 0.28% can reduce tooth decay by 36%.

Despite the clear benefits of fluoride in reducing dental caries, it has become a double-

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edged sword especially for children. During the process of enamel mineralization, over-exposure to fluoride can cause demineralization of enamel; this condition is known as fluorosis [11,12]. It generally occurs when children drink water that has a fluoride concentration greater than 1.5 ppm [13] and use toothpaste with more than 0.5% of fluoride [14]. As fluoride is used in greater quantity, it causes in-situ toxic effects on the 'ameloblasts' during the formation of enamel and changes in mineralization take place [15]. In the cellular environment, during the process of maturing enamel, an increase in the concentration of fluoride ions changes the rate of amelogenin (protein of enamel matrix) breakdown by the actions of enzymes. Furthermore, the excess amount of fluoride also alters the removal of breakdown products. This will cause the reduction of free calcium ions and result in an indirect change in the protease enzyme's action. Consequently, the enamel becomes less mineralized with different optical properties, and a lusterless and opaque appearance [16,17]. It is difficult to estimate the global burden of fluorosis but an estimated 10 million cases of dental and skeletal fluorosis have been recorded over the years due to high fluoride content of drinking water [18].

Several studies have been done worldwide that assess the prevalence of fluorosis in the adult population. Idon & Enabulele [19] conducted a study on the prevalence of dental fluorosis in Nigerian adults. The study revealed a prevalence of 41.7% among the sample, with a predilection of developing fluorosis in females (p=0.003). Similarly, Do et al. [20] studied the prevalence of dental fluorosis among the Australian adult population. The researchers used data from participants aged 15 to 44 years in Australia's National Survey of Adult Oral Health 2017-18. Diagnosis of dental fluorotic opacities were assessed using the Thylstrup and Fejerskov Index (TFI). The results indicated that one in ten Australian adults were found to have dental fluorosis at TF2+ [20]. Yemen, a country located along the Gulf Coast was constantly in civil wars for many decades until today, and has to date no known national data on the fluorosis status of its adult population. Only very few studies have been conducted on the prevalence of dental fluorosis in school-going children in Yemen. Kadir & Al-Maqtari [21] studied the prevalence of endemic fluorosis among 14-year-old adolescents in Yemen. They found that 30.8% of the total sample was affected by dental fluorosis, males (32.3%) were affected slightly more than females (29.3%) and rural children (31.3%) were more affected than urban children (29.7%). Few years later, Al-Akwa & Al-Maweri [22] studied the association between dental caries and the level of fluoride in drinking water in Sana'a, Yemen. The study found that around 67.6% of children had dental caries and also found a significant negative correlation between caries experience and fluoride level ($p<0.05$).

The present study identified the paucity of studies on the prevalence of dental fluorosis in the adult Yemeni population. It aims to fill this gap in literature and explore the prevalence of dental fluorosis among Yemeni adults living in Riyadh.

Materials and Methods

Design

The present study is a cross-sectional study conducted on Yemeni adults living in the city of Riyadh, Saudi Arabia. Ethical approval for the study was obtained from the Institutional Review Board at Riyadh Elm University with IRB number RC\IRB\2016\406.

The study was conducted and reported according to the STROBE guidelines.

Sample size and sample selection

A convenience sampling method was used to recruit participants for this study. Sample size was estimated using the following formula:

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$n = Z1\text{-}\alpha/2^2[p(1-p)]/d^2$

Where, n is the sample size, $Z1\text{-}\alpha/2^2$ is the standard normal variate (at 5% Type 1 error and 95% CI [$p<0.05$] it is 1.96), p is the expected proportion in population based on previous studies and, d is the absolute error or precision.

According to this formula, with a present prevalence level of 15% based on previous studies and a precision of 5%, a minimum sample of 198 participants were needed to produce statistically accurate results.

Survey and clinical examination

A self-designed, close ended questionnaire was distributed among the patients that assessed the demographic characteristics of the patient as well their self-reported use of tobacco and tooth brushing frequency. Clinical examination was conducted for each participant to check for dental fluorosis using the WHO fluorosis index. The medical, dental and social history of the participants was also recorded as well as the history of application of fluoride or bleaching.

Statistical analysis

Data were collected, tabulated and analyzed using SPSS software (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.).

Qualitative data were summarized using number and percentages. Quantitative data were summarized using Median (Mdn) and Inter-Quartile Range (IQR) or Mean (M) and Standard Deviation (SD) according to their distribution.

ANOVA (F) and independent t-test (t) tests were used to compare normally distributed variables between two or more-than-two groups respectively. The Kruskal-Wallis test was used to compare ordinal variables among more-than-two groups (i.e., place of birth in terms of governorate and provinces). Spearman's correlation test was used to test for linear relation between ordinal variables. Significance test results were quoted as two-tailed probabilities and judged at the 5% level and a p value of <0.05 was considered statistically significant.

Results

A total of 147 Yemeni adults participated in this study. Age of the participants ranged from 17 to 56 years with mean age of 29.4 ± 7.7 (Table 1). Majority of the participants (62%) reported not brushing their teeth. Few (20%) brushed their teeth less than once per day, still fewer (8%) brushed once per day and only 10% brushed their teeth twice daily. Most of the participants (56%) reported the use of tobacco while the rest (44%) did not use it. Mean DMFT of the sample was found to be 6.5 ± 4.2 (range 0-20). Majority (92%) of the participants had no enamel anomaly accompanying dental fluorosis while 8% had enamel anomaly (Table 2).

Age, place of birth with respect to governorate and place of birth with respect to province were tested as predictors of dental fluorosis (Table 3, 4 and Figure 1, 2). The difference in fluorosis diagnosis was not statistically significant with respect to age (p=0.482) and place of birth (province; p=0.116). There was however, a statistically

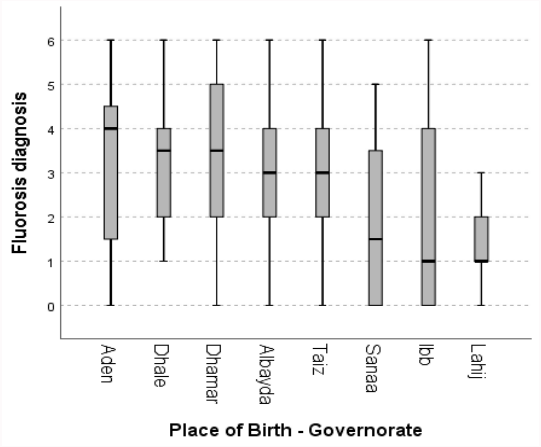

Figure 1: Dental fluorosis in relation to governorate of birth.

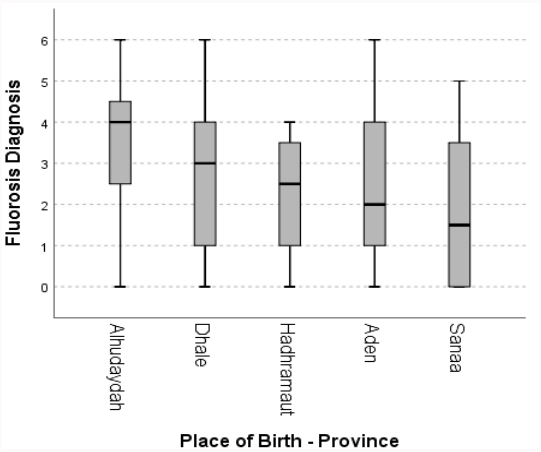

Figure 2: Fluorosis diagnosis in relation to province of birth.

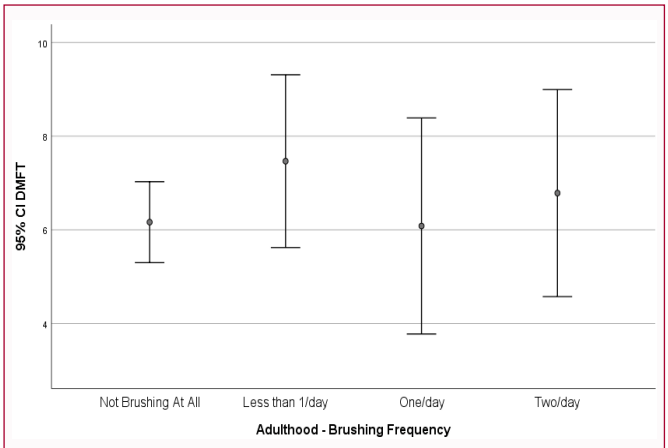

Figure 3: DMFT in relation to tooth brushing frequency.

significant difference in fluorosis diagnosis among participants with respect to place of birth (governorates; p=0.006) (Table 5).

The study also assessed the correlation of DMFT with tooth brushing frequency and tobacco use among the participants (Table 6). No correlation was found between DMFT score and tooth brushing frequency (ρ=0.084; p=0.314) and use of tobacco (t=0.982; p=0.328) (Figure 3, 4).

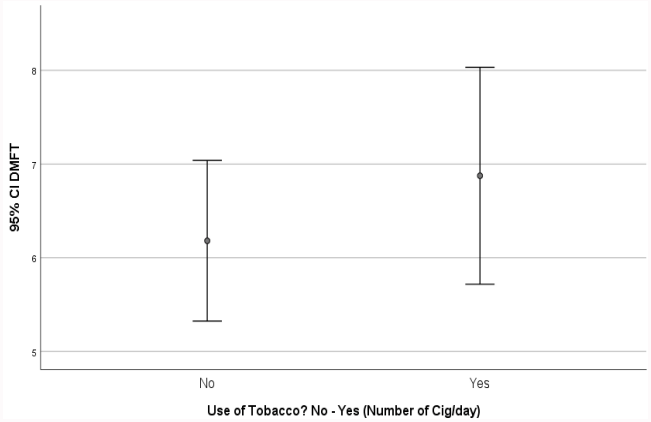

Figure 4: DMFT in relation to use of tobacco.

Table 1: General descriptive analysis.

Variable	Statistical summary		
Age	M (SD)	29.4 (7.7)	
	(Min, Max)	(17, 56)	
Place of Birth – Governorate	Albayda	28	(19)
	Sanaa	24	(16)
	Taiz	24	(16)
	Ibb	20	(14)
	Aden	16	(11)
	Dhale	10	(7)
	Lahij	9	(6)
	Dhamar	6	(4)
	Shabwah	3	(2)
	Hajjah	2	(1)
	Raymah	2	(1)
	Al Mahwit	1	(1)
	Alhudaydah	1	(1)
	Hadhramaut	1	(1)
Place of Birth – Province	Dhale	58	(39)
	Aden	49	(33)
	Sanaa	24	(16)
	Alhudaydah	12	(8)
	Hadhramaut	4	(3)
Adulthood brushing frequency	Not Brushing at All	91	(62)
	Less than 1/day	30	(20)
	One/day	12	(8)
	Two/day	14	(10)
Use of tobacco	No	83	(56)
	Yes	64	(44)

Values are number and (Percentages) unless otherwise specified

Finally, correlation between fluorosis diagnosis and DMFT score was assessed (Table 7). No correlation exists between the two diagnoses either in the whole group of patients (ρ=0.105; p=0.206) and in patients without enamel anomaly (ρ=0.126; p=0.146).

Discussion

To the best of the author's knowledge, this is the first study that

Table 2: DMFT scores and fluorosis diagnosis.

Variable	Statistical summary	
Decayed	M (SD)	5.1 (3.6)
	(Min, Max)	(0, 20)
Missing	M (SD)	0.4 (1)
	(Min, Max)	(0, 6)
Filled	M (SD)	0.9 (1.9)
	(Min, Max)	(0, 10)
DMFT index	M (SD)	6.5 (4.2)
	(Min, Max)	(0, 20)
Fluorosis diagnosis	Mdn (IQR)[a]	3 (3)
	(Min, Max)	(0, 6)
	Enamel anomaly	12 (8)
	No Enamel anomaly	135 (92)
	Mdn (IQR)[b]	2 (3)
	(Min, Max)	(0, 5)

Values are number and (Percentage) unless otherwise specified
M: Mean; SD: Standard Deviation; Mdn: Median; IQR: Interquartile Range; Min: Minimum; Max: Maximum
[a] Among the whole group of patients (n=147) and enamel anomaly is given score 6
[b] Among patients with no enamel anomaly (n=135)

assesses the prevalence of dental fluorosis among Yemeni adults and tries to establish causal relationships with dental caries. The results of this study indicate a high mean DMFT score among the participants. Previous studies [22-24] have already indicated a high dental caries prevalence in Yemen, and there can be several reasons. In this study, two possible predictors for DMFT scores have been studied among Yemeni adults, namely the use of frequency of brushing teeth and the use of tobacco. Only 10% of Yemen adults in this study brush twice a day, so this can be a potential reason for caries prevalence. Nevertheless, surprisingly, in this study, a significant correlation between tooth brushing and prevalence of caries was not found. This study also found no correlation between DMFT scores and use of tobacco among the participants. A similar study was conducted in Japan to find the relation between brushing frequency and the prevalence of caries among more than 200 adults. The findings of this study are similar to our study; it fails to establish any significant correlation between brushing frequency and dental caries [25]. According to a meta-analysis by Kumar et al. [26], infrequent brushing can increase the incidence of dental caries. On the other hand, Petersson & Twman [27] conducted research to find the relation between smoking tobacco use and dental caries. They found that tobacco smoking is significantly associated with dental caries; the higher the smoking, the higher the caries risk. Furthermore, a meta-analysis conducted by Jiang et al. [28] to study the correlation

Table 3: Fluorosis diagnosis by place of birth in terms of governorate or provinces.

			Enamel anomaly				
		Fluorosis diagnosis[a]	Yes		No		Fluorosis diagnosis[b]
			(n=12)		(n=135)		
	N	Mdn (IQR)	n	(%)	n	(%)	Mdn (IQR)
Place of Birth (Governorate)							
Aden	16	4 (4)	2	(12.50%)	14	(87.50%)	4 (3)
Dhale	10	4 (3)	2	(20.00%)	8	(80.00%)	3 (3)
Dhamar	6	4 (4)	1	(16.70%)	5	(83.30%)	3 (4)
Albayda	28	3 (2)	1	(3.60%)	27	(96.40%)	3 (2)
Taiz	24	3 (2)	4	(16.70%)	20	(83.30%)	2 (2)
Sanaa	24	2 (4)	0	(0.00%)	24	(100%)	2 (4)
Ibb	20	1 (4)	2	(10.00%)	18	(90.00%)	1 (3)
Lahij	9	1 (1)	0	(0%)	9	(100%)	1 (1)
Shabwah	3	3 (1)	0	(0%)	3	(100%)	3 (1)
Raymah	2	5 (1)	0	(0%)	2	(100%)	5 (1)
Hajjah	2	2 (2)	0	(0%)	2	(100%)	2 (2)
Al Mahwit	1	4	0	(0%)	1	(100%)	4
Alhudaydah	1	4	0	(0%)	1	(100%)	4
Hadhramaut	1	0	0	(0%)	1	(100%)	0
Place of Birth (Province)							
Alhudaydah	12	4 (3)	1	(8.30%)	11	(91.70%)	4 (2)
Dhale	58	3 (3)	5	(8.60%)	53	(91.40%)	3 (3)
Hadhramaut	4	3 (3)	0	(0%)	4	(100%)	3 (3)
Aden	49	2 (3)	6	(12.20%)	43	(87.80%)	2 (3)
Sanaa	24	2 (4)	0	(0%)	24	(100%)	2 (4)

[a] Among the whole group of patients and enamel anomaly is given score 6
[b] Among patients with no enamel anomaly

Table 4: Results of statistical tests for predictors of fluorosis diagnosis.

Factors	Statistical test	
	Test statistic	(p-value)
Age	ρ= -0.059	(0.482)
Place of birth-Governorate	H=19.6	(0.006)
Place of birth- Provinces	H=7.4	(0.116)

ρ: Stands for Spearman's correlation coefficient
H: Stands for test statistic from Kruskal-Walli's test

Table 5: Pairwise comparisons of place of birth - governorate.

Governorate1	Governorate 2	(p-value)	Adjusted p-value[a]
Lahij	Sanaa	(0.605)	(1.000)
Lahij	Ibb	(0.604)	(1.000)
Lahij	Taiz	(0.022)	(0.619)
Lahij	Albayda	(0.016)	(0.452)
Lahij	Aden	(0.019)	(0.522)
Lahij	Dhale	(0.032)	(0.908)
Lahij	Dhamar	(0.056)	(1.000)
Sanaa	Ibb	(0.985)	(1.000)
Sanaa	Taiz	(0.017)	(0.463)
Sanaa	Albayda	(0.01)	(0.272)
Sanaa	Aden	(0.016)	(0.447)
Sanaa	Dhale	(0.038)	(1.000)
Sanaa	Dhamar	(0.078)	(1.000)
Ibb	Taiz	(0.023)	(0.655)
Ibb	Albayda	(0.015)	(0.414)
Ibb	Aden	(0.021)	(0.597)
Ibb	Dhale	(0.045)	(1.000)
Ibb	Dhamar	(0.087)	(1.000)
Taiz	Albayda	(0.922)	(1.000)
Taiz	Aden	(0.79)	(1.000)
Taiz	Dhale	(0.814)	(1.000)
Taiz	Dhamar	(0.807)	(1.000)
Albayda	Aden	(0.852)	(1.000)
Albayda	Dhale	(0.868)	(1.000)
Albayda	Dhamar	(0.852)	(1.000)
Aden	Dhale	(0.995)	(1.000)
Aden	Dhamar	(0.957)	(1.000)
Dhale	Dhamar	(0.964)	(1.000)

[a] Significance values have been adjusted by the Bonferroni correction for multiple tests

between tobacco smoking and dental caries concludes that a direct relation exists between tobacco smoking and caries; the results of both of these studies are do not concur with our findings.

Our study also tried to assess the predictors for fluorosis among the adults of Yemen. Three potential predictors were studied; namely age, governorate as place of birth, and the province as place of birth. Participants in this study were in the age group of 17 to 56 years; it is quite possible that the old age of participant may be a reason for high fluorosis, but the results of this study exclude this possibility, and showed that the prevalence of fluorosis is independent of age factor. A similar study done on the Australian adult population found that participants born during the 1870s to 1980s have more prevalence

Table 6: Correlation of DMFT with adult tooth brushing frequency and tobacco use.

	N	M (SD)	(Min, Max)	Statistical test	
				Test statistic	(p-value)
Adulthood brushing frequency					
Not Brushing at All	91	6.2 (4.2)	(0, 20)	F=0.764	(0.517)
Less than 1/day	30	7.5 (4.9)	(1, 20)	ρ=0.084	(0.314)
Once/day	12	6.1 (3.6)	(2, 12)		
Twice/day	14	6.8 (3.8)	(1, 12)		
Total	147	6.5 (4.2)	(0, 20)		
Use of Tobacco					
No	83	6.2 (3.9)	(0, 20)	t=0.982	(0.328)
Yes	64	6.9 (4.6)	(1, 20)		

M: Mean; SD: Standard Deviation; Mdn: Median; IQR: Interquartile Range; Min: Minimum; Max: Maximum; ρ: Spearman's correlation coefficient; F: ANOVA test; t: Independent t-test

Table 7: Correlation between fluorosis diagnosis and DMFT.

Factors	N	Statistical test	
		Test statistic	(p-value)
Fluorosis diagnosis[a]	147	ρ=0.105	(0.206)
Fluorosis diagnosis[b]	135	ρ=0.126	(0.146)

ρ: Spearman's correlation coefficient
[a] Among the whole group of patients (n=147) and enamel anomaly is given score 6
[b] Among patients with no enamel anomaly (n=135)

of dental fluorosis as compared to those born during the 1990s. The study postulates that the reason for this prevalence is the use of dietary fluorides [20]. The results of this study are opposite of ours; they have a relation between age and prevalence of fluorosis, but in our study, no such relation is found.

While the study of the other two potential predictors showed different results; for place of birth - governorate, it was noted that different governorates showed a different prevalence of fluorosis. And the difference was statistically significant. It is important to assess the fluoride concentration in water in those governorates that have displayed high median dental fluorosis score.

A study done on the Nigerian adult population on patients of ages within the range of 16 to 25 years also showed that dental fluorosis was significantly affected by age ($p<0.001$) which is also opposite to our study [19]. This study also demonstrated that dental fluorosis differed significantly among different localities in the country. It shows the locality difference can also affect the reason for the prevalence of dental fluorosis and agrees with the findings in our study [19]. Another study was conducted in five different geographical locations within China. The researchers found that when the fluoride level in drinking water was increased to 1.2 ppm, it increased the prevalence of dental fluorosis among the participants of different ages [29]. This study also supports the results of our study; that different localities can have a different prevalence of dental fluorosis.

The predictors of dental caries are social-demographic factors, food habits, and lack of fluoride. The rural public is generally more vulnerable to dental caries as compared to the urban public because of a lack of knowledge regarding oral health [30]. It is also noted that adult females have a higher predilection for dental caries [31]. Consumption of food with higher dietary carbohydrates [32] or low pH causes dental caries [33]; both of these assist the oral bacterial to

grow and colonize, and the use of tobacco also increases risk of dental caries [33]. Lack of fluoride is also a predictor of dental caries; there should be enough concentration of fluoride in the oral environment *via* toothpaste, mouthwashes, and drinking water [15,34]. On the other hand, predictions for the prevalence of dental fluorosis can be the use of highly fluoridated drinking water and food within a locality or using a toothpaste having a higher concentration of fluoride [35]. Any combination of these predictors can be the reason for high dental caries or fluorosis prevalence in developing countries like Yemen.

A limitation of this study was the small sample size which may hamper the conflation of these results to the larger Yemeni population. Furthermore, due to the ongoing civil war in Yemen, people from within the country could not be recruited which would have resulted in a much larger sample. As brushing frequency and tobacco use was self-reported, the study carries a risk of response bias.

Conclusion

The present study assessed the prevalence of dental caries and fluorosis among Yemeni adults living in Riyadh, Saudi Arabia. This research also assessed the predictors for dental caries and dental fluorosis diagnosis among the participants. A high DMFT and median fluorosis index was revealed in the results of this study. Age and province of birth did not prove to be a predictor for dental fluorosis while governorate of birth was a predictor for fluorosis diagnosis. There was no correlation between DMFT scores and tooth brushing frequency or tobacco use. Similarly, no correlation was found between DMFT scores and fluorosis. We recommend that more nationwide, multi-center studies with larger samples be conducted inside Yemen to provide comprehensive data on the fluorosis status of the population.

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