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The Relationship Between Salivary Flow And Dental Caries Among Teenagers

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Abstract:

Background: *Saliva is one of the intraoral host factors that influence caries development. Dental caries is the most prevalent chronic oral disease, influencing the oral and systemic health of the individuals, being the result of the interaction of multiple factors, such as microbial agents, the oral environment, the salivary pH, and the host response. The role of saliva in the etiology of dental caries is a major one, by influencing the homeostasis through the altering of its buffer capacity. The properties of saliva are influenced either by local pathogens or through a general mechanism with direct implications upon the salivary components.* ***The study aims:*** *to assess the relationship between salivary flow and caries experience among teenagers.* ***Methods:*** *A cross-sectional study was conducted Sixty-eight male adolescents, aged between 15 and 19 years, in KSA. They answered a structured questionnaire, and oral examination was performed by the Decayed, Missing, and Filled Teeth (DMFT) index. The salivary flow rate was obtained using the mechanically stimulated total saliva method. Adjusted Poisson regression was used for the association with total DMFT and its decayed component, using the salivary flow (continuous fashion) or the hypo salivation (≤1 ml/min) as independent variables.* ***Results:*** *Participants were divided into two groups, those who did not have any decayed teeth at the moment of the examination (n = 39) and those who had at least one decayed tooth (n = 29). Moreover, two groups were formed based on the DMFT: those who had DMFT = 0 (n = 20) and those who had DMFT≥1 (n = 48). In the multivariate analysis, hypo salivation wa[1]s associated with DMFT≥1 (p = 0.048), but when the salivary flow was included, no significant association with DMFT index was identified (p = 0.178). Conversely, the presence of at least one decayed tooth was significantly associated with the salivary flow (p = 0.004), but not with hypo salivation (p = 0.091).* ***Conclusions:*** *Adolescents who present hypo salivation or low salivary flow are associated with DMFT≥1 index or presence of at least one decayed tooth, respectively.*

Keywords: *Adolescent, Dental caries DMF index, Salivation.*

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Introduction

Dental caries is one of the most common diseases in the world, making Dental caries a public health problem. A World Health Organization (2012) [1] report on oral health stated that 60%–80% of children worldwide suffer from dental caries, and almost 100% of adults have them [1]. In KSA, several studies have been conducted to measure the prevalence of dental caries; most of them concluded that there is a high prevalence of caries among children and adults. Some of the studies were systematic reviews; for example, Al Agili et al. (2013) [2] conducted a systematic review to measure the prevalence of dental caries in KSA between 1988 and 2010 [2]. They concluded that 70% of children in primary schools had caries of their permanent dentition, while 80% of them had dental caries cavity in their primary dentition.

The dmft (decayed, missing, and filled primary teeth) and DMFT (decayed, missing, and filled permanent teeth) are some of the most important epidemiological indices in dentistry. Evaluation of these two indicators in the population can help in future planning of healthcare programs to improve oral health status [3]. Another review concluded that the amount of dental caries in permanent dentition is high, with a mean DMFT of 3.34; they also found that mean DMFT in primary dentition is 5.38 [4]. Similarly, Al-Ansari et al. (2014) [5] found that the mean DMFT in primary dentition is 7.34, while the mean DMFT in permanent dentition for adults is 7.35 [5]. Other studies across KSA have reported different amounts of dental caries in different areas [6-12]. A systematic review was conducted to identify all relevant reports and risk factors due to the wide variation in reported dental caries prevalence across KSA. Each of these reports was critically appraised.

Additionally, dental caries, one of the most prevalent oral diseases, manifest as the localized degradation of robust dental structures, rendering them susceptible to acidic by-products resulted from the bacterial fermentation of dietary carbohydrates [13]. If untreated, this invasive and destructive condition can culminate in tooth loss. It is a multifactorial disease, wherein certain risk factors encompass a reduction in the rate of salivary flow and decline buffering capacity [14, 15]. Saliva is known to perform an important role in maintaining oral health, acting in functions such as digestion, lubrication of oral tissues, neutralization, depuration of unwanted products [16, 17] as well as having its characteristics associated with the onset and progression of dental caries [18, 19].

The salivary flow and composition are extremely important for adequate buffering capacity [20]. It means that through calcium, phosphate, and fluoride ions, it neutralizes acids produced by cariogenic bacteria, reversing the pH of the oral cavity and reducing the solubility of tooth enamel [21]. Saliva also protects against bacterial, fungal and viral immune infections, maintaining the integrity of soft and hard tissues and acting as a cleansing agent [21, 22]. Among Saudi Arabia (SA) regions, the dental caries prevalence was much higher than in European countries. Since the implementation of the well-being framework; the prevalence of dental caries is high in Saudi populations, especially among young people [23]. Nationally, the prevalence of caries among children between the ages of 6 and 7 was 74% to 90% in the primary teeth; while it was 59 80% in permanent teeth [24].

The Decayed, Missing and, Filled Teeth (DMFT) index developed by World Health Organization (WHO) is the most commonly used tool in caries assessment [25]. The assessment of caries prevalence by the World Health

Organization (WHO) in several countries is performed through the decayed, missing and filled teeth (DMFT) index [3]. On the other hand, DMFT index is an essential criterion for the evaluation of tooth decay and, it is applied to recognize the level of oral health [26, 27]. The DMFT index has been applied in the world at least 70 years for evaluating the dental and oral health status. Moreover, this index is more significant in epidemiological studies of the community health status [28]. Through the application of this index in the monitoring and evaluation of oral health interventions within the community by the improvement of the programs and the policies that are related to this field [29, 30].

It should be noted that there is a shortage of information about the oral health status, periodontal tissue status, and prevalence of dental caries in this Saudi population group and the fundamental role of saliva in the preventing dental caries. For these reasons, this study was designed to evaluate the potential association between salivary flow and the experience of dental caries among teenagers in KSA.

Methods

The study is reported according to the guidelines proposed in the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statements [31].[22] A cross-sectional observational study involved male adolescents, aged between 15 and 19 years, in KSA. The present study was approved by the Ethical Committee of University. The inclusion criteria were: adolescent aged between 15 and 19 years, agreed to participate in the study, and signed the Informed Consent. No exclusion criterion was performed. Data were collected from January to May 2022, the period of data collection that had 74 teenagers. All of them were invited to participate. Sixty-eight adolescents agreed to participate in the research, and then an Informed Consent was signed.

Clinical examination, interview and salivary flow collection

The study consisted of two teams, each one composed by one interviewer, and one oral health examiner. All of them were previously trained by the study coordinators to ensure uniformity of data. A structured questionnaire that included socio-demographic data, history and general health behavior, and oral health habits was applied [32]. For the diagnosis of dental caries, the DMFT index was used, based on the criteria of the WHO (1997) [33].[24]

The examiners were trained and calibrated for the examination and the application of the questionnaires, using a group of selected adolescents of the same age, from a public school. The initial training for the DMFT index was performed by theoretical lectures, using a series of images for the classification of caries. For the application of the questionnaire, discussion of each question was performed, and researchers were instructed how to apply the questionnaire. All study participants selected for training were examined by examiners on two occasions, with an interval of 15 days between measurements. All data were tabulated and used to verify intra and inter examiner reproducibility using DMFT index as a discrete variable. The inter-examiner ($k = 0.74$) and intra-examiner ($k= 0.81$) reproducibility were calculated with kappa test. Therefore, inter-examiner and intra-examiner reproducibility were, respectively, moderate and strong.

The salivary flow was obtained using the mechanically stimulated total saliva method [34]. At the moment of collection, adolescents were comfortably

seated, with their heads erect and their eyes open. They were instructed to chew for 6 min a sterile and standardized piece of rubber. In the first minute, saliva was swallowed and then, participants were instructed to periodically spit it into a waste cup. Time was controlled by a CITIZEN® analog wristwatch (Tokyo, Japan). The liquid component of the salivary flow was then measured with a waste syringe, and the salivary flow was determined in milliliters per minute (ml/min).

Outcome definition and main exposure

Based on the DMFT index, two dependent variables were defined: the presence of at least one decayed tooth and DMFT≥1. The main exposure variable was determined as the salivary flow. Antoniazzi et al., (2017) [35] classified stimulated salivary flow as normal flow (>1 ml/min), low flow (0.7–1.0 ml/min) or very low flow (<0.7 ml/min). Hypo salivation was considered when there is low salivary flow (≤1 ml/min). In the present study, for this variable, two definitions were used of which one dichotomized the adolescent with normal flow (>1 ml/min) or with hypo salivation/low salivary flow (≤1 ml/min). The salivary flow in a continuous fashion was also used.

Independent variables

Age was used continuously. The level of education of the adolescent was dichotomized into those with incomplete elementary education, including the illiterate, and those with at least complete elementary education. Smoking exposure was categorized as current smokers, former smokers, and never smokers. The use of daily medication was dichotomized into yes or no. Those adolescents that reported the use of at least one daily medication were categorized as "yes." Access to the dentist in the last 12 months was also classified as yes or no. Tooth brushing frequency was categorized into two groups, those who reported tooth brushing more than three times a day and those who reported at least three times a day.

Statistical analysis

Data analysis was performed using the SPSS 28.0 statistical package. Univariate analysis for the association between dependent and independent variables was performed with Mann Whitney test. To both age and salivary flow variables, the Shapiro-Wilk test was used and an asymmetric distribution was detected. Associations between dependent variables and independent variables were assessed using the chi-square or Fisher's exact tests. Bi- and multivariate analyses were performed using Poisson regression with robust variance.

Four independent multivariate models were constructed, considering both outcomes (presence of decayed teeth and DMFT index) and both forms of salivation assessment (continuously or in the presence or absence of hypo salivation). The literature reports that the frequency of tooth brushing and visits to the dentist are associated with the history of dental caries [36]. Therefore, both variables were included in the multivariate models regardless of the p-value detected. Moreover, all variables that presented a p-value <0.25 in the bivariate analysis were included in the initial multivariate analyses. The combination of $p < 0.05$ and changes in the models were used to determine the final multivariate model. A backwards strategy was used in all models.

Results

Table (1) shows all adolescents were invited to participate. Among them, only six adolescents did not consent to participate, obtaining a response rate of

91.89 %. Study participants (n = 68) were divided into the following groups: those who did not have any decayed teeth (n = 39, mean age: 17.03 ± 1.01) and those who had at least one tooth decayed (n = 29, mean age: 17.31 ± 1.05); those who had DMFT = 0 (n = 20, mean age: 16.95 ± 0.95) and those who had DMFT≥1 (n = 48, mean age: 17.23 ± 1.10). **Table (1)** presents a univariate analysis for the association between dependent and independent variables. In this analysis, age was not significantly associated with any of the reported outcomes (p > 0.05). However, a higher level of education was significantly associated with no decayed teeth (p = 0.045). The lower mean of salivary flow was significantly associated with both outcomes: the presence of at least one decayed tooth (p = 0.029) and DMFT≥1 (p = 0.034). In addition, the presence of hypo salivation was significantly associated only with DMFT≥1 (p = 0.017) (**Table 1**).

The bivariate analyses are demonstrated in **Table 2**. Similar variables were included in all initial multivariate models, which were adolescent's level of education, access to the dentist in the last 12 months, and tooth brushing frequency (per day).

In the final multivariate analysis, the variable hypo salivation was significantly associated with DMFT≥1 (p = 0.048), with a prevalence ratio (PR) of 0.647 (95 % confidence interval [95%CI]: 0.420–0.997). It means that adolescents who did not present hypo salivation had 35.3 % lower PR for having at least one decayed, missing or filled tooth (**Table 3**). However, when the salivary flow was included as a continuous variable, no significant association with DMFT index was identified (p = 0.178) (**Table 4**).

On the other hand, the salivary flow was significantly associated with the presence of at least one decayed tooth (p = 0.004), with a PR of 0.842 (95%CI: 0.749–0.947). In this case, for each increase of 1 ml/min in the salivary flow, there is a decrease of 15.8 % in PR of having a decayed tooth (Table 4). No statistically significant association was identified between the presence of hypo salivation (≤1 ml/min) and at least one decayed tooth in these adolescents (p = 0.091) (**Table 3**). In all four models performed, tooth brush frequency and access to the dentist in the last 12 months were not significantly associated with both outcomes.

Table (1): Description of characteristics of study participants

Variables		**No decayed teeth (n = 39; 57.4 %)**	**At least one decayed tooth (n = 29; 42.6 %)**	**p-value**	**DMFT = 0 (n = 20; 29.4 %)**	**DMFT≥1 (n = 48; 70.6 %)**	**p-value**
Age	Mean ± SD n – (%)	17.03 ± 1.01	17.31 ± 1.05	0.258&	16.95 ± 0.95	17.23 ± 1.10	0.400&
Adolescent's level of	**Incomplete elementa**	27 (69.2)	26 (89.7)	0.045*	15 (75.0)	38 (79.2)	0.706*

Variables		No decayed teeth (n = 39; 57.4 %)	At least one decayed tooth (n = 29; 42.6 %)	p-value	DMFT = 0 (n = 20; 29.4 %)	DMFT≥1 (n = 48; 70.6 %)	p-value
education	ry school						
	At least complete	12 (30.8)	3 (10.3)		5 (25.0)	10 (20.8)	
	elementary school						
Smoking exposure	Smokers Former	9 (23.1)	8 (27.6)	0.671*	6 (30.0)	11 (22.9)	0.539*
	smokers/ Never smokers	30 (76.9)	21 (72.4)		14 (70.0)	37 (77.1)	
Access to the dentist in the last 12 months	Yes	24 (61.5)	16 (55.2)	0.598*	10 (50.0)	30 (62.5)	0.340*
	No	15 (38.5)	13 (44.8)		10 (50.0)	18 (37.5)	
Tooth brushing frequency	≤3 times	2 (5.1)	4 (13.8)	0.390#	16 (80.0)	43 (89.6)	0.288*
(per day)	>3 times	37 (94.9)	25 (86.2)		4 (20.0)	5 (10.4)	
Hypo salivation	Yes	23 (59.0)	22 (75.9)	0.145*	9 (45.0)	36 (75.0)	0.017*
Salivary flow (in ml/min)	No	16 (41.0) 5.51 ± 3.12	7 (24.1) 3.91 ± 1.82	0.029&	11 (55.0) 5.68 ± 2.59	12 (25.0) 4.47 ± 2.76	0.034&

Legend: *Chi-square; #Fisher exact test; &Mann-Whitney test. To all continuous variables, Shapiro-Wilk test showed a p-value <0.001. Therefore, it was used a non- parametric test.

Table (2): Bivariate analysis for the association of different independent variables with presence of decayed teeth and total DMFT

Variables	Prevalence ratio (95%CI) for at least one decayed tooth	p-value	Prevalence ratio (95%CI) for DMFT≥1	p-value
Age	1.158 (0.894–1.499)	0.266	1.077 (0.943–1.230)	0.274
Adolescent's level of education				
Incomplete elementary school	Ref.	0.094	Ref.	0.719
At least complete elementary School	0.408 (0.143–1.163)		0.930 (0.626–1.381)	
Smoking exposure				
Smokers **Former smokers/Never smokers**	Ref. 0.875 (0.479–1.597)	0.663	Ref. 1.121 (0.759–1.655)	0.565
Access to the dentist in the last 12 months				
Yes **No**	0.480 (1.95–1.182) Ref.	0.595	1.000 (0.702–1.425) Ref.	0.358
Tooth brushing frequency (per day)				
≤3 times **>3 times**	1.161 (0.670–2.012) Ref.	0.125	0.857 (0.617–1.191) Ref.	0.379
Hypo salivation				
Yes **No**	0.605 (0.318–1.149) Ref.	0.176	0.762 (0.416–1.396) Ref.	0.045
Saliva flow				
	0.623 (0.313–1.237) 0.850 (0.750–0.964)	0.011	0.652 (0.430–0.990) 0.949 (0.878–1.026)	0.192

Table (3): Multivariate analysis for the association of different independent variables with presence of decayed teeth and total DMFT, considering the individuals with hypo salivation

Variables	Prevalence ratio (95%CI) for at least one decayed tooth [a]		p-value	Prevalence ratio (95%CI) for DMFT≥1[b]	p- value
Access to the dentist in the last 12 months	Yes	Ref.	0.237	Ref.	0.808
	No	0.452 (0.121–1.686)		1.042 (0.750–1.447)	
Tooth brushing frequency (per day)	≤3 times	Ref.	0.260	Ref.	0.295
	>3 times	1.349 (0.802–2.270)		1.382 (0.755–2.531)	
Hypo salivation	Yes	Ref.	0.091	Ref.	0.048
	No	0.550 (0.275–1.101)		0.647 (0.420–0.997)	

The initial model included the following variables:

[a] Adolescent's level of education, use of marijuana, use of alcohol, access to the dentist in the last 12 months, tooth brushing frequency (per day) and hypo salivation.

[b] Access to the dentist in the last 12 months, tooth brushing frequency (per day) and hypo salivation.

Table (4): Multivariate analysis for the association of different independent variables with presence of decayed teeth and total DMFT, considering the salivary flow

Variables	Prevalence ratio (95%CI) for at least one decayed tooth [a]		p-value	Prevalence ratio (95%CI) for DMFT≥1[b]	p- value
Access to the dentist in the last 12 months	Yes	Ref.	0.354	Ref.	0.482
	No	1.271 (0.766–2.110)		0.889 (0.642–1.233)	
Tooth brushing frequency (per day)	≤3 times	Ref.	0.203	Ref.	0.317
	>3 times	0.435 (0.121–1.566)		0.738 (0.406–1.339)	
Hypo salivation		0.842 (0.749–0.947)	0.004	0.949 (0.878–1.024)	0.178

The initial model included the following variables:

[a] Adolescent's level of education, use of marijuana, use of alcohol, access to

the dentist in the last 12 months, tooth brushing frequency (per day) and hypo salivation.
[b] Access to the dentist in the last 12 months, tooth brushing frequency (per day) and hypo salivation

Discussion

The present study evaluated whether salivary flow could be associated with the experience of dental caries in adolescents. In KSA, few studies are investigating oral health conditions in this population [23, 24], which highlights the importance of the present findings, understanding the reality of the oral health conditions of these individuals, in an attempt to adapt the dental care provided to them. In this study, among the twenty-nine young people who had at least one decayed tooth at the moment of the exam, twenty-six (89.7 %) had incomplete an elementary school. A low level of education can generate numerous impacts on the lives of young people, from the weakening of their oral health, due to limited access to information, to the decrease in income [37, 38]. In addition, there is a marked degree of fragility in the families of these adolescents, leading to worse health conditions [39].

Previous studies have demonstrated that dental caries is a multifactorial disease affected by both salivary flow and its composition, encompassing fluidic components, which include ions, and protein constituents [40-42]. When these are inadequate, they become important risk factors for the development of oral diseases, due to the deleterious effects on immunological responses. In this context, the current study demonstrated that increased salivary flow is associated with lower PR of dental caries occurrence, while hypo salivation is significantly associated with presence of decayed teeth.

Different results were detected from the continuous and dichotomous evaluation of salivary flow. Hypo salivation is defined as the quantifiable reduction in the rate of salivary flow. The gold standard to determine the limit between the flow considered normal and low is still not well clear in the literature [35]. There are divergent perspectives among authors, where some consider hypo salivation when the stimulated salivary flow rate is below 0.5 ml/min [43], while others designate this at a threshold of less than 0.7 ml/min,35 and some still consider 1 ml/min as a cutoff point [35]. The present study used the current threshold for hypo salivation, as the prevalence of salivary flow <0.7 ml/min was very low. In addition, the use of salivary flow ≤1.0 ml/min was proposed by another study [35] with similar characteristics of the current sample.

Saliva can generally be classified as un-stimulated, when at rest, or stimulated. The salivary stimulation, in the present study, was made through the chewing of a sterile rubber, but alternative methods for stimulating salivary secretion are recognized, including chewing gum and pieces of paraffin [45]. Optimally stimulated saliva has been reported for values between 1 and 2 ml/min [46]. Therefore, it is recommended that both continuous and dichotomous modes of salivary flow assessment be included in clinical protocols and population surveys, to assess the risk factors for oral diseases.

It is remarkable that missing and filled teeth may be the result of other oral issues, such as trauma, fractures, or periodontal diseases. Additionally, due to economic constraints, access to dental healthcare services among these adolescents could be precarious, resulting in inadequate treatment for each condition. Although the DMFT index only assesses missing teeth and fills because of dental caries, it is

not uncommon for young people to be uncertain or do not know the reason for the extraction or filling. Consequently, potential misclassifications for the DMFT index should not be ruled out. While tooth loss due to periodontal diseases is improbable within this age support, readers should acknowledge this as a constraint of the present study. Importantly, while the DMFT index is widely used by dental researchers, its efficacy in assessing disease activity may not be presumed.

Conclusions: Dental caries experience among adolescents who present hypo salivation or low salivary flow are associated with DMFT≥1 index or presence of at least one decayed tooth, respectively.

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