

Is self interdental cleaning associated with dental plaque levels, dental calculus, gingivitis and periodontal disease?

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Background and Objective: To ascertain whether interdental cleaning behaviours of Australian adults were associated with lower levels of plaque, gingivitis and periodontal disease.

Material and Methods: Data were obtained from the National Survey of Adult Oral Health 2004–06. Outcome variables were three indicators of oral hygiene outcomes (the presence or not of dental plaque, dental calculus and gingivitis) and two of periodontal disease (the presence or not of at least one tooth with a periodontal pocket or clinical attachment loss of ≥ 4 mm). The independent variable was classified into the following three groups: regularly clean interproximally ‘at least daily’ (daily+); ‘less than daily’ (< daily); and ‘do not regularly clean interproximally’ (reference group). Poisson regression with robust variance estimation was used to calculate prevalence ratios (PRs) and 95% confidence intervals (95% CIs) relative to the reference group, adjusted for covariates.

Results: Regular self interdental cleaning was associated with less dental plaque (< daily, PR = 0.89, 95% CI = 0.84, 0.95; and daily+, PR = 0.89, 95% CI = 0.82, 0.96), less dental calculus (< daily, PR = 0.88, 95% CI = 0.80, 0.97; and daily+, PR = 0.79, 95% CI = 0.70, 0.89) and lower levels of moderate/severe gingivitis (daily+, PR = 0.85, 95% CI = 0.77, 0.94). Periodontal pocketing was less likely for the < daily group (PR = 0.61, 95% CI = 0.46, 0.82), but was not associated with daily+ cleaning (PR = 0.99, 95% CI = 0.663, 1.49). There was not a significant association between interdental cleaning and clinical attachment loss (< daily, PR = 0.90, 95% CI = 0.77, 1.05; and daily+, PR = 1.17, 95% CI = 0.95, 1.44).

Conclusion: Regular interdental cleaning was associated with better oral hygiene outcomes, such as dental plaque and gingivitis, although there was no significant association between regular interdental cleaning and clinical attachment loss.

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Löe's studies in the 1960s–1970s suggested that the aetiology of gingivitis and periodontal disease was associated

with bacteria present in microbial plaque (1). It seemed plausible that periodontal disease could be prevented by

removing bacterial flora. It also seemed plausible that as toothbrushing did not remove plaque between teeth (2) and

interdental cleaning did (3), that interdental cleaning would reduce the incidence of periodontal disease. However, the evidence for the effectiveness of three common methods of cleaning between teeth (flossing, interdental brushing and woodsticks) in plaque removal and in the prevention of gingivitis and periodontal disease is equivocal.

Flossing

Berchier *et al.* (4) reviewed the efficacy of dental flossing in addition to toothbrushing on plaque and parameters of gingival inflammation. Of the 11 studies that observed the effect of dental floss on plaque removal, three studies showed an additional effect of floss as an adjunct to brushing. None of the eight studies that studied gingival inflammation found a significant effect of floss as an adjunct to brushing. Four studies used the bleeding index as the clinical parameter, of which only one found a significant difference in favour of floss. A meta-analysis of plaque index and gingival index scores showed that only three individual studies out of a total of 11 observed a statistically significant difference in favour of floss as an adjunct to toothbrushing. The authors concluded that routine instruction to use floss as an adjunct to toothbrushing to prevent periodontal disease was not supported by scientific evidence and suggested that the dental profession should determine, on an individual basis, whether high-quality flossing is an achievable goal.

However, while gingivitis parallels the level of oral hygiene in a population, it is by itself a poor predictor of subsequent periodontal disease (5–7). It is now known that though the presence of bacteria is essential for periodontal disease to occur, the presence of bacteria alone is insufficient to cause periodontal disease (8). At the first European Workshop on Periodontology, consensus was reached that periodontitis was always preceded by gingivitis to support the suggestion that prevention of gingivitis should also prevent periodontitis (9).

Interdental brushing

Slot *et al.* (10) evaluated the efficacy of interdental brushes on plaque and the parameters of periodontal inflammation. Nine studies were eligible to be included in the review, though they varied considerably in design. All three studies that compared interdental toothbrushing as an adjunct to brushing alone showed a significant difference in favour of the use of interdental toothbrushing on the plaque score. The majority of the studies showed a positive significant difference on the plaque index when using interdental toothbrushing when compared with floss. No differences were found for the gingival index or bleeding indices. Two out of three studies showed that interdental toothbrushing, when compared with floss, has a significant positive effect on pocket reduction.

Slot and colleagues concluded that as an adjunct to brushing, interdental brushing removes more plaque than brushing alone. Studies showed a positive significant difference using interdental brushing with respect to plaque scores, bleeding scores and probing pocket depth. The majority of the studies presented a positive significant difference in plaque index when using interdental brushing compared with floss. However, the authors clarified that it is not appropriate to suggest interdental brush use in areas where the gingival papilla fills the interdental space.

Woodsticks

Hoenderdos *et al.* (11) reviewed the efficacy of woodsticks on plaque and gingival inflammation. Seven studies were eligible for inclusion in the review. The effect of woodsticks on visible plaque removal from the interdental surface after the use of a toothbrush was negligible. They concluded that the evidence from controlled trials, most of which were also randomized, showed that woodsticks do not have an additional effect over toothbrushing alone on visible interdental plaque or gingival index, but do provide an improvement in interdental

gingival inflammation by reducing the bleeding tendency.

Though the evidence for the effectiveness of interdental cleaning is equivocal, recommendation of interdental cleaning as a method to prevent dental disease has persisted (12–16). In the Proceedings of the European Workshop on Mechanical Plaque Control, the vast majority (94%) of participating oral health professionals believed that interproximal cleaning was an essential component of oral hygiene (17). However, the consensus of an expert committee is not accepted as a high level of evidence. Others have suggested that it may be smoking, and not dental plaque, that is the primary health-related behaviour influencing periodontal disease (18,19). If so, interdental cleaning would not be expected to reduce the prevalence of periodontal disease.

Hypothesis

As the public receives many health behaviour recommendations, it is important that these recommendations are based on evidence. This paper aimed to determine whether self interdental cleaning was associated with lower levels of plaque, gingivitis and periodontal disease.

Material and methods

Sampling and data collection

The data were obtained from the National Survey of Adult Oral Health 2004–06 (NSAOH; 20); a nationwide cross-sectional study, with a multistage, stratified random sample selection process among dentate Australians aged 15 years or more. The NSAOH used a clustered stratified random sampling design to select a representative sample of people aged 15 years or more. Survey participants were interviewed by telephone, and those who had one or more natural teeth were asked to attend a nearby dental clinic, where standardized oral epidemiological examinations were conducted by one of 30 dentist-examiners trained in the survey methods. The examination

included measures of plaque, calculus, gingivitis and periodontal disease that formed the dependent variables analysed in this study.

Of the 14,123 people interviewed, 5505 (43.7%) were examined. Extensive analysis was undertaken to investigate potential nonparticipation bias, with the results showing that the survey underestimated some estimates of oral disease, although the degree of underestimation was no more than three percentage points for measures of prevalence. Full details of sampling, examination protocol and survey participation have been described elsewhere (20). At the completion of the clinical examination, participants were given a pamphlet explaining that within a few days a questionnaire would be mailed to their homes. The 16-page questionnaire asked, amongst other things, about oral health behaviour, including interdental cleaning behaviours that formed the main independent variable for this study.

Dependent variables

Three indicators of oral hygiene outcomes (the presence or not of dental plaque, dental calculus and gingivitis) and two of periodontal disease (the presence or not of at least one tooth with a periodontal pocket of ≥ 4 mm (21–23) and the presence or not of at least one tooth with a clinical attachment loss of ≥ 4 mm (22,24,25) were used. Both the measures of periodontal disease are commonly used, but there is no accepted standard definition of periodontitis (26). Conceptually, the oral hygiene outcomes were seen to indicate the short-term outcome of oral hygiene, while periodontal pocketing was seen to indicate the presence of current periodontal disease, and clinical attachment loss was seen to indicate a history of periodontal disease.

Plaque was recorded according to the Silness and Loe (27) index of up to six index teeth (the first present molars in each quadrant, teeth 11 and 31). The plaque index of the survey participant was represented by the highest plaque accumulation of the six index

teeth, and survey participants were dichotomized into those with the highest plaque score of 0 (no plaque) or 1 (a film of plaque adhering to the free gingival margin and adjacent area of the tooth found by using a probe on the surface), and those with a plaque score of 2 (moderate accumulation of soft deposits within the gingival pocket, or gingival margin which can be seen with the naked eye) or 3 (abundance of soft matter within the gingival pocket and/or on the tooth and gingival margin).

The Loe and Silness (28) gingival index was used to assess the inflammation of the marginal tissues of the same six index teeth. The gingival index was dichotomized into those survey participants with at least one tooth with the highest rating of 3 (severe inflammation; marked redness and oedema, ulceration or tendency to spontaneous bleeding) or 2 (moderate inflammation; redness, oedema, glazing or bleeding after applying pressure with the probe), and those with a rating of 1 (mild inflammation; slight change in colour or slight oedema but no bleeding after applying pressure with the probe) or 0 (none of the above).

The presence or absence of dental calculus per person was recorded from the same six index teeth. The greatest periodontal pocketing depth and clinical attachment loss per person was recorded from three sites (mesial, mid and distal) of the buccal surfaces of all teeth except wisdom teeth.

Independent variable

Respondents were asked whether they regularly used interdental cleaning devices, with possible answers of 'none', 'dental floss', 'dental tape' and 'interdental brush'. Those respondents who gave an answer other than 'none' were asked the number of times they had cleaned between their teeth in the last week, to which they gave a numeric response. People were classified into the following three groups: 'clean interproximally at least daily'; 'clean interproximally regularly but less than daily'; and 'do not regularly clean interproximally'.

Covariates

The covariates were three indicators on noninterdental oral hygiene [frequency of toothbrushing (1), and the use of either mouthrinse (29–35) or sugar-free gum in the last week (36)] and the following eight socio-demographic variables: age group (15–34, 35–54, 55–74, ≥ 75 years) (37); sex (38,39); household income (< \$30,000, \$30,000–< \$60,000 or \geq \$60,000) (40); highest qualification (degree/teacher/nurse, trade/diploma/certificate or no post-secondary education) (41); occupation (manager/professional/paraprofessional, trades/clerical or blue collar workers/labourers) (41); regional location (metropolitan or nonmetropolitan) (42); country of birth (Australia or not Australia); usual reason for dental visiting (check-up or problem) (41); and eligibility for public dental care (40,43). Public funded dental care for adults is limited to those who hold health concession cards which are issued by Centrelink, an agency of the Australian Government's Family Assistance Office (National Advisory Committee on Oral Health, 2004). Healthcare card holders are means tested largely by income and include aged pensioners. Two covariates that have been shown to affect periodontal disease were also included: self-reported diabetes (44); and smoking (current smoker, past smoker or never smoked) (45).

A tooth brushing dichotomy was used because Attin and Hornecker (46) recommended twice daily brushing. A systematic review has indicated that sugar-free gum was associated with lower dental caries experience (36), and it is reasonable to consider that it may also be associated with oral hygiene and periodontal indicators. Four age categories were used because one could expect periodontal disease to start arising by age 35 years, be in progress by age 55 years and to show its results by age 75 years. The occupation split was based on the Australian Standard Classification of Occupations.

Analysis

Data were analysed using complex sampling procedures, thereby producing

population-representative estimates of dentate Australian adults. Categorical variables were presented as percentages and corresponding 95% confidence intervals (CIs). Descriptive analysis of the dependent, independent and covariates was presented, followed by bivariate analysis to estimate crude effects of self interdental cleaning and to find potential confounders. Those covariates that were statistically associated ($p < 0.05$) with the independent variables and at least one dependent variable were defined as confounders and included in the multivariate analysis. However, as diabetes (44) and smoking (45) have been shown to have strong associations with periodontal disease, the regressions were calculated with these two variables included to ascertain their influences on the outcomes. The multivariate analysis was undertaken with the three categories of use of self interdental cleaning devices. For the regression model, the 'not regularly cleaning between teeth' group was selected to be the reference category, and prevalence ratios were estimated for the cleaning regularly interdentally groups relative to that group. Poisson regression with robust variance estimation was used to calculate the prevalence ratios and 95% CIs for multivariate-adjusted relationship at the person level (using SUDAAN proc loglink, Research Triangle Institute, Research Triangle Park, NC, USA). The method is designed for Poisson (count) variables, but it yields correct point estimates, and 95% CIs are acceptable when robust variance estimation is used (47).

The NSAOH was reviewed and approved by the University of Adelaide's Human Research Ethics Committee.

Results

Descriptive analysis

A total of 4170 dentate participants were examined and completed the questionnaire. Weighted estimates revealed that one-fifth (20.0%) cleaned interproximally regularly and at least daily, while two-fifths reported either cleaning interproximally regularly, but less than daily (40.4%), or not regularly cleaning interproximally (39.5%).

Over half the participants brushed twice or more per day (55.5%) and had used a mouthrinse in the last week (58.1%), but less than a third (29.6%) used sugar-free gum in the last week (Table 1). Less than half the respondents were male, but the age/sex/regional location weighted percentage of males came to 50%. Three-quarters of the respondents were under 55 years of age (74.6%), nearly half had a household income of \geq \$60,000 (46.5%), a third had a degree, teacher or nursing qualification (33.9%), two-thirds resided in metropolitan areas (65.1%) and four-fifths were born in

Australia (79.0%). There were a lower number of responses to the more sensitive questions, such as household income and highest qualification. More than half reported usually visiting a dentist for a check-up (58.5%) as opposed to a problem and more than a quarter were eligible for public dental care (28.5%). A small number were diabetic (4.3%) and under half were current or former smokers (42.4%).

An estimated one-quarter of dentate Australian adults had a plaque score of two or more (27.6%), two-thirds had calculus present (65.7%) and under a fifth had moderate or severe gingivitis

Table 1. Distribution of the covariates and dependent variables

Covariates and dependent variables	<i>n</i> ^a	Percentage	95% Confidence interval
Oral hygiene measures (not interdental)			
Brushed twice or more per day	2535	55.5	52.7, 58.2
Used mouthrinse in the last week	2308	58.1	55.4, 60.6
Used sugar-free gum in the last week	975	29.6	27.1, 32.2
Socio-demographic variables			
Age (years)			
15–34	754	37.2	34.0, 40.4
35–54	1674	37.3	34.9, 39.7
55–74	1494	20.3	18.5, 22.0
\geq 75	248	5.3	4.3, 6.2
Sex			
Male	1604	50.0	47.3, 52.6
Household income			
< \$30,000	1253	24.1	21.7, 26.4
\$30,000 to < \$60,000	1219	29.3	26.9, 31.8
\geq \$60,000	1441	46.5	43.3, 49.7
Highest qualification			
Degree/teacher/nurse	1372	33.9	31.1, 36.9
Trade/diploma/certificate	1169	28.3	25.8, 30.9
No postsecondary education	1439	37.7	34.8, 40.5
Metropolitan geographic location			
Born in Australia	2648	65.1	62.9, 67.3
Usually visits a dentist for a check-up	3214	79.0	76.8, 81.2
Eligible for public dental care	2375	58.5	55.8, 61.3
Eligible for public dental care	1414	28.5	25.9, 40.0
Covariates affecting periodontal disease			
Diabetes	213	4.3	3.1, 5.5
Smoking			
Current	578	15.1	13.2, 17.1
Past	1315	27.3	25.1, 29.5
Never	2277	57.5	55.0, 60.1
Oral hygiene outcomes (six index teeth)			
Plaque score 2+	1197	27.6	25.1, 30.2
Presence of dental calculus	2773	65.7	62.7, 68.7
Gingival index score 2+	667	18.7	16.4, 21.0
Periodontal disease			
People with at least one site with periodontal pockets \geq 4 mm	839	18.4	16.2, 20.7
People with at least one site with clinical attachment loss \geq 4 mm	1939	40.7	37.6, 43.7

^a*n* is the unweighted number of study participants; percentages and 95% confidence intervals were weighted to produce estimates for the Australian population of dentate adults.

(18.7%). Clinical attachment loss was more common (40.7%) than the presence of periodontal pocketing (18.4%).

Bivariate analysis

Regularly cleaning between teeth was associated with a lower plaque score, and regular interdental cleaning at least twice daily was associated with both less calculus and less gingivitis, but self interdental cleaning was not associated with periodontal pocketing (Table 2). Those who cleaned regularly but less than daily had the lowest likelihood of having at least one site with clinical attachment loss of ≥ 4 mm.

People who brushed more frequently or used a mouthrinse were also more likely to clean interdentally (Table 3). People aged < 55 years showed a greater propensity to clean interdentally regularly less than daily. Females and people who usually visited a dentist for a check-up were more likely to clean interdentally than males and people who usually visited a dentist for a problem, respectively. People with an

income of $< \$30,000$ and those who were eligible for public dental care were less likely to clean regularly but less than daily. People without a post-secondary education were less likely to clean regularly interdentally.

Brushing teeth more frequently was associated with lower dental plaque and gingivitis, and chewing sugar-free gum was associated with a lower presence of calculus (Table 4). The presence of plaque was higher in older age groups, while those aged between 35 and 74 years were more likely to have calculus present. Females and more qualified people had better oral hygiene outcomes than males and lesser qualified people. People on lower incomes, those eligible for public dental care and those with diabetes had more visible plaque and gingivitis than people on higher incomes, who were not eligible for public dental care and those without diabetes, respectively. Problem attenders had poorer oral hygiene outcomes than regular attenders.

People who brushed more often and who did not use sugar-free gum were

more likely to have clinical attachment loss, while people who used a mouthrinse were more likely to have periodontal pockets. The presence of periodontal pockets was greatest at ages 35–54 years and ≥ 75 years. The presence of clinical attachment loss was higher in older age groups. Sex, highest qualification, country of birth and usual reason for dental visit were all statistically associated with both periodontal pockets and clinical attachment loss. Household income and eligibility for public dental care were associated with clinical attachment loss. Smoking, but not diabetes, was associated with poorer periodontal outcome measures.

The covariates of times brushed in the last week, used a mouthrinse in the last week, age, sex, household income, highest qualification, eligibility for public dental care and usual reason for dental visiting were defined as confounders because they were significantly associated with both the independent and at least one of the dependent variables, and each has been shown in previous studies to be causally related to oral hygiene or periodontal outcomes.

Table 2. Bivariate relationships between dependent variables and self interdental cleaning

Dependent variables	Self interdental cleaning			χ^2 p-value
	At least daily (Col %)	Regularly but less than daily (Col %)	Not regularly (Col %)	
Oral hygiene outcomes				
Dental plaque ^a				
Plaque score < 2	73.3	75.9	65.2	< 0.01
Plaque score $2+$	26.7	24.1	34.8	
Calculus				
Absence	40.0	33.7	27.9	< 0.01
Presence	60.0	66.3	72.1	
Gingivitis ^b				
Index score of $2+$	14.7	16.7	20.7	0.03
Index score < 2	85.3	83.3	80.3	
Periodontal disease				
Periodontal pockets				
People with no pockets	76.5	80.3	75.6	0.22
People with pockets ≥ 4 mm	23.5	19.7	24.4	
Clinical attachment loss				
People with clinical attachment loss ≥ 4 mm	57.9	45.9	52.7	< 0.01
People with no clinical attachment loss	42.1	54.1	47.3	

Abbreviation: Col %, column percentage.

^aPlaque score of $2+$ was defined as at least a moderate accumulation of soft deposits within the gingival pocket, or gingival margin which can be seen with the naked eye.

^bGingival index of $2+$ was defined as at least moderate inflammation, assessed as redness, oedema, glazing or bleeding after applying pressure with the probe.

Multivariate analysis

There were statistically significant associations between regular self interdental cleaning and better oral hygiene outcomes as follows: less dental plaque was significantly associated with both frequencies of interdental cleaning; the more one cleaned interdentally the less calculus was present; and daily or more frequent interdental cleaning was associated with less gingivitis (Table 5). A higher frequency of tooth brushing was associated with less plaque and calculus, while using a mouthrinse was associated with higher levels of calculus and gingivitis. Older age was associated with more plaque. People aged 35–54 years were more likely to have calculus. Females, people with a degree/teacher/nurse level of education and people who usually visited a dentist for a check-up had better oral hygiene outcomes than males, people without a postsecondary education or people who usually visited a dentist with a problem, respectively.

Table 3. Bivariate relationships between the covariates and self interdental cleaning

Covariates	Self interdental cleaning			χ^2 <i>p</i> -value
	At least daily (Col %)	Regularly but less than daily (Col %)	Not regularly (Col %)	
Oral hygiene measures (not interdental)				
Times brushed				
Twice or more per day	75.1	60.2	52.7	< 0.01
Less than twice per day	24.9	39.8	47.3	
Used mouthrinse in the last week				
Did	63.8	58.9	47.4	< 0.01
Did not	36.2	41.1	52.6	
Used sugar-free gum in the last week				
Did	25.3	26.4	20.0	0.59
Did not	74.7	73.6	80.0	
Socio-demographic variables				
Age (years)				
15–34	11.5	21.4	20.1	< 0.01
35–54	40.8	44.4	38.5	
55–74	48.5	30.3	35.2	
≥ 75	9.0	3.8	6.2	
Sex				
Male	29.0	35.4	47.5	< 0.01
Female	71.0	64.6	52.5	
Household income				
< \$30,000	37.7	27.5	32.2	< 0.01
\$30,000 to < \$60,000	31.5	32.0	30.1	
≥ \$60,000	30.8	40.5	37.7	
Highest qualification				
Degree/teacher/nurse	33.4	38.4	31.4	< 0.01
Trade/diploma/certificate	30.4	29.5	28.5	
No postsecondary	36.2	32.1	40.1	
education				
Geographic location				
Metropolitan	65.2	64.6	60.7	0.62
Nonmetropolitan	34.8	35.4	39.3	
Country of birth				
Australia	74.4	77.5	78.7	0.21
Not Australia	25.6	22.5	21.3	
Usual reason for dental visit				
Check-up	62.7	61.3	49.3	< 0.01
Problem	37.3	38.7	50.7	
Public dental care				
Eligible	39.9	28.2	35.0	< 0.01
Not eligible	60.1	71.8	65.0	
Risk factors for periodontal disease				
Diabetes				
Yes	5.9	3.9	5.7	0.43
No	94.1	96.1	94.3	
Smoking				
Current smoker	12.5	13.9	14.4	0.56
Past smoker	36.0	29.7	30.6	
Never smoked	51.5	56.3	55.0	

Abbreviation: Col %, column percentage.

Having diabetes was significantly associated with higher dental plaque scores and the presence of gingivitis, but smoking was not significantly associated with any of the oral hygiene outcomes.

There was a statistically significant association between a lower percentage of people with periodontal pockets with regular interdental cleaning less than daily, but not with more frequent regular dental cleaning. There was not

an association between interdental cleaning and clinical attachment loss (Table 6). Using a mouthrinse was significantly associated with more periodontal pockets. The lowest age group (15–34 years) had significantly less periodontal pocketing than the oldest age group, and there was an association between increasing age and increasing clinical attachment loss. Being female was associated with less clinical attachment loss than being male, and usually visiting a dentist for a check-up with less periodontal pocketing than usually visiting a dentist for a problem. Having an income lower than \$30,000 was also associated with more clinical attachment loss. Smoking, but not diabetes, was associated with both greater periodontal pocketing and clinical attachment loss.

Discussion

The results indicated that regular self interdental cleaning was associated with lower levels of dental plaque, dental calculus and gingivitis. These indicators respond relatively rapidly to change in oral hygiene behaviours. However, there was not an association between interdental cleaning and clinical attachment loss. As clinical attachment loss conceptually indicated a person's a history of periodontal disease, this result suggested that regular interdental cleaning may not reduce the probability of having periodontal disease in the long term.

The result of reduced periodontal pocketing with less than daily self interdental cleaning, but not with more frequent interdental cleaning was, at first glance, puzzling. This was also true with the mouthrinse results. One of the shortcomings of results from a cross-sectional survey such as NSAOH is that it cannot determine whether a behaviour was adopted before or after onset of disease, thereby creating uncertainty about the causal relationship.

The shortcomings of this study should be noted. Conceptually, the oral hygiene outcomes were seen to indicate the short-term outcome of oral hygiene, periodontal pocketing the presence of current periodontal

Table 4. Bivariate relationships between the covariates and dependent variables

Covariates	Dependent variables									
	Oral hygiene outcomes						Periodontal disease			
	Dental plaque		Calculus		Gingivitis		Periodontal pockets		Clinical attachment loss	
	Score 2+ (Row %)	<i>p</i> -Value	Presence Row %	<i>p</i> -Value	Index 2+ (Row %)	<i>p</i> -Value	≥ 4 mm (Row %)	<i>p</i> -Value	≥ 4 mm (Row %)	<i>p</i> -Value
Times brushed										
≥ 2 per day	25.9	< 0.01	64.4	0.68	15.7	< 0.01	20.0	0.07	53.5	< 0.01
< 2 per day	33.6		70.6		20.9		26.1		48.2	
Mouthrinse in last week										
Did	19.1	0.37	68.4	0.42	18.8	0.11	24.3	< 0.05	52.1	0.67
Did not	18.6		64.8		16.3		19.8		50.5	
Sugar-free gum in last week										
Did	23.4	0.05	63.1	0.03	14.8	0.09	19.3	0.15	41.6	< 0.01
Did not	30.6		68.0		18.6		23.3		54.5	
Socio-demographic variables										
Age (years)										
15–34	18.9	< 0.01	60.4	< 0.01	15.9	0.72	12.4	< 0.01	16.8	< 0.01
35–54	24.5		69.8		17.2		24.5		45.8	
55–74	35.7		68.1		18.8		19.3		72.2	
≥ 75	47.9		59.6		22.5		24.7		83.3	
Sex										
Male	38.1	< 0.01	70.6	0.02	21.2	0.03	24.6	< 0.01	60.3	< 0.01
Female	22.9		64.5		15.6		19.7		46.2	
Household income										
< \$30,000	35.4	< 0.01	68.3	0.54	20.6	0.04	22.9	0.62	64.9	< 0.01
\$30,000 to < \$60,000	27.6		68.5		17.2		22.1		50.2	
≥ \$60,000	24.7		65.5		16.0		23.2		44.0	
Highest qualification										
Degree/teacher/nurse	24.7	< 0.01	63.7	0.03	15.1	0.01	22.0	0.02	46.8	0.02
Trade/diploma/certificate	30.4		68.7		18.6		24.0		56.7	
No postsecondary	30.4		68.3		20.0		20.8		49.9	
education										
Location										
Metropolitan	27.3	0.20	67.0	0.57	13.0	0.30	23.2	0.30	48.7	0.07
Nonmetropolitan	31.6		66.7		19.5		21.0		56.2	
Country of birth										
Australia	28.1	0.26	66.8	0.96	17.6	0.89	19.8	< 0.01	48.6	< 0.01
Not Australia	31.6		67.0		18.1		31.1		61.7	
Usual reason for visit										
Check-up	24.4	< 0.01	63.4	< 0.01	15.2	< 0.01	19.6	< 0.01	47.9	< 0.01
Problem	34.6		71.4		21.0		15.8		56.6	
Public dental care										
Eligible	35.6	< 0.01	67.0	0.53	19.5	0.04	21.8	0.90	62.1	< 0.01
Not eligible	25.4		66.8		16.9		22.6		46.6	
Covariates/periodontal disease										
Diabetes										
Yes	44.6	0.04	66.8	0.08	26.4	0.01	26.9	0.95	68.6	0.19
No	28.0		66.9		17.5		22.1		50.7	
Smoking										
Current	33.7	0.02	75.4	< 0.01	15.4	0.80	34.1	< 0.01	57.3	< 0.01
Past	29.6		65.1		17.1		25.0		59.0	
Never	27.2		65.7		18.7		17.8		45.8	

Abbreviation: Row %, row percentage.

disease, and clinical attachment loss a history of periodontal disease. However, these were conceptual distinctions, as the outcomes were measured at one point in time. As noted above,

cause and effect cannot be obtained from cross-sectional surveys such as NSAOH. In addition, the regularity or not of interdental cleaning was reported by the survey participants. It

may be that some respondents reported regular interdental cleaning because they did not want to inform the interviewer of their own shortcomings. Furthermore, a respondent could be

Table 5. Multivariate regression models of oral hygiene outcomes

Parameters	Dental plaque (2+) ^a			Calculus (yes)			Gingivitis (2+) ^b		
	PR	95% CI	p-Value	PR	95% CI	p-Value	PR	95% CI	p-Value
Times brushed in the last week (≥ 2/day; ref. = < 2/day)	0.93	0.87, 0.98	< 0.01	0.89	0.81, 0.97	< 0.01	0.94	0.87, 1.02	0.12
Used a mouthrinse in the last week (yes; ref. = no)	1.01	0.96, 1.07	0.60	1.18	1.09, 1.28	< 0.01	1.09	1.02, 1.17	< 0.01
Age (15–34 years; ref. ≥ 75 years)	0.73	0.63, 0.84	< 0.01	1.04	0.82, 1.32	0.74	0.96	0.79, 1.16	0.66
Age (35–54 years; ref. ≥ 75 years)	0.79	0.70, 0.89	< 0.01	1.24	1.01, 1.51	0.04	1.02	0.85, 1.23	0.84
Age (55–74 years; ref. ≥ 75 years)	0.89	0.80, 0.99	0.03	1.19	0.98, 1.44	0.08	1.06	0.89, 1.26	0.51
Sex (ref. male = 0, female = 1)	0.80	0.76, 0.85	< 0.01	0.91	0.83, 0.99	0.03	0.87	0.80, 0.94	< 0.01
Income (\$30,000–\$59,999; ref. \$29,999 or less)	0.97	0.89, 1.06	0.50	1.00	0.86, 1.17	0.95	0.95	0.84, 1.07	0.41
Income (≥ \$60,000; ref. \$29,999 or less)	0.92	0.83, 1.02	0.10	1.00	0.85, 1.17	0.97	0.95	0.84, 1.07	0.43
Education (trade/diploma/certificate; ref. no postsecondary education)	0.95	0.89, 1.02	0.13	1.04	0.94, 1.15	0.44	0.93	0.85, 1.02	0.14
Education (degree/teacher/nurse; ref. no postsecondary education)	0.88	0.82, 0.94	< 0.01	0.88	0.80, 0.97	0.01	0.84	0.77, 0.91	< 0.01
Eligibility for public dental care (yes; ref. = no)	1.04	0.95, 1.13	0.41	1.01	0.88, 1.16	0.87	1.01	0.89, 1.13	0.93
Usual reason for dental visit (check-up; ref. = problem)	0.87	0.83, 0.93	< 0.01	0.82	0.76, 0.90	< 0.01	0.88	0.82, 0.95	< 0.01
Diabetes (yes; ref. = no)	1.18	1.07, 1.30	< 0.01	1.08	0.89, 1.32	0.42	1.18	1.00, 1.40	< 0.05
Smoking (current; ref. = never smoked)	1.09	1.00, 1.19	0.06	1.08	0.97, 1.21	0.17	1.05	0.95, 1.16	0.35
Smoking (former; ref. = never smoked)	0.99	0.92, 1.05	0.65	0.95	0.87, 1.04	0.31	0.95	0.89, 1.03	0.23
Interdental clean (< daily; ref. not regular)	0.89	0.84, 0.95	< 0.01	0.88	0.80, 0.97	0.01	0.93	0.86, 1.01	0.07
Interdental clean (daily+; ref. not regular)	0.89	0.82, 0.96	< 0.01	0.79	0.70, 0.89	< 0.01	0.85	0.77, 0.94	< 0.01

The prevalence ratio is relative to the reference group of each category, denoted by 'ref. = '.

Abbreviations: PR, prevalence ratio; and 95% CI, 95% confidence interval.

^aPlaque score of 2+ was defined as at least a moderate accumulation of soft deposits within the gingival pocket, or gingival margin which can be seen with the naked eye.

^bGingival index of 2+ was defined as at least moderate inflammation, assessed as redness, oedema, glazing or bleeding after applying pressure with the probe.

Table 6. Multivariate regression models of periodontal disease

Parameters	Periodontal pockets (≥ 4 mm)			Clinical attachment loss (≥ 4 mm)		
	PR	95% CI	p-Value	PR	95% CI	p-Value
Times brushed in the last week (≥ 2/day; ref. = < 2/day)	0.62	0.47, 0.83	< 0.01	1.07	0.92, 1.23	0.39
Used a mouthrinse in the last week (yes; ref. = no)	1.59	1.17, 2.16	< 0.01	1.09	0.92, 1.30	0.30
Age (15–34 years; ref. ≥ 75 years)	0.48	0.24, 0.96	0.04	0.09	0.07, 0.13	< 0.01
Age (35–54 years; ref. ≥ 75 years)	1.09	0.58, 2.06	0.79	0.40	0.31, 0.53	< 0.01
Age (55–74 years; ref. ≥ 75 years)	0.88	0.49, 1.59	0.68	0.73	0.59, 0.91	< 0.01
Sex (ref. male = 0, female = 1)	0.83	0.64, 1.07	0.15	0.69	0.60, 0.80	< 0.01
Income (\$30,000–\$59,999; ref. \$29,999 or less)	0.92	0.60, 1.42	0.71	0.77	0.63, 0.95	0.01
Income (≥ \$60,000; ref. \$29,999 or less)	0.92	0.57, 1.49	0.73	0.64	0.50, 0.81	< 0.01
Education (trade/diploma/certificate; ref. no postsecondary education)	0.99	0.69, 1.41	0.95	1.06	0.88, 1.28	0.53
Education (degree/teacher/nurse; ref. no postsecondary education)	0.90	0.63, 1.27	0.54	1.02	0.84, 1.25	0.81
Eligibility for public dental care (yes; ref. = no)	0.99	0.65, 1.50	0.97	1.02	0.83, 1.25	0.86
Usual reason for dental visit (check-up; ref. = problem)	0.71	0.54, 0.92	0.01	0.89	0.77, 1.03	0.12
Diabetes (yes; ref. = no)	1.47	0.78, 2.75	0.23	1.23	0.86, 1.74	0.26
Smoking (current; ref. = never smoked)	2.69	1.95, 3.73	< 0.01	1.97	1.60, 2.44	< 0.01
Smoking (former; ref. = never smoked)	1.20	0.91, 1.59	0.20	1.35	1.17, 1.56	< 0.01
Interdental clean (< daily; ref. not regular)	0.61	0.46, 0.82	< 0.01	0.90	0.77, 1.05	0.17
Interdental clean (daily+; ref. not regular)	0.99	0.66, 1.49	0.97	1.17	0.95, 1.44	0.15

The prevalence ratio is relative to the reference group of each category, denoted by 'ref. = '.

Abbreviations: PR, prevalence ratio; and 95% CI, 95% confidence intervals.

regularly cleaning interdental at the time of the survey or for say, a year before the survey, but not have a longer term history of regular interdental cleaning. Finally, the link between more frequent tooth brushing and interdental cleaning may be attributable to some other characteristic that was not used as a covariate in the multivariate analysis, for example systemic inflammation. The NSAOH is only the second nationwide oral health survey held in Australia; it had a large sample size, and the degree of non-participation bias was small (48).

The results were consistent with previous research. More frequent tooth brushing was associated with better oral hygiene outcomes. Løe *et al.* (1) found this link in 1965. Younger age groups had less dental plaque, less dental calculus and less clinical attachment loss, but not less gingivitis or periodontal pocketing than the oldest age group (≥ 75 years). As clinical attachment loss indicated the history of periodontal disease, it was expected that there would be a dose effect with age, and this was the case. Females had better results than males with all five outcome indicators. Women are reported to be more inclined to self-care, to visit the dentist more often and to be more likely to report symptoms such as pain (49). Not surprisingly, then, adult females were less likely than males at each age group to have periodontal disease as measured by clinical attachment loss (50).

In bivariate analysis, smoking was associated with the presence of plaque, calculus, periodontal pocketing and clinical attachment loss. This finding supports the contention that smoking may be the primary driver of periodontal disease (17,18) and is consistent with previous findings from NSAOH (20). Do *et al.* (45) found that the population attributable fraction of smoking for moderate to severe periodontitis was 32%.

This research is relevant for dental clinicians and oral health promoters when they advise people on the most effective oral health behaviours. In principle, advice regarding effectiveness of prevention should be based on findings from randomized controlled trials, although a trial of interdental cleaning

would require lengthy follow-up of large numbers of people, some of whom would be asked to refrain from interdental cleaning. Such a study is unfeasible and probably unethical. In the absence of such studies, evidence must come from observational studies. Health promotion messages should be simple and limited to recommendations that can be supported by evidence of benefit. These results support recommendations for interdental cleaning as a method to prevent dental plaque and gingivitis, both of which respond quickly to changes in oral hygiene. However, evidence was lacking to support interdental cleaning as a means to prevent the longer term outcome of destructive periodontal disease.

Conclusions

Regular interdental cleaning by Australian adults was associated with better oral hygiene outcomes, such as dental plaque and gingivitis, and regular interdental cleaning less than two times a day was associated with a lower prevalence of periodontal pockets. However, there was no significant association between regular interdental cleaning and clinical attachment loss.

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