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Salivary characteristics and dental caries: Evidence from general dental practices

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Abstract

Background—Saliva is one of the intraoral host factors that influence caries development. The authors conducted a study to investigate whether salivary characteristics are associated with recent dental caries experience.

Methods—Dentist-investigators and dental staff members collected data pertaining to a two-year cumulative incidence of dental caries (previous 24 months) and salivary characteristics during baseline assessment in an ongoing longitudinal study. The systematic random sample consisted of patients (n = 1,763) visiting general dental practices (n = 63) within the Northwest Practice-based REsearch Collaborative in Evidence-based DENTistry (PRECEDENT). The authors estimated adjusted rate ratios (RRs) by using generalized estimating equations log-linear regression to relate salivary characteristics to coronal carious lesions into dentin.

Results—Low resting pH (≤ 6.0) in the overall sample and low stimulated salivary flow rate (≤ 0.6 milliliter/minute) in older adults (≥ 65 years old) were associated with increased dental caries (RR, 1.6; 95 percent confidence interval [CI], 1.1–2.2; RR, 2.4; 95 percent CI, 1.5–3.8,

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respectively). Low buffering capacity was associated with decreased dental caries in children and adolescents (RR, 0.3; 95 percent CI, 0.1–1.0; RR, 0.2; 95 percent CI, 0.1–0.7, respectively). A thick, sticky or frothy salivary consistency also was associated with decreased dental caries in adults (RR, 0.6; 95 percent CI, 0.4–1.0). Associations between other salivary characteristics and dental caries for the overall sample and within each age group were not statistically significant.

Conclusions—Salivary characteristics were associated weakly with previous dental caries experience, but the authors did not find consistent trends among the three age groups. Different salivary characteristics were associated with an increased caries experience in older adults and a lowered caries experience in children and adolescents and adults.

Practical Implications—Further investigations are needed in this population setting to understand the study's conflicting results. The study findings cannot support the use of salivary tests to determine caries risk in actual clinical settings.

INTRODUCTION

Saliva is the complex mixture of fluids that surrounds the oral tissues, and it originates from major and minor salivary glands and nonglandular sources such as crevicular fluids, oral microorganisms and host cells.[1] The consistency of saliva can be watery, thick, sticky or frothy depending on its composition; the amount of proteins in saliva mainly will determine its thickness or frothiness. A basal unstimulated secretion is produced continuously to moisturize and lubricate the oral tissues for more than 90 percent of the day.[2] The normal resting salivary flow rate ranges from 0.25 to 0.35 milliliter per minute. Mechanical, gustatory, olfactory or pharmacological stimuli increase the production and secretion of saliva. Stimulated saliva represents 80 to 90 percent of daily salivary production, and the stimulated flow rate varies from 1 to 3 mL/minute.[3] The salivary pH and the salivary buffering capacity are determined by the hydrogen bicarbonate balance in saliva. Salivary pH is approximately neutral, and buffering agents, such as inorganic phosphate in resting saliva and carbonic acid-bicarbonate system in stimulated saliva, help maintain neutrality.[3]

Among the various protective functions of saliva, including diluting and cleaning the oral cavity, serving as a host defense, and buffering and enabling ion exchange, certain salivary characteristics outside the normal range of values may contribute to the caries process.[4] Dental caries results from the dissolution of minerals from the tooth surface by organic acids formed from the bacterial fermentation of sugars. The capacity of saliva to flush microorganisms and substrates and maintain oral cleanliness may be influenced by its consistency and flow rate.[5,6] Salivary pH and buffering capacity can contribute to the ion exchanges during re-mineralization and demineralization of enamel, with supersaturation of calcium and phosphate at pH 7 and in the presence of fluoride.[7] The concentration of hydrogen ions (pH) at the tooth surface also will affect the rate of demineralization.[7] The statements above are based primarily on the results of in vitro studies[5,6,7] that reveal the biological plausibility for changes in salivary characteristics to contribute to the development of dental caries.

Another source of evidence of the influence of saliva on dental caries is studies conducted in people who have chronic salivary disturbances.[8,9] Sjögren syndrome, an autoimmune disease, is characterized by a dramatically decreased salivary flow rate, and patients with this syndrome have higher rates of caries experience than those in control participants.[10,11,12,13,14,15] The long-term use of some medications with antisialogogue effects, such as β-adrenergic agonists,[16,17] corticosteroids[18] and psychotropics,[19,20] also has been shown to be associated with a high rate of caries experience.

However, the effect of saliva on dental caries in people without pathological conditions or chronic salivary gland hypofunction is less well under-stood. Evidence from epidemiological studies is scarce, and most studies lack statistical power. In a general population in which salivary function typically is within the normal range, the early identification of patients who may develop dental caries may contribute to the use of less invasive treatments. We hypothesize that a low salivary flow rate, low pH and low buffering capacity are associated with a higher dental caries rate.

Therefore, our objective in this study was to investigate the association between salivary characteristics and dental caries within the previous 24 months in a sample of patients in general dental practices.

METHODS

We conducted a longitudinal study of caries risk assessment within the Northwest Practice-based REsearch Collaborative in Evidence-based DENTistry (PRECEDENT), a dental practice–based research network. From May 2008 through February 2011, 63 general dentists enrolled patients from their practices and collected baseline and retrospective data.

We determined sample sizes on the basis of the requirement to have sufficient power within each age group to detect a difference between the predictive value of a traditional risk assessment tool (based only on historical and environmental parameters such as previous caries experience, demographics) and that of an augmented risk assessment tool that includes salivary markers. Therefore, the study had adequate power to detect associations between salivary measures and caries. We randomly assigned to each practice a specific weekday to begin patient selection, with the goal of enrolling 30 patients per practice. We assigned an interval for randomly sampling approximately one patient per day from the daily appointment schedule on the basis of a typical two-week schedule reflecting the average daily patient load. The objective of enrolling approximately equal numbers of patients in three age groups—9 through 17 years, 18 through 64 years and 65 years and older—dictated that practices joining later than the beginning of the study or those wishing to enroll more than 30 patients (up to a maximum of 50 patients) would target patients at either end of the age spectrum, as the sample size for the group aged 18 to 64 years was reached first. Practices accomplished this by using a sampling scheme in which they enrolled the first patient of the day in either the 9 through 17 years or 65 years and older age groups. To be eligible for study participation, a patient had to be 9 years of age or older, have at least four permanent teeth, be able to understand English and provide consent (or obtain parental consent). The dentist-investigators or their dental practice staff members explained the purpose and procedures of the study to participants and obtained written informed consent. The institutional review board of the University of Washington, Seattle, approved the study protocol.

Dentist-investigators and dental practice staff members underwent training for this study by reviewing the manual of operations and data collection forms, as well as by participating in telephone training sessions given by research coordinators (M.R. and others) regarding the study-specific procedures and the Web-based data entry system. We provided detailed instructions for the clinical measures on the data collection forms. Each dentist-investigator assigned a dental staff member to perform the six salivary tests. Dentists and staff members participated in the telephone training session with the salivary test kit in hand. The training included a step-by-step review of the instructions for each test that were provided on the data collection form. Before beginning the study, the dentist-investigator observed a practice run to certify the assigned staff member’s ability to perform the six salivary tests per the

protocol. Research coordinators were available by telephone to answer any queries from dentists or staff members.

We collected data via a questionnaire completed by the patients, a dental examination performed by the dentist-investigator, a dental record review and six salivary tests conducted by a dental staff member.

Questionnaire

The questionnaire completed by participants contained questions regarding demographics, social conditions, general health, medication use and general health– and oral health–related behaviors that might affect salivary characteristics or dental caries. Participants were queried about sex, age, race/ethnicity, income and education. We defined acidic beverages as weekly consumption of regular or diet sodas, sport drinks and orange juice, as well as other 100 percent juices. The questionnaire also queried participants about the frequency and amount of consumption of drinks containing alcohol, as well as cigarette and cigar smoking. We defined the use of medications affecting saliva as use of the following drug types: cardiovascular, central nervous system, endocrine and metabolic, gastrointestinal, genitourinary or respiratory medications. We defined “fluoride toothbrushing” as the frequency of brushing with a toothpaste that contains fluoride.

Dental examination

The dental examination consisted of assessing dental caries experience (decayed, missing or filled permanent teeth; visible cavitation; and visible inter-proximal enamel carious lesions), visible heavy plaque and other dental conditions. The dentist-investigator or a dental staff member reviewed dental records for the preceding 24 months for patients who had been in the practice for at least 24 months to gather information about dental caries (enamel and dentin lesions), extractions, restorations and advanced restorative procedures. We instructed dentists to record for each tooth whether the patient had any coronal carious lesion into dentin, arrested carious lesion into dentin or carious lesion that involved the pulp, necessitating extraction or pulpal treatment.

Salivary tests

The salivary tests enabled the dental staff member to assess the following salivary characteristics: consistency, resting and stimulated flow, resting and stimulated pH and buffering capacity. The assigned dental staff member classified saliva consistency as watery and clear or thick, sticky or frothy by observing the saliva in the floor of the mouth. He or she measured resting salivary flow as the time (up to 90 seconds) required to form new saliva droplets from the minor glands on the mucosa inside the lower lip. The dental staff member measured the stimulated salivary flow rate as the volume of saliva collected while the patient chewed a wax pellet for five minutes. He or she measured resting and stimulated salivary pH values by dipping pH strips (Advantec MFS, Tokyo) into unstimulated and stimulated saliva for 10 seconds and comparing them with a pH reference chart. The staff member measured salivary buffering capacity with the use of a colorimetric paper strip test, following the manufacturer’s instructions (Saliva- Check Buffer test, GC America, Alsip, Ill.). Using a pipette, the staff member dispensed stimulated saliva onto a test strip containing three different acid challenges; after two minutes, he or she recorded the color observed for each test pad. We determined the patient’s buffering capacity by adding the values assigned to each color, according to the manufacturer’s instructions: green, 4; blue/green, 3; blue, 2; blue/red, 1; and red, 0 (the higher the number, the better the buffering capacity). We matched other colors or color combinations to these colors as much as possible. We considered interexaminer reliability for the salivary tests performed in this

study setting to be adequate, with intraclass correlation coefficients ranging from 0.55 to 0.94.21

Statistical analysis

We defined dental caries as the number of permanent teeth with coronal carious lesions into dentin diagnosed within the previous 24 months. To elucidate potential associations between the salivary characteristics and caries—with the eventual aim of assessing the utility of saliva for caries risk assessment—we categorized the salivary measures into three levels on the basis of the 90th and 75th percentiles for each measure to compare the caries experience. The main exposures were saliva consistency (watery and clear versus thick, sticky or frothy), resting salivary flow rate (≤ 60 seconds, > 60 to < 90 seconds, ≥ 90 seconds), stimulated salivary flow rate (≤ 0.6 mL/minute, > 0.6 to < 1.0 mL/minute, ≥ 1.0 mL/minute), resting salivary pH (5.0 to ≤ 6.0, > 6.0 to < 6.4, ≥ 6.4 to 7.8), stimulated salivary pH (5.0 to ≤ 7.0, > 7.0 to < 7.6, ≥ 7.6 to 7.8) and salivary buffering capacity (low, 0–3 points; moderate, 4–5 points; high, 6–12 points). We determined the cutoff values for the main exposures a priori.

We used descriptive statistics to examine the distribution of dental carious lesions, main exposures and covariates. We estimated crude and adjusted rate ratios (RRs) to examine the association between salivary characteristics and dental caries experience. We performed multiple log-linear regressions for each salivary characteristic individually. We used generalized estimating equations with robust standard error estimates to take into account the clustering of participants within practices.[22] We entered into the model selected covariates from different domains (demographics, socioeconomic status, general health and health-related behaviors, and oral health). We presented separate results for children and adolescents (9–17 years old), adults (18–64 years old) and older adults (≥ 65 years old). We performed analyses by using statistical software (STATA Version 10.1, StataCorp, College Station, Texas).

RESULTS

Of 1,763 participants enrolled in the study at the time of data analysis, 376 were not included in the analyses because they had medical conditions that affected their saliva (that is, radiation treatment for head and neck cancer or Sjögren syndrome [n = 19]), or they had not been a patient in the dental practice for at least 24 months (n = 357). Participants included in our analysis (N = 1,387) were more likely than those enrolled in the study, but not included in the analysis, to be older, white and in a high income group, as well as to have less visible heavy plaque and a lower resting salivary flow rate. Other salivary characteristics were similar between the two groups (data not shown).

Table 1 presents data pertaining to patients' demographics, socioeconomic status, general health, oral health and salivary characteristics. Of the 1,387 participants, 25 percent were younger than 18 years, 49 percent were 18 to 64 years and 26 percent were 65 years or older.

A thick, sticky or frothy saliva consistency was observed in 7 percent of the participants. The mean (standard deviation [SD]) stimulated salivary flow rate and buffering capacity were 1.4 (0.7) mL/minute and 7.2 (2.5) points, respectively. The mean (SD) resting and stimulated pH were 6.7 (0.5) and 7.5 (0.3), respectively (Table 1).

Frequencies of low resting salivary flow (≥ 90 seconds) increased with age. Low resting and stimulated salivary pH also increased with age, whereas low salivary buffering capacity decreased with age (Table 1).

Table 2 presents dental carious lesions in participants in the previous 24 months, according to age and salivary characteristics. Mean (SD) dental caries in the preceding 24 months was 1.1 (2.5) for children and adolescents, 1.6 (2.7) for adults and 1.4 (2.3) for older adults.

After adjustment for covariates, the following associations were statistically significant: mean dental caries overall was 60 percent higher for participants with a resting salivary pH ≤ 6.0 compared with that in participants with a resting salivary pH ≥ 6.4. Interactions between age and salivary characteristics were present for salivary consistency (P = .03), stimulated salivary flow rate (P = .006), resting salivary pH (P = .01) and buffering capacity (P < .001). Mean dental caries for adults aged 18 through 64 years who had a thick, sticky or frothy salivary consistency was 40 percent lower than that for adults aged 18 through 64 years who had a watery and clear salivary consistency. Mean dental caries in older adults with a stimulated salivary flow rate of 0.6 mL/minute or less was 140 percent higher than that in older adults with a stimulated salivary flow rate of 1 mL/minute or higher. Mean dental caries in children and adolescents with low buffering capacity was 70 percent lower than that in children and adolescents with a higher buffering capacity (Table 3).

DISCUSSION

In this study, salivary characteristics were related to patients' caries experience within the previous two years. We found that salivary characteristics were associated inconsistently across the three age groups. Although for the population as a whole, most associations were not statistically significant, some salivary characteristics were associated with increased caries experience in older adults (65 years and older) and others were associated with lowered caries experience in children and adolescents and in adults aged 18 through 64 years.

Associations between dental caries and low resting salivary flow rate and between dental caries and low stimulated salivary pH for the entire population and for the three age groups were not statistically significant. For adults aged 18 through 64 years, thick, sticky or frothy salivary consistency was associated with a decrease in dental caries. For children and adolescents, low buffering capacity was associated with a decrease in dental caries, not an increase in dental caries, as we had hypothesized. For older adults, a low stimulated salivary flow rate was associated with increased dental caries. Resting salivary pH was statistically significant overall, but not within the specific age groups.

A low stimulated salivary flow rate was associated with increased dental caries among older adults, but not among children or adults. The results of studies in which investigators reported on this association are inconsistent,[23,24,25,26,27,28] and most studies in which investigators found a positive association between low stimulated salivary flow rate and dental caries were conducted in children with syndromes such as cleft lip or palate or in hospitalized older adults.[29] Our study results show that a low resting salivary pH was not associated with higher caries experience in the three age groups. However, resting salivary pH was significant overall. Resting saliva bathes the oral cavity 90 percent of the time, and its pH usually is lower than the pH of stimulated saliva.30 Studies rarely indicate resting pH as a risk factor for dental caries,[29,31] but our findings may warrant further investigation.

A thick, sticky or frothy salivary consistency in adults aged 18 through 64 years and a low buffering capacity in children and adolescents were associated with lower caries experience, unexpected findings that are not in agreement with results of previous studies.[32,33] Because the study results for these characteristics were not significant overall or significant among the other age groups, we hypothesize that differences exist in the interplay of saliva and caries among age groups, but we have been unable to determine which factors contribute to

these findings. However, the buffering capacity findings are not precise because only 30 (8.6 percent) children had a low buffering capacity. In addition, although Rothen and colleagues[21] reported a moderate reliability of the buffering capacity test overall, the reliability for the strongest and weakest acid challenges was low, and the lack of a color reference guide made it challenging to measure the buffering capacity consistently.

Study strengths

The strengths of this study were the large sample size and the study setting. To our knowledge, this is the largest study in the published literature in which researchers assessed salivary characteristics.[29] The study findings help to determine the normal range of values for the salivary characteristics in a population of patients visiting general dental practices for routine dental care. For example, the overall mean resting salivary pH was more acidic than the mean stimulated salivary pH, and the mean stimulated salivary flow rate was 1.4 mL/minute. Sixty-three general dental practices were involved in this study, and dentists and staff members received meticulous training in the study procedures, including conducting the salivary tests. Rothen and colleagues[21] reported acceptable interexaminer reliability of the salivary tests used in various settings of this type.

Study limitations

Among the limitations of this study, the collection of retrospective data pertaining to the outcome hampers our ability to establish a cause-and-effect relationship between the salivary characteristics and the dental caries experience; thus, we report on associations between salivary characteristics and dental caries without implying causality. In addition, dentist-investigators and their staff members abstracted dental caries data from dental records without assessing the validity or reliability of this method. When we complete the study participant follow-up, in which we capture the development of new carious lesions, we will be able to assess the associations reported here on the basis of prospective clinical examination findings.

CONCLUSIONS

Our study findings show that salivary characteristics were associated weakly with recent dental caries experience, but we did not find consistent trends among the three age groups. Thus, one should interpret with caution an assessment of salivary consistency, salivary pH or salivary flow rate to determine the caries risk of all patients. Further studies are needed in this population setting to understand our conflicting results. Our findings cannot support the use of salivary tests in dental caries risk assessment in clinical settings.

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TABLE 1

Characteristics of patients from Northwest PRECEDENT* general dental practices.

CHARACTERISTIC	NUMBER (%) OF PARTICIPANTS			
	Children and Adolescents (9–17 Years Old) (n = 350)	Adults (18–64 Years Old) (n = 676)	Older Adults (≥65 Years Old) (n = 361)	TOTAL (N = 1,387)
Demographics				
Sex				
Female	188 (53.7)	403 (59.6)	200 (55.4)	791 (57.0)
Male	162 (46.3)	273 (40.4)	161 (44.6)	596 (43.0)
Race				
White	322 (92.0)	625 (92.4)	347 (96.1)	1294 (93.3)
Other	21 (6.0)	43 (6.4)	8 (2.2)	72 (5.2)
Missing data	7 (2.0)	8 (1.2)	6 (1.7)	21 (1.5)
Socioeconomic Status				
Income per capita				
Low income	153 (43.7)	159 (23.5)	24 (6.6)	336 (24.2)
Middle income	98 (28.0)	190 (28.1)	88 (24.4)	376 (27.1)
High income	14 (4.0)	276 (40.8)	173 (47.9)	463 (33.4)
Missing data	85 (24.3)	51 (7.6)	76 (21.1)	212 (15.3)
Education†				
< High school	16 (4.6)	35 (5.2)	32 (8.9)	83 (6.0)
High school	97 (27.7)	226 (33.4)	122 (33.8)	445 (32.1)
> High school	233 (66.6)	415 (61.4)	203 (56.2)	851 (61.3)
Missing data	4 (1.1)	0	4 (1.1)	8 (0.6)
General Health				
No. of Acidic beverages per week				
0–2	69 (19.7)	182 (26.9)	112 (31.0)	363 (26.2)
3–6	126 (36.0)	181 (26.8)	93 (25.8)	400 (28.8)
> 6–9.5	68 (19.4)	135 (20.0)	93 (25.8)	296 (21.3)
> 9.5	87 (24.9)	177 (26.2)	63 (17.4)	327 (23.6)
Missing data	0	1 (0.1)	0	1 (0.1)
Alcohol consumption				
No	342 (97.7)	204 (30.2)	128 (35.5)	674 (48.6)
Yes	8 (2.3)	472 (69.8)	233 (64.5)	713 (51.4)
Smoking				
Never smoked	345 (98.6)	458 (67.8)	190 (52.6)	993 (71.6)
Ever smoked	4 (1.1)	213 (31.5)	170 (47.1)	387 (27.9)
Missing data	1 (0.3)	5 (0.7)	1 (0.3)	7 (0.5)
No. of medications affecting saliva				
0–2	348 (99.4)	615 (91.0)	292 (80.9)	1255 (90.5)

CHARACTERISTIC	NUMBER (%) OF PARTICIPANTS			
	Children and Adolescents (9–17 Years Old) (n = 350)	Adults (18–64 Years Old) (n = 676)	Older Adults (≥65 Years Old) (n = 361)	TOTAL (N = 1,387)
≥3	2 (0.6)	61 (9.0)	69 (19.1)	132 (9.5)
Oral Health				
No. of teeth present, mean (SD[‡])	23.5 (6.2)	27.0 (2.5)	24.1 (5.5)	25.4 (4.8)
Toothbrushing with fluoride				
< 1 per day	64 (18.3)	73 (10.8)	56 (15.5)	193 (13.9)
1 per day	94 (26.9)	151 (22.3)	76 (21.1)	321 (23.2)
≥2 per day	192 (54.8)	452 (66.9)	229 (63.4)	873 (62.9)
Visible heavy plaque				
Yes	102 (29.1)	87 (12.9)	74 (20.5)	263 (19.0)
No	246 (70.3)	588 (87.0)	286 (79.2)	1120 (80.7)
Missing data	2 (0.6)	1 (0.1)	1 (0.3)	4 (0.3)
Salivary Characteristics				
Salivary consistency				
Thick, sticky or frothy	16 (4.6)	42 (6.2)	40 (11.1)	98 (7.1)
Watery and clear	334 (95.4)	634 (93.8)	321 (88.9)	1289 (92.9)
Resting salivary flow, in seconds				
≤ 60	328 (93.7)	508 (75.1)	229 (63.4)	1065 (76.8)
> 60 to < 90	7 (2.0)	52 (7.7)	27 (7.5)	86 (6.2)
≥ 90	15 (4.3)	116 (17.2)	105 (29.1)	236 (17.0)
Stimulated salivary flow rate, in mL[§]/ minute				
≤ 0.6	47 (13.4)	69 (10.2)	40 (11.1)	156 (11.2)
> 0.6 to < 1.0	96 (27.4)	111 (16.4)	61 (16.9)	268 (19.3)
≥ 1.0	207 (59.1)	495 (73.2)	260 (72.0)	962 (69.4)
Missing data	0	1 (0.2)	0	1 (0.1)
Mean (SD)	1.1 (0.6)	1.4 (0.8)	1.5 (0.8)	1.4 (0.7)
Resting salivary pH				
≤ 6.0	8 (2.3)	66 (9.8)	51 (14.1)	125 (9.0)
> 6.0 to < 6.4	14 (4.0)	80 (11.8)	60 (16.6)	154 (11.1)
≥ 6.4	328 (93.7)	530 (78.4)	248 (68.7)	1106 (79.8)
Missing data	0	0	2 (0.6)	2 (0.1)
Mean (SD)	7.0 (0.4)	6.6 (0.4)	6.5 (0.4)	6.7 (0.5)
Stimulated salivary pH				
≤ 7.0	31 (8.9)	80 (11.8)	42 (11.6)	153 (11.0)
> 7.0 to < 7.6	68 (19.4)	150 (22.2)	56 (15.5)	274 (19.8)
≥ 7.6	250 (71.4)	446 (66.0)	262 (72.6)	958 (69.1)
Missing data	1 (0.3)	0	1 (0.3)	2 (0.1)
Mean (SD)	7.5 (0.3)	7.5 (0.3)	7.5 (0.3)	7.5 (0.3)

CHARACTERISTIC	NUMBER (%) OF PARTICIPANTS			
	Children and Adolescents (9–17 Years Old) (n = 350)	Adults (18–64 Years Old) (n = 676)	Older Adults (≥65 Years Old) (n = 361)	TOTAL (N = 1,387)
Salivary buffering capacity¶				
0–3	30 (8.6)	56 (8.3)	26 (7.2)	112 (8.1)
4–5	49 (14.0)	101 (14.9)	39 (10.8)	189 (13.6)
6–12	269 (76.8)	519 (76.8)	295 (81.7)	1083 (78.1)
Missing data	2 (0.6)	0	1 (0.3)	3 (0.2)
Mean (SD)	7.0 (2.4)	7.1 (2.3)	7.5 (2.7)	7.2 (2.5)

* PRECEDENT: Northwest Practice-based Research Collaborative in Evidence-based DENTistry.

† For participants 18 years and younger, the authors used parental education.

‡ SD: Standard deviation.

§ mL: Milliliter.

¶ Buffering capacity determined by adding the values assigned to each color, according to the manufacturer's instructions: green, 4; blue/green, 3; blue, 2; blue/red, 1; and red, 0.

TABLE 2

Carious lesions in the previous 24 months, according to patient's age and salivary characteristics.

SALIVARY CHARACTERISTIC	MEAN (SD*) NO. OF CARIES LESIONS			
	Children and Adolescents (9–17 Years Old) (n = 350)	Adults (18–64 Years Old) (n = 676)	Older Adults (≥ 65 Years Old) (n = 361)	TOTAL (N = 1,387)
Overall	1.1 (2.5)	1.6 (2.7)	1.4 (2.3)	1.4 (2.5)
Salivary Consistency				
Thick, sticky or frothy	0.6 (0.9)	1.1 (1.9)	1.9 (3.3)	1.3 (2.5)
Watery and clear	1.1 (2.5)	1.7 (2.7)	1.3 (2.1)	1.4 (2.5)
Resting Salivary Flow, in seconds				
≤ 60	1.1 (2.5)	1.7 (2.8)	1.5 (2.6)	1.5 (2.7)
> 60 to < 90	1.9 (2.1)	1.7 (2.7)	1.1 (1.6)	1.5 (2.3)
≥ 90	0.7 (1.6)	1.4 (1.9)	1.2 (1.7)	1.3 (1.8)
Stimulated Salivary Flow Rate, in mL†/minute				
≤ 0.6	1.0 (2.0)	1.7 (2.6)	2.5 (3.5)	1.7 (2.7)
> 0.6 to < 1.0	1.2 (3.3)	1.8 (2.8)	1.7 (3.2)	1.5 (3.1)
≥ 1.0	1.1 (2.2)	1.6 (2.6)	1.1 (1.7)	1.4 (2.3)
Resting Salivary pH				
≤ 6.0	1.3 (2.8)	2.3 (3.3)	1.9 (2.7)	2.1 (3.0)
> 6.0 to < 6.4	2.2 (3.9)	1.3 (1.9)	1.2 (1.6)	1.4 (2.1)
≥ 6.4	1.1 (2.4)	1.6 (2.7)	1.2 (2.2)	1.4 (2.5)
Stimulated Salivary pH				
≤ 7.0	1.6 (2.6)	1.7 (2.6)	1.6 (2.7)	1.7 (2.6)
> 7.0 to < 7.6	1.0 (2.0)	1.9 (3.1)	1.0 (1.4)	1.5 (2.6)
≥ 7.6	1.1 (2.6)	1.5 (2.5)	1.3 (2.3)	1.4 (2.5)
Salivary Buffering Capacity‡				
0–3	0.8 (2.3)	3.0 (4.6)	1.7 (1.9)	2.1 (3.7)
4–5	1.2 (1.9)	1.6 (2.2)	1.0 (1.6)	1.4 (2.0)
6–12	1.1 (2.6)	1.5 (2.4)	1.3 (2.3)	1.4 (2.4)

* Standard deviation.

† mL: Milliliter.

‡ Buffering capacity determined by adding the values assigned to each color, according to the manufacturer's instructions: green, 4; blue/green, 3; blue, 2; blue/red, 1; and red, 0.

TABLE 3

Association between dental caries and salivary characteristics.

SALIVARY CHARACTERISTIC	CHILDREN AND ADOLESCENTS (9–17 YEARS OLD)		ADULTS (18–64 YEARS OLD)		OLDER ADULTS (≥ 65 YEARS OLD)		OVERALL	
	Crude RR* (95% CI†)	Adjusted RR (95% CI)‡	Crude RR (95% CI)	Adjusted RR (95% CI)	Crude RR (95% CI)	Adjusted RR (95% CI)	Crude RR (95% CI)	Adjusted RR (95% CI)
Salivary Consistency Thick, Sticky or Frothy	0.5 (0.2–1.6)	0.8 (0.3–2.4)	0.7 (0.4–1.2)	0.6§ (0.4–1.0)	1.9§ (1.0–3.5)	1.8 (0.9–3.6)	1.0 (0.7–1.6)	1.0 (0.6–1.5)
Resting Salivary Flow Rate (Reference: ≤ 60 Seconds)								
> 60 to < 90 seconds	1.4 (0.5–4.3)	1.0 (0.3–3.2)	1.2 (0.6–2.2)	1.2 (0.7–2.1)	1.0 (0.6–1.8)	1.2 (0.7–2.0)	1.2 (0.8–1.9)	1.2 (0.8–1.8)
≥ 90 seconds	0.4 (0.1–1.3)	0.3 (0.1–1.2)	0.9 (0.6–1.2)	0.9 (0.6–1.2)	0.9 (0.6–1.4)	0.9 (0.6–1.3)	0.9 (0.7–1.2)	0.8 (0.6–1.1)
Stimulated Salivary Flow Rate (Reference: ≥ 1.0 mL¶/Minute)								
= 0.6 mL/minute	1.1 (0.7–1.8)	1.2 (0.7–2.0)	1.0 (0.7–1.5)	0.8 (0.5–1.2)	2.7# (1.6–4.6)	2.4# (1.5–3.8)	1.3 (1.0–1.8)	1.2 (0.8–1.6)
> 0.6 to < 1.0 mL/minute	0.9 (0.4–2.4)	1.6 (0.6–4.1)	1.0 (0.8–1.4)	0.9 (0.7–1.3)	1.5 (1.0–2.2)	1.4 (0.9–2.2)	1.1 (0.8–1.4)	1.0 (0.8–1.4)
Resting Salivary pH (Reference: ≥ 6.4)								
≤ 6.0	0.3§ (0.1–1.0)	0.3 (0.1–1.6)	1.5 (1.0–2.4)	1.4 (0.9–2.2)	2.0** (1.2–3.4)	1.7 (1.0–2.7)	1.6§ (1.1–2.4)	1.6§ (1.1–2.2)
> 6.0 to < 6.4	2.5 (0.9–6.5)	1.3 (0.5–3.2)	0.9 (0.6–1.3)	0.9 (0.7–1.4)	1.2 (0.7–1.9)	1.0 (0.6–1.8)	1.1 (0.8–1.5)	1.1 (0.8–1.4)
Stimulated Salivary pH (Reference: ≥ 7.6)								
≤ 7.0	1.0 (0.5–2.0)	0.7 (0.4–1.5)	1.1 (0.7–1.7)	1.0 (0.7–1.5)	1.4 (0.7–2.9)	1.2 (0.6–2.4)	1.2 (0.8–1.8)	1.1 (0.7–1.6)
> 7.0 to < 7.6	1.3 (0.6–2.6)	1.7 (1.0–2.9)	1.0 (0.7–1.4)	1.0 (0.7–1.4)	0.8 (0.5–1.4)	0.6§ (0.4–1.0)	1.1 (0.8–1.4)	1.0 (0.7–1.3)
Salivary Buffering Capacity†† (Reference: 6–12)								
0–3 (low)	0.3** (0.1–0.7)	0.3** (0.1–0.7)	1.7§ (1.1–2.8)	1.5 (1.0–2.5)	1.4 (0.8–2.4)	1.1 (0.8–1.7)	1.5 (1.0–2.1)	1.3 (0.9–2.0)
4–5 (moderate)	1.1 (0.5–2.0)	1.0 (0.4–2.4)	1.1 (0.8–1.4)	1.0 (0.7–1.3)	0.7 (0.4–1.2)	0.7 (0.4–1.1)	1.0 (0.8–1.3)	1.0 (0.7–1.3)

† CI: Confidence interval.

[‡] Adjusted for age, sex, race, income, education, alcohol consumption, smoking status, medication affecting saliva, acidic beverage intake, fluoride toothbrushing, heavy plaque and number of teeth present.

[§] $P < .05$.

[¶] mL: Milliliter.

[#] $P < .001$.

[**] $P < .01$.

[††] Buffering capacity determined by adding the values assigned to each color, according to the manufacturer's instructions: green, 4; blue/green, 3; blue, 2; blue/red, 1; and red, 0