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Oral Hygiene Behaviors and Caries Experience in Northwest PRECEDENT Patients

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Abstract

Objectives—To investigate the association between oral hygiene behaviors (toothbrushing, water rinsing after brushing, interproximal cleaning, and adjunctive use of fluoride products) and recent caries (past 24 months) in a random sample of patients in Northwest PRECEDENT practices.

Methods—Practitioner-members of Northwest PRECEDENT dental Practice-based Research Network (PBRN) conducted a longitudinal study on caries risk assessment. At baseline patients completed a questionnaire on oral self-care, snacking, health, and socio-demographics. A dental exam recorded readily-visible heavy plaque and DMFT; chart review captured new caries and treatments in the previous 24 months. Bivariate and multiple GEE log-linear regression models stratified by age groups were used to relate oral hygiene behaviors to the primary outcome of mean dental caries in the past 24 months on data from 1400 patients in 63 practices. The primary exposure of interest was fluoride toothbrushing frequency.

Results—Fluoride toothbrushing once per day or more by patients 9-17 was significantly associated with a 50% lower mean caries rate compared to fluoride toothbrushing less than once per day, after adjustment for age, gender, race, education, income, between-meal carbohydrate snacks, sugar-added beverages, alcohol consumption, smoking, BMI, exercise, stimulated salivary pH, number of teeth, and all other oral hygiene behaviors captured [Rate Ratio (RR)=0.5; 95% confidence interval (CI)=0.3-0.8]. After adjustment, for patients 18-64 fluoride toothbrushing two or more times per day was significantly associated with a 40% lower recent mean caries rate (RR=0.6; 95% CI=0.4-0.9); in patients 65+, twice a day or more fluoride toothbrushing was not associated with lower caries rates (RR=1.1; 95% CI=0.7-1.8). Of the other oral hygiene variables,

after adjustment, patients 18-64 who rinsed with water after brushing had a 40% lower mean caries rate compared to no rinsing (RR=0.6; 95%CI=0.4-0.9) and the presence of readily-visible heavy plaque was significantly associated with an increase in the mean caries rate for patients 18-64 (RR=1.6; 95%CI=1.2-2.2) and 65+ (RR=2.5; 95%CI=1.8-3.5).

Conclusions—In the present study, the frequency of fluoride toothbrushing and the presence of readily-visible heavy plaque were the factors most strongly associated with mean caries rate. In young patients with permanent dentition the daily application of fluoride toothpaste appears more important than emphasis on thorough plaque removal. While for adults, the protective effect of twice daily fluoride toothbrushing disappears with advancing age and the presence of readily-visible heavy plaque becomes increasingly associated with caries risk.

Keywords

Fluoride toothbrushing; oral hygiene behaviors; caries risk assessment; Practice-based Research Network; Dental PBRN; Northwest PRECEDENT

Introduction

Good oral hygiene habits are considered important for preventing dental caries in all age groups. Routine advice is to brush twice daily with fluoride toothpaste and clean between teeth once per day, preferably with dental floss (1-3). The assumption is that toothbrushing and interproximal cleaning will remove dental plaque and prevent demineralization of teeth by reducing the concentration of caries causing pathogens and fluoride will inhibit demineralization and promote remineralization of tooth structure damaged by acid producing cariogenic bacteria (4).

There is substantial evidence that the main caries preventive effect of toothbrushing is the regular application of a fluoride containing toothpaste to teeth (3, 5). This effect may be particularly important for hard to clean interproximal areas (6). Oral hygiene habits can be effective at plaque removal, but without the benefit of fluoride, have been shown to reduce gingivitis and caries increments on easily accessible smooth surfaces, but not caries increments overall (7, 8). A Cochrane review of 70 studies evaluating the effect of fluoride toothpaste on caries reduction in the permanent teeth of children 5 to 16 years of age found, on average, a 24% reduction in decayed, missing and filled tooth surfaces (DMFS) with fluoridated toothpaste use versus non-fluoridated toothpaste (3). These studies demonstrate that toothpaste is an effective delivery vehicle for the benefits of fluoride.

Variations in the application of fluoride toothpaste, such as the frequency of fluoride toothbrushing and the method of rinsing after toothbrushing, have been shown to affect caries incidence. Several studies and the Cochrane review have demonstrated that the effectiveness of brushing with fluoride toothpaste increases with higher frequency of use (3, 9-12). In a three-year study of 2621 adolescents, Chestnutt et al. observed there was an 18% decrease in mean DMFS when fluoride toothbrushing increased from once per day to more than once per day and the frequency of brushing accounted for 48% of the variance in DMFS increments (9). O'Mullane et al. also reported a decrease in mean three year DMFS increments in response to increasing frequency of brushing with fluoride toothpaste for a

study of 3467 adolescents (5.61 < 1/day; 4.20 1/day; 3.39 > 1/day) (11). The Cochrane review assessed the frequency of brushing with fluoride toothpaste and determined that twice a day fluoride toothbrushing accounted for a 14% reduction in DMFS compared to once a day (3).

Post-brushing behaviors, such as the method of rinsing after fluoride toothbrushing, affect the fluoride levels retained in saliva and in dental plaque (13, 14). It has been demonstrated that consistent low levels of fluoride in saliva and plaque, achieved through the regular application of fluoride toothpaste, play an important role in inhibiting demineralization and promoting remineralization of teeth (4, 15, 16). Increasing the volume of water used to rinse after fluoride toothbrushing has a greater effect on decreasing the residual fluoride levels than the duration and frequency of rinsing (14, 17). Three large scale studies of adolescents using fluoride toothpaste for three years determined that those who used a method for rinsing that employed less water than use of a cup, including no rinsing, had a significant decrease in caries experience ranging from 9% to 15% compared to those who used a cup for water rinsing (9, 11, 12).

The primary objective of this paper is to assess whether the frequency of brushing with fluoride toothpaste is associated with lower rates of recent caries (past 24 months) for patients attending the practices of dentist-members of the practice-based research network Northwest PRECEDENT. A secondary objective is to evaluate the association of reported oral hygiene behaviors and/or combinations of behaviors with recent caries experience and whether those associations are related to age, gender, socioeconomic or other factors.

Materials and Methods

Northwest PRECEDENT (**P**ractice-based **R**esearch **C**ollaborative in **E**vidence-based **D**ENTistry), one of three dental practice-based research networks (PBRNs) funded and established by the National Institute of Dental and Craniofacial Research in 2005, conducted a longitudinal study on factors related to caries risk assessment. Faculty and staff from the University of Washington (UW) and Oregon Health & Science University (OHSU), who have oversight and management responsibility for the network, developed the study protocol in response to network-dentists expressed interest in the topic. Sixty-three member-dentists, drawn from the five state region of Washington, Oregon, Idaho, Montana, and Utah, performed a caries exam on permanent teeth and collected data on historical, environmental and behavioral factors, in addition to salivary characteristics at the baseline visit.

Dentists and their office staff completed an online course in the Responsible Conduct of Research from OHSU prior to study participation. The UW Human Subjects Division (institutional review board) reviewed and approved the study protocol. All materials necessary for study conduct were sent to offices, including a detailed Manual of Procedures, salivary test kits assembled by PRECEDENT staff, and data collection forms with line-by-line instructions. Offices were instructed to review the Manual of Procedures and data collection forms prior to a telephone training session with their Regional Coordinator. Upon completion of all training requirements offices were approved for study initiation.

In this longitudinal study, sample sizes were calculated to provide sufficient power within each age group to detect a difference between the predictive value of a traditional caries risk assessment tool that includes the risk factors being assessed here and a tool augmented with salivary measures. Consequently, the study had adequate power to detect associations between oral hygiene behaviors and dental caries. Beginning in May 2008 through February 2011 PRECEDENT dentists enrolled patients from their practices in this study. Each practice was randomly assigned a specific weekday to begin patient selection with the goal of enrolling thirty patients. A unique interval for randomly sampling approximately one patient per day from the daily appointment schedule was assigned based on the average number of patients seen per day. The enrollment objective was approximately equal numbers of patients in three age groups: 9 – 17, 18 – 64, and 65 and older. Practices joining the study later or wishing to enroll beyond thirty patients (up to 50) targeted patients in the 9 - 17 and 65 and older age groups as the sample size for 18 - 64 year olds was reached first. This was accomplished by using a sampling scheme that enrolled the first patient of the day in either the 9 - 17 or 65 and older age group. To be eligible for study participation a patient had to be nine years of age or older, have at least four permanent teeth, be able to understand English, and provide consent (or parental consent) for participation.

At the baseline appointment all patients volunteering to participate signed a written consent (or their parents), then completed a questionnaire gathering information on self-reported oral hygiene habits, smoking and alcohol use, snacking and beverage consumption, health and medications, education level and other sociodemographic variables. A battery of salivary tests was conducted assessing resting salivary characteristics of consistency, flow from labial salivary glands and pH, and stimulated salivary characteristics of flow-rate, pH and buffering capacity. The dentist, blind to the results of salivary tests and patient questionnaire, performed a dental examination and recorded the decayed, missing and filled teeth (DMFT) index for all permanent teeth. The dentist indicated whether or not readily-visible heavy plaque was evident, as well as the presence of any exposed roots, deep pits and fissures, developmental defects, dental fluorosis, visible cavitation, white spots, occlusal wear, or removable appliances. For patients who had been in the practice for at least 24 months, a chart review documented caries diagnosed, treatments (restorations, extractions, and advanced restorative procedures) and reasons for treatment (caries, other or unknown) performed in the 24 months prior to the baseline appointment. Caries diagnosed were indicated as either root and/or coronal caries at the tooth level, and if coronal caries, whether the lesion was restricted to enamel, into dentin, or the depth could not be determined. The information from the patient questionnaire, salivary tests, chairside exam and chart review were entered into an online data capture system by trained office staff.

The patient questionnaire collected oral self-care information about toothbrushing habits, interproximal cleaning, and the use of fluoride products in addition to fluoride toothpaste. The question, “How often do you brush your teeth?” allowed patients to indicate a frequency of less than once per week, once or twice per week, 3 - 6 times per week, once per day, twice per day, or 3 or more times per day. Patients were asked if they used toothpaste that contains fluoride, if they rinsed the mouth with water after brushing, and if they used floss, a toothpick, or other device to clean between their teeth (response options: yes, no, unknown). If they responded positively to the question about the use of interproximal cleaning devices,

they were asked if their use was less than once per week, once or twice per week, 3 - 6 times per week, or 1 or more times per day. The question, “Do you use fluoride products, other than over-the-counter toothpaste? (such as fluoride mouth rinse or mouthwash)” had the same response options as the question about toothbrushing frequency.

Statistical Analysis

Bivariate and multiple GEE log-linear regression models stratified by age groups were used to relate oral hygiene behaviors to dental caries in the past 24 months (18). The primary outcome was the number of teeth in the past 24 months with dental caries defined as coronal caries into dentin. The primary exposure of interest was fluoride toothbrushing frequency. This variable first assessed whether or not the patient brushed with fluoride toothpaste. If the response was positive, the frequency of toothbrushing determined the “fluoride toothbrushing frequency” variable. If the patient did not brush with fluoride toothpaste, the frequency of fluoride toothbrushing was zero. This variable was evaluated at 3 levels: no fluoride toothbrushing or less than once per day; once per day; and twice per day or greater. Secondary exposures were interproximal cleaning frequency, other fluoride products frequency, water rinsing after brushing, and presence of readily-visible heavy plaque as an indication of oral hygiene effectiveness. The association of the mean dental caries rate in the past 24 months and oral hygiene behaviors were adjusted for age, gender, race, education, income, between-meal carbohydrate snacks, sugar-added beverages, alcohol consumption, smoking, body mass index (BMI), physical exercise, stimulated salivary pH, number of teeth present, and all other oral hygiene behaviors captured. Of the six salivary characteristics measured at baseline, stimulated salivary pH was most consistently associated with caries in children and adults and was chosen to be included in this study. In addition, 95% confidence intervals are reported for all crude and adjusted rate ratios, which convey the precision of the results. Analyses were performed using SAS software (Version 9.2.; SAS Institute, Inc., Cary, NC). Results are presented, stratified by age group, for all patients with data on caries diagnosis in the 24 months prior to the baseline visit.

Results

Data on self-reported oral hygiene behaviors was collected on a total of 1763 patients enrolled in the study. This paper reports on the oral hygiene behaviors and recent caries experience (past 24 months) of the 1400 patients (ages 9 - 17, n = 350; 18 - 64, n = 682; 65 and older, n = 368) who had been in the practices of PRECEDENT member-dentists for at least 24 months. These patient participants were 57% female, 93% white, 61% (or their parents for patients under age 18) educated beyond high school, and 34% high income (\$31,250 or greater per capita, with 15% not reporting income). Patients had on average 25 teeth present at the baseline examination (see Table 1 for a description of patient characteristics by age group).

The frequency of fluoride toothbrushing reported by patients was: no fluoride toothbrushing or less than once per day 14%, once per day 23%; and twice per day or greater 63%. The frequency of other oral hygiene behaviors were: 84% reported water rinse after brushing; 60% used an interproximal cleaning device 3 or more times per week; and 28% used a

fluoride product other than fluoride toothpaste at least occasionally (15% less than once per day; 13% once a day or more often). Readily-visible heavy plaque was noted for 19% of all patients (see Table 1 for the percentages by age group for these oral hygiene behaviors).

Table 2 shows the mean number of new dental caries in the previous 24 months by age group for the oral hygiene variables assessed. The mean caries rate for patients of all ages who reported no fluoride toothbrushing or less than once per day was 1.7 [standard deviation (sd) 3.0] compared with 1.3 (sd 2.4) for twice per day or greater fluoride toothbrushing. By age group, the mean number of new dental caries decreased for 9 - 17 year olds and 18 - 64 year olds with increasing frequency of fluoride toothbrushing. In 9 - 17 year olds not fluoride toothbrushing or less than once per day, the mean caries rate was 1.7 (sd 3.9) versus 0.9 (sd 1.8) for twice a day or greater fluoride toothbrushing and in 18 - 64 year olds, 2.1 (sd 2.7) and 1.5 (sd 2.6) respectively. However, for patients age 65 and older, the mean caries rate for no fluoride toothbrushing and less than once a day [1.2 (sd 2.1)] was lower than for twice a day or greater fluoride toothbrushing [1.4 (2.5)]. Water rinsing after brushing had a converse relationship to the number of mean new caries for the 9 - 17 age group and the 18 - 64 age group. The 9 - 17 year olds had a lower mean caries rate if they reported no water rinse after brushing [0.7 (sd 1.8)] than those who rinsed [1.2 (sd 2.6)]. The 18 - 64 year olds had a higher mean caries rate [2.4 (sd 3.5)] if not water rinsing than if they did water rinse after brushing [1.5 (2.5)]. For patients 65 and older the trend reversed again; patients not water rinsing had 1.1 (sd 1.7) mean new caries compared to 1.4 (sd 2.4) for those who water rinsed.

Among other oral hygiene behaviors, increasing interproximal cleaning frequency was associated with a very small decrease in mean caries rate overall. For patients of all ages, increasing the frequency of use of fluoride products other than fluoride toothpaste was associated with an increase in mean caries: no other fluoride products 1.4 (sd 2.4), less than once per day 1.5 (sd 3.1), and once or greater per day 1.7 (sd 2.7). The presence of readily-visible heavy plaque as assessed by the dentist was associated with a higher mean caries rate for all patients [1.9 (sd 3.0)] than for those patients without readily-visible heavy plaque [1.3 (sd 2.4)]. By age group, the mean new caries in the past 24 months for 9 - 17 year olds was 1.1 (sd 2.2) without heavy plaque and 1.2 (sd 3.0) with heavy plaque while in the 18 - 64 year olds, this difference was 1.5 (sd 2.6) mean caries for patients without readily-visible heavy plaque compared to 2.6 (sd 3.1) for those with heavy plaque and in 65+ year olds, 1.2 (sd 2.2) versus 2.1 (sd 2.5) respectively.

The crude and adjusted rate ratios for the association between recent dental caries (past 24 months) and oral hygiene behaviors by age group are shown in Table 3. After adjustment, fluoride toothbrushing one time per day or more by patients 9 - 17 was significantly associated with a 50% lower mean caries rate compared to fluoride toothbrushing less than once per day [Rate Ratio (RR) = 0.5; 95% confidence interval (CI) = 0.3 - 0.8]. For patients 18 - 64, after adjustment, fluoride toothbrushing two or more times per day was significantly associated with a 40% lower recent mean caries rate (RR = 0.6; 95% CI = 0.4 - 0.9). For patients overall, after adjustment, fluoride toothbrushing twice per day or more was associated with a mean caries reduction of 30% (RR = 0.7; 95% CI = 0.5 - 0.9).

Of the other oral hygiene variables, after adjustment, water rinsing after brushing, the use of fluoride products other than fluoride toothpaste, and readily-visible heavy dental plaque were significantly associated with dental caries. Those 18 – 64 year olds who rinsed with water after brushing had a 40% lower mean caries rate compared to no rinsing (RR = 0.6; 95% CI = 0.4 – 0.9). In patients age 65 and older, use of a fluoride product other than fluoride toothpaste once a day or more was significantly associated with a higher mean caries rate (RR = 1.6; 95% CI = 1.0 – 2.6). The presence of readily-visible heavy plaque was significantly associated with an increase in the mean caries rate overall (RR = 1.5; 95% CI = 1.2-1.9) and in patients 18 – 64 (RR = 1.6; 95% CI = 1.2 – 2.2) and 65+ (RR = 2.5; 95% CI = 1.8 – 3.5).

Discussion

Overall, in the PRECEDENT practices enrolled in this study, one third of the patients had been treated for caries in the previous 24 months illuminating the fact that, although these are regular dental practice attendees, caries is not under control for a significant portion of patients. There is still a need for caries risk assessment and to determine how patients can be most successful at controlling caries risk through effective oral hygiene behaviors. In the present study, no oral hygiene behavior showed a consistent association with mean dental caries rate across all age groups. However, the frequency of fluoride toothbrushing and the presence of readily-visible heavy dental plaque were the factors most strongly associated with mean caries rate and at opposite ends of the age spectrum. As the association of fluoride toothbrushing frequency to mean caries rate decreased with increasing age, the presence of readily-visible heavy plaque as a predictor of dental caries increased with advancing age. Not water rinsing after brushing did not demonstrate the decreased caries rate previously seen in 9 - 17 year olds, and the opposite association was seen in 18 - 64 year olds.

The findings of the Cochrane review (3) for the effectiveness of fluoride toothbrushing at reducing caries in children and adolescents was upheld among the same age group enrolled in this study based on their recent caries experience. However, in the present study the association with lower dental caries for one time a day fluoride toothbrushing was equivalent to twice a day or more in this age group. Fluoride toothbrushing had to be increased to twice a day or more in the 18 - 64 age group to be associated with lower caries rates and in the 65+ group, twice a day or more fluoride toothbrushing was not significantly associated with lower caries rates. Fluoride, and in particular fluoride toothbrushing, may play a role in controlling caries as patients age, however, the effect may be overshadowed by other aspects of this multifactorial disease that become more prominent with age. Some of the factors that may have an increasing influence with advancing age include medical conditions that may both affect salivary function, primarily through medication effects, as well as physical function, including the ability to perform oral hygiene behaviors and the cumulative effects of a patient's dental history such as multiple restorations at risk for recurrent caries and the exposure of root surfaces.

By contrast, the association of readily-visible heavy plaque with recent caries rate was the inverse of the association of fluoride toothbrushing frequency with recent caries rate in the

age groups examined. In the 65+ age group, the presence of readily-visible dental plaque was associated with a significantly higher caries rate. The association decreased, but was present, for 18 - 64 year olds, and was not significant for 9 - 17 year olds. This increase in the association of readily-visible heavy plaque with recent caries rate with increasing age may be a reflection of a change in the composition of the plaque itself brought about by the other factors mentioned above that are associated with advancing age and this multifactorial disease.

Plaque reduction has been associated with a decrease in gingivitis, but much of the literature indicates that plaque reduction has not had an effect on caries reduction (7, 8, 19). It has been difficult to distinguish between effective plaque removal and the use of fluoride toothbrushing on caries reduction as for many years now almost all toothpaste marketed has contained fluoride (3). Because of the large sample size of patients and practices in this study and an age range from 9 years and older, the results of this study may begin to clarify the relative importance of these two variables on caries control in different age groups. It may be that readily-visible heavy plaque is an indication for lack of effective toothbrushing and that the anticaries effect of fluoride application by toothbrushing is dependent on effective plaque removal with increasing age.

Before adjustment, rinsing with water after fluoride toothbrushing was associated with increased caries for the 9 - 17 age group in agreement with previous studies (9, 11, 12). After adjustment, it was not expected to find in patients 18 - 64 that water rinsing after brushing would be associated with a 40% decrease in caries rate. Oral hygiene behaviors, such as the frequency of fluoride toothbrushing and the effect of water rinsing after brushing, have been studied primarily in school populations for their effectiveness in caries reduction.

Studies examining the effect of water rinsing after fluoride toothbrushing in children and adolescents are based primarily on self-report. Large scale adolescent studies self-reported on rinsing with a cup of water versus other methods including no rinsing. The cup method was described as using more water, but other methods of rinsing that included a smaller volume of water were still effective at caries reduction (10, 12). A study in eight adult participants confirmed that the volume of water used for rinsing was inversely related to the amount of fluoride retained in the mouth after brushing (13). Limiting the amount of water rinsing has been shown to decrease the rate of approximal caries in four year olds, orthodontic patients, and high caries risk adults (6, 20, 21). However, these studies instructed patients after brushing to swish the toothpaste slurry, usually with a small amount of water, between the teeth for thirty seconds to one minute before expectorating. No further rinsing was allowed and participants could not eat or drink for two hours after brushing. One prospective study in 407 age 10 – 12 year old school children did not find a difference in caries prevalence between those that rinsed and those that simply spit out the toothpaste after brushing (22). Despite the limited evidence, an expert panel has provided a recent consensus statement recommending that the amount of water used to rinse after fluoride toothbrushing be limited or avoided altogether (23).

In the present study participants were simply asked whether or not they rinsed with water after brushing. It is possible that if more nuanced methods of rinsing had been assessed an effect on caries reduction might have been seen for 9 – 17 year olds after adjustment. However, it is doubtful it would have reversed the association of water rinsing with a lower caries rate for 18 – 64 year olds.

Interproximal cleaning frequency was not associated with a change in recent caries rate. While the use of interproximal cleaning devices increased with each advancing age group, before and after adjustment there was no association with recent caries rate. The use of dental floss and other interproximal cleaning aids have been associated with a decrease in gingivitis, but no studies have demonstrated their association with a reduction in interproximal caries (3, 24).

The use of fluoride products other than fluoride toothpaste showed a trend before and after adjustment to be associated with decreased recent caries rate in 9 – 17 year olds and was significantly associated with an increased caries rate in 65+ year olds. This may be a further demonstration of fluoride's effectiveness in the 9 – 17 age group and the additional confounding factors for dental caries in those 65 and older. However, it is possible that those patients using adjunctive products do so at the recommendation of a dental professional due to the patient's already higher rate of caries experience.

This study was limited by self-reported oral hygiene behaviors in a population of patients who visited the dental practices of Northwest PRECEDENT members. Additionally, measurement of some risk factors were based on dentists' responses to simple yes/no questions in the chairside exam form that were derived from traditional risk assessment tools and caries experience in the past 24 months was collected retrospectively from patient dental charts. We assessed coronal caries into dentin and whether inclusion of root caries would have had an impact, particularly for the 65+ age group, is unknown. Given the greater vulnerability of exposed root surfaces to acid producing cariogenic bacteria in plaque, fluoride toothbrushing (with over-the-counter fluoride toothpaste) may not be as successful at controlling root caries as coronal caries, especially when plaque is not adequately removed (25). Prospective data collection of up to 2-year incidence rate of new caries lesions from this study may provide more definitive information about oral hygiene behaviors that are associated with a reduced risk for caries. The large sample size, wide age spectrum available, and variety of practice settings in the PRECEDENT network are strengths of this study that increase the external validity of the results in a population with access to dental care. The results are important because even in this population one third of the study participants were at risk for dental caries in the 24 months prior to their baseline visit.

Although no oral hygiene behavior showed a consistent association with recent dental caries across all age groups in this fairly highly educated, homogeneous population of regular dental attendees, fluoride toothbrushing frequency was clearly associated with a decreased recent mean caries rate in patients 9 – 64 years of age when fluoride toothpaste was applied to the teeth by toothbrushing at least two times per day. While the anticaries effect of fluoride application by toothbrushing was not dependent on effective plaque removal in 9 -

17 year olds, the presence of readily-visible heavy plaque was increasingly associated with a higher caries experience in the previous 24 months for 18 - 64 year olds and those 65 and older respectively and may be an indicator for the importance of effective plaque removal with advancing age. The simple procedure of a quick visual assessment for the presence of readily-visible heavy plaque may be enough to provide oral health professionals with an efficient method for assessing patients 18 and older for an increased risk of dental caries.

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Table 1
Characteristics of the participants by age group

	Age			Total (N=1400)
	9-17 (N=350)	18-64 (N=682)	64+ (N=368)	
Gender				
Male	162 (46.3%)	273 (40%)	164 (44.6%)	599 (42.8%)
Female	188 (53.7%)	409 (60%)	204 (55.4%)	801 (57.2%)
White race				
No	21 (6%)	43 (6.3%)	8 (2.2%)	72 (5.1%)
Yes	322 (92%)	631 (92.5%)	354 (96.2%)	1307 (93.4%)
Unreported	7 (2%)	8 (1.2%)	6 (1.6%)	21 (1.5%)
Education				
< High school	16 (4.6%)	35 (5.1%)	32 (8.7%)	83 (5.9%)
High school	97 (27.7%)	229 (33.6%)	127 (34.5%)	453 (32.4%)
> High school	233 (66.6%)	418 (61.3%)	205 (55.7%)	856 (61.1%)
Unreported	4 (1.1%)	.	4 (1.1%)	8 (0.6%)
Per capita income				
Low (<=17500)	153 (43.7%)	159 (23.3%)	24 (6.5%)	336 (24%)
Middle income (>17500-<31250)	98 (28%)	193 (28.3%)	91 (24.7%)	382 (27.3%)
High income (31250+)	14 (4%)	279 (40.9%)	176 (47.8%)	469 (33.5%)
Unreported	85 (24.3%)	51 (7.5%)	77 (20.9%)	213 (15.2%)
Fluoride toothbrushing				
No & <1 per day	64 (18.3%)	74 (10.9%)	57 (15.5%)	195 (13.9%)
1 per day	94 (26.9%)	151 (22.1%)	78 (21.2%)	323 (23.1%)
2+ per day	192 (54.9%)	457 (67.0%)	233 (63.3%)	882 (63.0%)
Water rinse after brushing				
No	68 (19.4%)	99 (14.5%)	41 (11.1%)	208 (14.9%)
Yes	270 (77.1%)	577 (84.6%)	322 (87.5%)	1169 (83.5%)
Unreported	12 (3.4%)	6 (0.9%)	5 (1.4%)	23 (1.6%)
Interproximal cleaning				
No & <3 per week	239 (68.3%)	240 (35.2%)	73 (19.8%)	552 (39.4%)
>=3 per week	108 (30.9%)	441 (64.7%)	294 (79.9%)	843 (60.2%)
Unreported	3 (0.9%)	1 (0.1%)	1 (0.3%)	5 (0.4%)
Other fluoride products				
No	203 (58%)	502 (73.6%)	256 (69.6%)	961 (68.6%)
<1 per day	91 (26%)	86 (12.6%)	30 (8.2%)	207 (14.8%)
1+ per day	42 (12%)	75 (11%)	62 (16.8%)	179 (12.8%)
Unreported	14 (4%)	19 (2.8%)	20 (5.4%)	53 (3.8%)
Visible dental plaque				
No	246 (70.3%)	593 (87%)	291 (79.1%)	1130 (80.7%)
Yes	102 (29.1%)	88 (12.9%)	76 (20.7%)	266 (19%)
Unreported	2 (0.6%)	1 (0.1%)	1 (0.3%)	4 (0.3%)

	Age			Total (N=1400)
	9-17 (N=350)	18-64 (N=682)	64+ (N=368)	
Between-meal carbohydrates snack (per day)				
<1 per day	38 (10.9%)	153 (22.4%)	137 (37.2%)	328 (23.4%)
1 per day	107 (30.6%)	251 (36.8%)	121 (32.9%)	479 (34.2%)
2 per day	129 (36.9%)	187 (27.4%)	87 (23.6%)	403 (28.8%)
3+ per day	76 (21.7%)	91 (13.3%)	23 (6.3%)	190 (13.6%)
Sugar-added beverages (per week)				
0 per week	50 (14.3%)	220 (32.3%)	182 (49.5%)	452 (32.3%)
1-3 per week	87 (24.9%)	178 (26.1%)	95 (25.8%)	360 (25.7%)
>3-8 per week	114 (32.6%)	131 (19.2%)	52 (14.1%)	297 (21.2%)
>8 per week	99 (28.3%)	152 (22.3%)	38 (10.3%)	289 (20.6%)
Unreported	.	1 (0.1%)	1 (0.3%)	2 (0.1%)
Alcohol consumption				
No	342 (97.7%)	209 (30.6%)	131 (35.6%)	682 (48.7%)
Yes	8 (2.3%)	473 (69.4%)	237 (64.4%)	718 (51.3%)
Smoker				
Never	345 (98.6%)	462 (67.7%)	193 (52.4%)	1000 (71.4%)
Former/Current	4 (1.1%)	215 (31.5%)	173 (47%)	392 (28%)
Unreported	1 (0.3%)	5 (0.7%)	2 (0.5%)	8 (0.6%)
BMI				
Underweight/Normal	243 (69.4%)	245 (35.9%)	131 (35.6%)	619 (44.2%)
Overweight/Obese	99 (28.3%)	435 (63.8%)	231 (62.8%)	765 (54.6%)
Unreported	8 (2.3%)	2 (0.3%)	6 (1.6%)	16 (1.1%)
Exercise (per week)				
None	14 (4%)	114 (16.7%)	129 (35.1%)	257 (18.4%)
<3 days	67 (19.1%)	226 (33.1%)	80 (21.7%)	373 (26.6%)
3+ days	264 (75.4%)	333 (48.8%)	151 (41%)	748 (53.4%)
Unreported	5 (1.4%)	9 (1.3%)	8 (2.2%)	22 (1.6%)
Stimulated pH				
<=7.0	31 (8.9%)	82 (12%)	44 (12%)	157 (11.2%)
>7.0 - <7.6	68 (19.4%)	152 (22.3%)	57 (15.5%)	277 (19.8%)
>=7.6	250 (71.4%)	448 (65.7%)	265 (72%)	963 (68.8%)
Unreported	1 (0.3%)	.	2 (0.5%)	3 (0.2%)
Number of teeth, mean (sd)				
	23.5(6.2)	27.0(2.5)	24.1(5.5)	25.4(4.8)

Table 2
Mean number of new dental caries in the past 24 months by age groups and oral hygiene variables

	Age			
	9-17 (N=350) Mean(SD)	18-64 (N=682) Mean(SD)	65+ (N=368) Mean(SD)	Total (N=1400) Mean(SD)
Fluoride toothbrushing				
No & <1 per day	1.7 (3.9)	2.1 (2.7)	1.2 (2.1)	1.7 (3.0)
1 per day	1.2 (2.4)	1.8 (2.9)	1.2 (1.6)	1.5 (2.5)
2+ per day	0.9 (1.8)	1.5 (2.6)	1.4 (2.5)	1.3 (2.4)
Water rinse after brushing				
No	0.7 (1.8)	2.4 (3.5)	1.1 (1.7)	1.6 (2.8)
Yes	1.2 (2.6)	1.5 (2.5)	1.4 (2.4)	1.4 (2.5)
Interproximal cleaning				
No & <3 per week	1.3 (2.7)	1.8 (2.9)	1.3 (1.9)	1.5 (2.7)
>=3 per week	0.8 (1.9)	1.5 (2.5)	1.4 (2.4)	1.4 (2.4)
Other fluoride products				
No	1.1 (2.2)	1.5 (2.5)	1.3 (2.3)	1.4 (2.4)
<1 per day	1.2 (3.3)	2.1 (3.3)	0.8 (1.1)	1.5 (3.1)
1+ per day	1.0 (1.9)	1.8 (3.0)	2.0 (2.8)	1.7 (2.7)
Visible dental plaque				
No	1.1 (2.2)	1.5 (2.6)	1.2 (2.2)	1.3 (2.4)
Yes	1.2 (3.0)	2.6 (3.1)	2.1 (2.5)	1.9 (3.0)

Table 3
Association of dental caries in the past 24 months and oral hygiene by age groups: Crude and Adjusted rate ratios.

	Age							
	9-17		18-64		65+		All	
	Crude RR	Adjusted RR**	Crude RR	Adjusted RR**	Crude RR	Adjusted RR**	Crude RR	Adjusted RR**
Fluoride toothbrushing (Ref. <1 per day)								
1 per day	0.6 (0.3, 1.3)	0.5* (0.3, 0.8)	0.9 (0.6, 1.3)	0.8 (0.5, 1.1)	1.0 (0.6, 1.7)	1.1 (0.6, 1.9)	0.9 (0.7, 1.2)	0.8 (0.6, 1.1)
2+ per day	0.5 (0.3, 1.0)	0.5* (0.3, 0.8)	0.7* (0.5, 1.0)	0.6* (0.4, 0.9)	0.9 (0.5, 1.7)	1.1 (0.7, 1.8)	0.7* (0.5, 1.0)	0.7* (0.5, 0.9)
Water rinse after brushing								
	1.9* (1.0, 3.8)	1.3 (0.6, 2.7)	0.6* (0.4, 0.8)	0.6* (0.4, 0.9)	1.2 (0.7, 2.3)	1.1 (0.6, 2)	0.8 (0.6, 1.1)	0.7* (0.5, 1.0)
Interproximal cleaning 3+ times per week								
	0.7 (0.4, 1.4)	1.1 (0.7, 1.8)	0.8 (0.6, 1.1)	0.9 (0.7, 1.2)	1.3 (0.8, 2)	1.3 (0.8, 2)	0.9 (0.7, 1.1)	1.0 (0.8, 1.2)
Other fluoride products (Ref. None)								
<1 per day	1.1 (0.6, 1.9)	1.1 (0.8, 1.6)	1.3 (0.9, 2.0)	1.3 (0.9, 1.9)	0.7 (0.4, 1.1)	0.8 (0.5, 1.4)	1.1 (0.8, 1.6)	1.1 (0.8, 1.5)
1+ per day	0.9 (0.4, 1.9)	0.8 (0.3, 2.1)	1.2 (0.8, 1.9)	1.3 (0.7, 2.1)	1.5 (0.9, 2.5)	1.6* (1.0, 2.6)	1.2 (0.8, 1.7)	1.3 (0.9, 1.8)
Visible dental plaque								
	1.1 (0.5, 2.4)	0.9 (0.5, 1.6)	1.7* (1.2, 2.5)	1.6* (1.2, 2.2)	2.6* (1.8, 3.8)	2.5* (1.8, 3.5)	1.5* (1.2, 2)	1.5* (1.2, 1.9)

* $P < 0.05$

** Adjusted for age, gender, race, education, income, between-meal carbohydrate snacks, sugar-added beverages, alcohol consumption, smoking, BMI, exercise, stimulated salivary pH, number of teeth present, and all other oral hygiene variables captured.