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Original Article

Association of dental and gingival health status with level of salivary characteristics and *Streptococcus mutans* in children

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Abstract *Background/purpose:* Caries and periodontal diseases are the most common oral diseases that lead to teeth loss. The aim of this study is to assess the association of combination of salivary characteristics, *Streptococcus mutans* levels and clinical parameters to the dental and gingival health statuses of children.
Materials and methods: Saliva samples were collected from 89 children. Children were allocated to the low caries group (45 children: mean DMFT/dmft ≤ 2) or high caries group (44 children: mean DMFT/dmft ≥ 5) according to WHO method and criteria. Additionally, gingival health status was assessed as fair (gingival index and plaque index < 2) or bad (gingival index and plaque index ≥ 2). Each participant's resting saliva hydration (RSH), viscosity (RSV), pH (RSpH), stimulated saliva flow rate (SSFR), buffering capacity of saliva (BCSS) and level of *S. mutans* (SSM) were determined by chair side test kits.
Results: The result showed statistically significant differences in all salivary characteristics and SSM levels for both types of dentition between the low and active caries groups as well as between fair and bad gingival health status (except for RSH for permanent teeth and RSH plus SSFR for primary teeth). Logistic regression showed that combination of plaque index (PI), RSH, RSV, RSpH and SSM provided accurate association (permanent teeth: 92.1%, primary teeth: 100%) of caries status and PI plus BCSS provided accurate association (permanent teeth: 92.1%, primary teeth: 93%) of gingival health status.
Conclusion: This study has suggested that combination of salivary characteristics, PI and SSM levels could provide significant association of caries and gingival health statuses of children.

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Introduction

Periodontal diseases and dental caries are considered as the most common oral diseases and major causes of teeth loss.[1] Despite the huge efforts made, a large proportion of the population worldwide still have these two oral diseases.[2] Dental caries is a multifactorial, chronic infectious disease that causes irreversible damage to the tooth structures. *Streptococcus mutans* is a type of *Mutans streptococci* that has been implicated as the main bacteria responsible for the initiation and development of dental caries.[3,4] Periodontal diseases, basically gingivitis and periodontitis, are biofilm initiated chronic inflammatory diseases. Bacteria are considered a major causative factor in periodontal diseases, however, most of the destruction is driven by host response.[5]

Dental caries is the most common disease affecting humankind and the peak ages are 6, 26 and 70 years.[6] According to a recent report, 621 million children had untreated dentine caries in primary teeth and 2.4 billion people had caries in permanent teeth.[7] Furthermore, it was reported that periodontitis, which is the most serious form of periodontal disease, affected 743 million people worldwide in 2010.[8] It has been estimated that the global economic impact of oral diseases in 2010 amounted to US$ 442 billion.[9] It has been shown that prevalence of dental caries has decreased over the last three decades, however, there is insufficient evidence to conclude that the prevalence of periodontitis has decreased in recent decades.[10]

Saliva is considered as the most important natural defense against dental caries and oral diseases.[11] Reductions in the quantity of salivary secretions are responsible for individual oral and dental problems which impact directly upon the quality of life.[12] Dental caries is probably the most common consequence of hyposalivation.[4] Furthermore, saliva pH, viscosity, buffering capacity and composition also play a role in dental caries and periodontal diseases.[13]

Epidemiological studies to determine the prevalence of dental caries and periodontal diseases are paramount to estimate the required manpower, treatment and preventive measures in studied populations. However, the use of this protocol in large surveys may not be feasible. Full-mouth examinations require considerable resources and are time and labor consuming. In addition, this method could trigger patient and examiner fatigue, which may potentially increase measurement errors and increase dropout rates.[14]

Finding a salivary profile that can identify different status of oral health would be of great value in terms of reducing cost, patients' discomfort and time taken to determine the prevalence of dental caries and periodontal disease in different populations. The aim of this study is to assess the usefulness of salivary characteristics and *S. mutans* levels in determining dental and gingival health statuses amongst children using chair side saliva test kits.

Patients and methods

Patient population

This prospective case control study was approved by the Ethics Committee of the Medical Faculty, University of Sulaimani (Ethical approval number 333). Patients were recruited at the Pedodontics clinics from March to October 2016. Potential participants were screened by a consultant pedodontist and potential participants were invited to join the study. A total of 1270 children aged from 7 to 12 years old were screened and 89 of them were accepted onto the study after obtaining consent from their parents. The selection criteria were: patients aged from 7 to 12 years old who were without systemic disease or medication that would affect salivary flow and consented to be part of the study.

Clinical measures

Children were allocated to the low caries group (45 children: mean DMFT/dmft ≤ 2) or high caries group (44 children: mean DMFT/dmft ≥ 5) according to WHO method and criteria,[15,16] using a mouth mirror and a community periodontal index probe. The DMFT and dmft index were recorded separately and never combined and usually started with the permanent teeth. Additionally, the oral hygiene status of each patient was assessed by plaque index (PI)[17] and by gingival index (GI)[18] for teeth numbers 16, 12, 24, 36, 32 and 44 in permanent dentition and teeth numbers 55, 52, 64, 75, 72 and 84 in primary dentition. The oral hygiene status was recorded as excellent (PI $= 0$), good (PI of 0.1—0.9), fair (PI of 1—1.9) or poor (PI of 2—3) and assessed as fair (plaque index < 2) or bad (plaque index ≥ 2).[17] Gingival health status was recorded as excellent (GI < 0.1), mild gingivitis (GI of 0.1—1), moderate gingivitis (1.1—2) or severe gingivitis (GI of 2.1—3) and assessed as fair (gingival index < 2) or bad (gingival index ≥ 2).[18] For purposes of comparison, gingival health statuses were dichotomized by allocating fair gingival health status to those with mean GI < 2 and poor gingival health status to those with mean GI ≥ 2. The examination was carried out by one examiner after being trained and monitored by the principal investigator (FA) with intra-examiner reliability of 0.91 (Kappa test), respectively.

Saliva sample collection and analysis

Saliva samples were collected in the morning (between 9:00 and 11:00 am), according to the following procedure described by Wong[19]: the participant was seated in the dental chair in a relaxed position for a few minutes, the patient refrained from eating and drinking for at least 90 min before sampling and rinsed the mouth to avoid presence of oral debris in the sample, then unstimulated

saliva was collected for 10 min, followed by collection of stimulated saliva for 5 min in another tube.

Each participant was evaluated for resting saliva hydration (RSH) as follows: low (greater than 60 s) normal (from 30 to 60 s) and high (less than 30 s), while resting saliva viscosity (RSV) was evaluated as: residue (Sticky, white and frothy saliva), increased viscosity (Frothy, bubbly saliva) or normal (Watery, clear saliva) and resting saliva pH (RSpH) level of unstimulated saliva as: highly acidic (pH 5.0–5.8), moderately acidic (pH 6.0–6.6) or healthy (pH 6.8–7.8). Moreover, stimulated saliva flow rate (SSFR), using unflavored paraffin wax for five minutes, was determined as: very low (<3.5 ml), low (3.5–5 ml) or normal (>5.0 ml), plus buffering capacity of saliva (BCSS) was tested using a chair side saliva check buffer kit (GC Corporation, Japan) according to the manufacturer's instructions.[19] Additionally, participants' *S. mutans* (SSM) levels were tested using saliva check *S. mutans* (GC Corporation, Japan) as the chair side diagnostic method according to the manufacturer's instructions.[19]

Statistical analysis

Fisher's exact test was used to find statistically significant differences among the different caries and gingival health statuses for all tested variables. To determine the diagnostic capability of the tested variables, logistic regression was used with caries status (low or active) as the dependent variable and salivary characteristics and clinical measures (PI and GI) as independent variables. Furthermore, logistic regression was used to find the diagnostic capability of salivary characteristics using PI as the independent variable and gingival health status (fair or bad) as the dependent variable. Redundant variables were excluded by backward stepwise logistic regression. Odds ratio (OR) estimates and 95% confidence intervals (CIs) were calculated and statistical significance was defined as $P \leq 0.05$. All data were analyzed using the Statistical Package for Social Sciences (version 20; SPSS Inc., Chicago, IL, USA). The null hypothesis was that no combinations of salivary characteristics would associate with the dental and gingival health statuses.

Results

Patients background

A total of 89 children (44 male and 45 female) were recruited with the mean age of 10.2 ± 1.5 years, ranging from 7 to 12 years (16 subjects: <9 years, 27 subjects: 9–10 years and 47 subjects: 11–12 years).

The active caries group comprised 44 subjects and there was no statistically significant difference in DMFT numbers between males and females (Fisher's exact test, $P = 0.9$). However, there were statistically significant differences in DMFT numbers between the various age groups (<9 years: 11 subjects, 9–10 years: 18 subjects, 11–12 years: 15 subjects) (Fisher's exact test, $P = 0.002$). On the other hand, no statistically significant differences in dmft numbers were exhibited between males and females (Fisher's exact test, $P = 0.6$) and in the above age groups (Fisher's exact test, $P = 0.068$). Furthermore, there were no statistically significant differences in PI and GI (in either primary or permanent) between males and females and the various age groups (Fisher's exact test, $P = >0.05$).

Salivary characteristics, *S. mutans* level and caries status (permanent and primary teeth)

Amongst the 89 subjects recruited, 45 of them were allocated to the low caries group and the other 44 were allocated to the high caries group according to DMFT assessment of their permanent teeth. However, only 71 subjects had primary teeth and among these 29 subjects were allocated to the low caries group and the other 42 to the high caries group. For all the salivary characteristics and *S. mutans* levels tested in this study statistically significant differences (Fisher's exact test) were found between the low and high caries groups for both permanent and primary teeth (Table 1).

Salivary characteristics and oral hygiene and gingival health status (permanent and primary teeth)

In this part of the study the oral hygiene statuses of the 89 subjects with permanent teeth (good: 44, fair: 35, poor: 10) and 58 subjects with primary teeth (good: 16, fair: 31, poor: 11) were examined (Table 2). There were statistically significant differences (Fisher's exact test) in all salivary characteristics between those with good, fair and poor oral hygiene of permanent teeth and primary teeth except for RSpH and SSFR in primary teeth (Table 2).

On the other hand, the gingival statuses of permanent dentition (89 subjects) were as follows: 2 excellent, 50 mild gingivitis, 30 moderate gingivitis and 7 severe gingivitis. Whereas the gingival statuses of primary teeth (58 subjects) were as follows: none excellent, 24 mild gingivitis, 31 moderate gingivitis and 3 severe gingivitis (Table 3). There were statistically significant differences in all salivary characteristics except for RSpH of subjects with different gingival health statuses of permanent teeth. Whereas in the case of primary dentition, the only statistically significant differences found were for RSV and BCSS in subjects with different gingival health statuses (Table 3).

Association value

To determine the diagnostic value of salivary characteristics for caries and gingival health statuses, logistic regression was used with salivary parameters as independent variables and caries status (low or active), on one hand, and gingival health status (fair or bad), on the other hand. In the case of caries status, the levels of PI, RSV, SSM, RSH and RSpH were able to associate with 92.1% certainty for permanent teeth and 100% for primary teeth, whereas the single biomarker was able to associate with 50.6% certainty for caries status of permanent teeth and 63% for caries status of primary teeth (Table 4). Backward stepwise logistic regression showed that GI, SSFR and BCSS are redundant variables for both primary and permanent dentition ($P > 0.05$) (Table 5).

Table 1 Salivary parameters amongst subjects with low and active caries (permanent and primary teeth).

Salivary parameters		Permanent teeth number (%)				Primary teeth number (%)			
		Low caries DMFT ≤ 5	Active caries DMFT ≥ 5	Total	*P* value*	Low caries dmft ≤ 5	Active caries dmft ≥ 5	Total	*P* value*
RSH	Low	3 (6.6)	14 (31.8)	17 (19.1)	**<0.001**	1 (3.4)	12 (28.6)	13 (18.3)	**<0.001**
	Normal	21 (46.7)	25 (56.8)	46 (51.7)		12 (41.4)	25 (59.5)	37 (52.1)	
	High	21 (46.7)	5 (11.4)	26 (29.2)		16 (55.2)	5 (11.9)	21 (29.6)	
RSV	Residue	0 (0)	18 (40.9)	18 (20.2)	**<0.001**	0 (0)	18 (42.9)	18 (25.4)	**<0.001**
	Increased	10 (22.2)	23 (52.3)	33 (37.1)		6 (20.7)	21 (50)	27 (38)	
	Normal	35 (77.8)	3 (6.8)	38 (42.6)		23 (79.3)	3 (7.1)	26 (36.6)	
RSpH	Highly acidic	0 (0)	3 (6.8)	3 (3.4)	**<0.003**	0 (0)	3 (7.1)	3 (4.2)	**<0.024**
	Moderately acidic	22 (48.9)	32 (72.7)	54 (60.7)		15 (51.7)	30 (71.4)	45 (63.4)	
	Healthy	23 (51.1)	9 (20.5)	32 (36)		14 (48.3)	9 (21.4)	23 (32.4)	
SSFR	Very low	1 (2.2)	17 (38.6)	18 (20.2)	**<0.001**	0 (0)	15 (35.7)	15 (1.1)	**0.001**
	Low	25 (55.6)	21 (47.7)	46 (51.7)		18 (62.1)	21 (50)	39 (54.9)	
	Normal	19 (42.2)	6 (13.6)	25 (28.1)		21 (37.9)	6 (14.3)	17 (23.9)	
BCSS	Highly acidic	0 (0)	3 (6.8)	3 (3.4)	**<0.001**	0 (0)	2 (4.8)	2 (2.8)	**<0.001**
	Moderately acidic	10 (22.2)	31 (70.5)	41 (46.1)		5 (17.2)	30 (71.4)	35 (49.3)	
	Healthy	35 (77.8)	10 (22.7)	45 (50.6)		24 (82.8)	10 (23.8)	34 (47.9)	
SSM	Positive	18 (40)	44 (100)	62 (69.6)	**<0.001**	10 (34.4)	42 (100)	52 (73.2)	**<0.001**
	Negative	27 (60)	0 (0)	27 (30.4)		19 (65.6)	0 (0)	19 (26.8)	
Total		45 (100)	44 (100)	89 (100)		29 (100)	42 (100)	71 (100)	

DMFT: Decay, missing, filling, treated in permanent teeth; dmft: Decay, missing, filling, treated in primary teeth; RSH: resting saliva hydration; RSV: resting saliva viscosity; RSpH: resting saliva pH; SSFR: stimulated saliva flow rate; BCSS: buffering capacity of saliva; SSM: *Streptococcus mutans* level: *Fisher's exact test ≤ 0.05.

For gingival health status, the levels of PI and BCSS were able to associate the gingival health status with 92.1% certainty for permanent teeth and 93% certainty for primary teeth. The single biomarker was able to associate gingival health status with 62.2% certainty for permanent teeth and 61% certainty for primary teeth (Table 4). Backward logistic regression showed that RSH, RSV, RSpH, SSFR and SSM levels are redundant variables for correlating gingival health status (Table 5). Odds ratios and 95% CI of the independent variables for both caries and gingival health status are shown in Table 5.

Discussion

The key findings of the present study are that combination of salivary characteristics, SSM levels and PI levels can provide good association of caries and gingival health statuses in children. The rationale behind the study was that both caries and periodontal diseases (gingivitis) are multifactorial and a single biomarker is not likely to reflect the complex nature of these diseases. Indeed, no single biomarker was able to associate the caries and gingival health statuses. Furthermore, the result of this study showed that saliva alone is able to associate caries status, whereas both saliva and PI are necessary to determine gingival health status.

Recently, a lot of researchers have concentrated on the examination of saliva as it is a mirror reflecting many disorders of the oral cavity and the body. Also, developments in medical technology have provided more opportunity to carry out different investigations on microorganisms and saliva.[20] In addition, compared to blood samples, saliva samples have the advantages of being non-invasive, easy to obtain, simple to handle, with no need to add a particular material, and are less infectious and more cost effective. Chair side evaluation of saliva characteristics and *S. mutans* allows all results to be obtained at the same appointment, which reduces time and cost. Also, the results of these tests can be used for reinforcement of motivation and instruction of the patient.

Dental caries is well recognized as an incurable and infectious disease that destroys hard tissue of the tooth. Unfortunately, there are no vaccination programs or preventive measures to prevent initiation of the disease in children and adults.[21] Therefore, an investigation that demonstrates the interaction of relationships or effects of component variables in the oral cavity may help in the assessment and determination of the disease in the susceptible individual. Saliva characteristics including RSH, RSV, RSpH, SSFR and BCSS were selected for this study due to their effect on oral health status, especially in relation to dental caries.

Active caries in both types of dentition was less evident in the older children aged 11—12 years than among those aged 9 years and the difference was statistically significant in permanent dentition. This result is not in line with Mohammed[22] who found that the mean of DMFT was significantly higher at age 10—12 years than age 6—9 years; however, the difference in the results may be due to sample size and the criteria selected for the present research.

Table 2 Salivary parameters of subjects with different oral hygiene status (permanent and primary teeth).

Salivary parameters		Oral hygiene by PI (%) permanent teeth				Oral hygiene by PI (%) primary teeth			
		Good	Fair	Poor	*P* value*	Good	Fair	Poor	*P* value*
RSH	Low	4 (9)	11 (31.5)	2 (20)	**0.006**	2 (12.5)	6 (19)	3 (27.3)	**0.042**
	Normal	21 (48)	17 (48.5)	8 (80)		4 (25)	17 (55)	7 (64.7)	
	High	19 (43)	7 (20)	0 (0)		10 (62.5)	8 (26)	1 (9)	
RSV	Residue	0 (0)	12 (34)	6 (60)	**<0.001**	0 (0)	9 (29)	5 (45)	**0.001**
	Increased	11 (25)	18 (51.5)	4 (40)		5 (31)	14 (45)	6 (55)	
	Normal	33 (75)	5 (14.5)	0 (0)		11 (69)	8 (26)	0 (0)	
RSpH	Highly acidic	0 (0)	1 (2.8)	2 (20)	**<0.001**	0 (0)	1 (3)	2 (19)	0.077
	Moderately acidic	21 (48)	25 (71.5)	8 (80)		8 (50)	21 (68)	8 (72)	
	Healthy	23 (52)	9 (25.7)	0 (0)		8 (50)	9 (29)	1 (9)	
SSFR	Very low	2 (4.5)	11 (31.5)	5 (50)	**<0.001**	1 (6)	8 (26)	4 (36)	0.202
	Low	23 (52)	19 (54)	4 (40)		9 (56)	18 (58)	6 (55)	
	Normal	19 (43.5)	5 (14.5)	1 (10)		6 (38)	5 (16)	1 (9)	
BCSS	Highly acidic	0 (0)	2 (5.7)	1 (10)	**<0.001**	0 (0)	1 (3)	1 (9)	**<0.001**
	Moderately acidic	10 (22.7)	24 (68.5)	7 (70)		2 (12.5)	21 (68)	8 (72)	
	Healthy	34 (77.3)	9 (25.8)	2 (20)		14 (87.5)	9 (29)	2 (19)	
Total		44 (100)	35 (100)	10 (100)	89	16 (100)	31 (100)	11 (100)	58

PI: plaque index; RSH: resting saliva hydration; RSV: resting saliva viscosity; RSpH: resting saliva pH; SSFR: stimulated saliva flow rate; BCSS: buffering capacity of saliva; *Fisher's exact test ≤ 0.05.

Table 3 Salivary parameters of subjects with different gingival health status (permanent and primary teeth).

Salivary parameters		Gingival health by GI (%) permanent teeth					Gingival health by GI (%) primary teeth				
		Excellent	Mild	Moderate	Severe	*P* value*	Excellent	Mild	Moderate	Severe	*P* value*
RSH	Low	0 (0)	4 (8)	12 (40)	1 (14)	**0.001**	0	3 (12.5)	8 (26)	0 (0)	0.098
	Normal	0 (0)	27 (54)	13 (43)	6 (86)		0	9 (37.5)	16 (52)	3 (100)	
	High	2 (100)	19 (38)	5 (17)	0 (0)		0	12 (50)	7 (22)	0 (0)	
RSV	Residue	0 (0)	2 (4)	12 (40)	4 (57)	**<0.001**	0	3 (12.5)	10 (32)	1 (33)	**0.001**
	Increased	0 (0)	14 (28)	16 (53)	3 (43)		0	6 (25)	17 (55)	2 (67)	
	Normal	2 (100)	34 (68)	2 (7)	0 (0)		0	15 (62.5)	4 (13)	0 (0)	
RSpH	Highly acidic	0 (0)	0 (0)	2 (7)	1 (14)	0.053	0	0 (0)	2 (6)	1 (33)	0.136
	Moderately acidic	1 (50)	27 (54)	21 (70)	5 (72)		0	14 (58)	21 (68)	2 (67)	
	Healthy	1 (50)	23 (46)	7 (23)	1 (14)		0	10 (42)	8 (26)	0 ()	
SSFR	Very low	0 (0)	3 (6)	11(37)	4 (57)	**<0.001**	0	2 (8)	10 (32)	1 (33.3)	0.108
	Low	1 (50)	27 (54)	16 (53)	2 (29)		0	15 (62.5)	17 (55)	1 (33.3)	
	Normal	1 (50)	20 (40)	3 (10)	1 (14)		0	7 (29.5)	4 (13)	1 (33.3)	
BCSS	Highly acidic	0 (0)	0 (0)	3 (10)	0 (0)	**<0.001**	0	1 (4)	1 (3)	0 (0)	**<0.001**
	Moderately acidic	0 (0)	15 (30)	21 (70)	5 (72)		0	5 (21)	24 (78)	2 (67)	
	Healthy	2 (100)	35 (70)	6 (20)	2 (28)		0	18 (75)	6 (19)	1 (33)	
Total		2 (100)	50 (100)	30 (100)	7 (100)	89	0	24 (100)	31 (100)	3 (100)	58

GI, gingival index; RSH: resting saliva hydration; RSV: resting saliva viscosity; RSpH: resting saliva pH; SSFR: stimulated saliva flow rate; BCSS: buffering capacity of saliva; *Fisher's exact test ≤ 0.05.

The rationale behind selecting the salivary characteristics and *S. mutans* levels for detection of oral status was as follows: low saliva washing effect has been associated with high caries[23] and increased plaque accumulation.[24] On the other hand, increased salivary viscosity increases the chance of caries and decreases its effect of washing out plaque that in turn increases PI and GI.[25] Furthermore, with decreasing pH of saliva, tooth demineralization and progression to dental caries will increase.[19] Saliva pH is an important influence on the microbial ecology of dental plaque as it serves to maintain a delicate balance between alkali and acid generation both in the saliva and dental plaque.[26] Dodds et al.[27] stated that stimulation of saliva flow results in an increase in washing out of the oral cavity, and also an increase in the amount and concentration of bicarbonate buffer and of remineralizing ions that help to decrease incidence of dental caries. Stimulation of salivary flow protects hard and soft oral tissues in many ways including mechanical cleaning away of bacteria and food debris from the oral cavity, and qualitative changes that can provide different ion, enzyme and antibacterial concentrations.[28] Moreover, one of the major protective qualities of saliva is its buffering capacity that neutralizes acid present in the oral cavity, increasing remineralization

Table 4 Logistic regression analysis with caries status (low or active) and gingival health status (fair or bad) as dependent variables (permanent and primary teeth).

Method	Caries status (low or active)		Gingival health status (fair or bad)	
	Permanent teeth (Association %)	Primary teeth (Association %)	Permanent teeth (Association %)	Primary teeth (Association %)
All	92.1	100 (all variables)	97.8	93 (all variables)
Stepwise (backward conditional)	92.1 (PI, RSV, SSM, RSH, RSpH)	100 (PI, RSV, SSM, RSpH, RSH)	92.1 (PI, BCSS)	93 (PI, BCSS)
Each single variable	50.6	63	62.2	61

PI: plaque index; RSH: resting saliva hydration; RSV: resting saliva viscosity; RSpH: resting saliva pH; BCSS: buffering capacity of saliva; SSM: *Streptococcus mutans* level.

Table 5 Logistic regression for each individual explanatory variable for caries and gingival health status (permanent and primary teeth).

Dentition type	Association variable	Caries status			Gingival health status		
		OR	95% CI for OR	*P* value	OR	95% CI for OR	*P* value
Permanent teeth	PI	196	78–492	**0.01**	379	81–839	**0.009**
	GI	0.06	0.001–137	0.31	–	–	–
	RSH	1.1	0.9–1.3	**0.02**	1.02	0.9–1.1	0.7
	RSV	0.3	0.1–2.2	**0.02**	0.16	0.003–9.9	0.4
	RSpH	0.1	0.03–3	**0.01**	3.7	0.05–234	0.27
	SSFR	0.5	0.09–2.9	0.4	1.06	0.02–39	0.9
	BCSS	1.2	0.5–2.6	0.6	6.7	0.9–7.1	**0.03**
	SSM (positive)	4.7	2.1–6.5	**0.0001**	1.2	0.001–1.3	0.99
Primary teeth	PI	6.2	1.8–10.2	**0.01**	287	78–1056	**0.001**
	GI	0.01	0.001–288	0.1	–	–	–
	RSH	3.9	1.4–7.2	**0.001**	1.2	0.9–1.7	0.1
	RSV	0.2	0.08–1.1	**0.02**	0.4	0.001–3.2	0.1
	RSpH	0.8	1.1–6.8	**0.001**	1.8	0.02–17.7	0.7
	SSFR	0.001	0.0001–33	0.99	1.7	0.3–162	0.1
	BCSS	1.5	0.001–13.4	0.99	6.9	1.2–12.4	**0.02**
	SSM (positive)	5.8	2.9–8.3	**0.0001**	0.01	0.0001–1.4	**0.99**

PI: plaque index; GI, gingival index; RSH: resting saliva hydration; RSV: resting saliva viscosity; RSpH: resting saliva pH; SSFR: stimulated saliva flow rate; BCSS: buffering capacity of saliva; SSM: *Streptococcus mutans* level. *Fisher's exact test ≤ 0.05.

and protecting the teeth from dental caries. For the same reason, individuals with high salivary buffer capacity are often caries resistant.[5] Puy[29] stated that saliva contains specific buffer mechanisms such as bicarbonate, phosphate and some protein systems which not only have a buffering effect of reducing acid but also provide ideal conditions for automatically eliminating certain bacterial components that require a very low pH to survive. In addition, Puy[29] stated that detection of *S. mutans* in saliva can be used in evaluation of risk of dental caries. Lastly, there is research supporting the central role of *S. mutans* count in the increase of dental caries in children.[30]

As shown in Table 1, statistically significant differences are evident in all tested salivary characteristics and *S. mutans* levels between active caries and low caries children for both types of dentition. These findings are in line with the data reported in previous studies.[19,27] Furthermore, statistically significant differences were found for all tested salivary characteristics between subjects with different oral hygiene statuses (good, fair and poor) except for RSpH and SSFR in primary teeth (Table 2). As shown in Table 3, there are statistically significant differences in all salivary characteristics in subjects with different gingival health statuses (excellent, mild, moderate and severe gingivitis) except for RSpH in permanent teeth and RSH, RSpH as well as SSFR in primary dentition. These data are again in line with others.[24,26]

In terms of determining caries and gingival health statuses, there is a shortage of literature on the usefulness of these data as a diagnostic tool for epidemiological study. The current study tried to fill this research gap. Using logistic regression analysis, caries statuses in both primary and permanent dentition were identified by PI, RSV, SSM, RSH and RSpH with certainty of 92.1% for permanent teeth and 100% for primary teeth. Furthermore, gingival health statuses were identified in permanent teeth by PI and BCSS with 92.1% certainty, whereas in primary teeth the association of gingival health status was 93% by PI and BCSS (Table 4). It is important to acknowledge that not all salivary characteristics were good indicators of caries and gingival health status ($P > 0.05$) and that is why they are considered as redundant variables (Table 5). However, there were statistically

significant differences in some of those variables, as shown in Tables 1—3. This can be explained by the overlaps in association value of these variables and the fact that their association values were better explained by another variable, which is why they could not add any additional association value to the overall combination of variables.

The size of the study sample was not sufficiently large to allow us to validate our results and there was particular difficulty in obtaining enough caries free subjects as their parents did not see the necessity for their children to have the examinations, hence why in a total of 1270 children screened, only 89 of them agreed to take part in the study. In addition, the presence of mixed dentition and lack of criteria for combining caries and gingival health statuses in mixed dentition in the same person caused difficulties in interpretation of the data.

In conclusions, this study has suggested that combination of salivary characteristics, PI and SSM levels could provide significant association of caries and gingival health statuses of children. Further study is necessary to validate the association values of these salivary characteristics and *S. mutans* levels.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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